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Editors: K S Pawar & A T Potter

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INTRODUCTION

We would like to welcome our friends and colleagues to the 17th annual International Symposium on Logistics (17th ISL). It is 19 years since the first Symposium on Logistics was held in Nottingham and it is now considered as the premier international event in the field of Logistics and Supply Chain Management. As always many members of the ISL community look forward to meeting, sharing and exchanging their research ideas and results in both the formal and informal settings which the symposium provides.

The concept of alternating the symposium every year between Europe and the rest of the World is now well established. This year's event in Cape Town, South Africa continues this tradition, following the very successful and productive event held in Berlin, Germany last year. By hosting the event in Africa, we hope to broaden the reach of the ISL community into an emerging area for supply chains. We would also encourage delegates to explore both this cosmopolitan city, with the iconic Table Mountain as its backdrop.

The theme of the 17th ISL is "***New Horizons in Logistics and Supply Chain Management*". This reflects the changes taking place across the world today in terms of shifting supply and demand for both goods and services, taking as a backdrop China's rapid rise, widely acknowledged now as the manufacturing hub of the world. Equally India is rapidly becoming the global services hub and other countries in the so-called 'developing world' are growing in confidence, infrastructure and capability. These changes have big implications for logistics and supply chain planning, representing a dynamic and interesting area of research and practice for both academics and practitioners alike. Papers will represent the latest in academic thinking, as well as case examples of successful logistical implementations.

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

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

We would like to take this opportunity to express our sincere thanks to all the presenters, delegates, reviewers, Advisory Committee members, 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 and Dr Andrew T Potter – July 2012

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SECTION 1 – SUPPLY CHAIN MANAGEMENT

A FRAMEWORK FOR POSTPONEMENT APPLICATION ACROSS THE SUPPLY CHAIN

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INTRODUCTION

For products with short life cycles, committing orders long before the occurrence of actual demand is a challenging task (Cachon &Terwiesch 2008). Especially when lead times are relatively longer, committing to suppliers early can result in underage or overage costs (Cachon & Terwiesch 2008), which can have serious repercussions in an environment of cut throat competition.

There could be different strategies to deal with this situation. One of such strategy is delaying the product differentiation and holding inventory at a generic level, which can be used later without any loss in actual value, till more information is available on downstream demand. This delayed differentiation is termed as postponement (Cachon & Terwiesch 2008).

The literature further distinguishes between various types of postponement depending upon the activities that are postponed. Logistics postponement is where goods are made to forecast but are dispatched based on actual demand or order confirmation. Manufacturing postponement is where the raw materials are purchased based on a forecast but the manufacturing activities are carried out based on actual demand. Similarly purchasing postponement is where the procurement of raw materials is done based on the order. In the case of product development postponement even the design activities are postponed till order placement (Yang & Burns, 2003).

SIGNIFICANCE OF STUDY

Postponement has remained an active area of research in operations management area. Some studies have explored the factors affecting the choice of postponement strategies such as lead time, demand variability, product life cycle and product characteristics (Battezatti and Magnini, 2000; Olhager, 2003; Yang et al., 2004; Yeung et al., 2007). Some studies have looked at implications of different postponement strategies, such as cost implications (Pagh & Cooper, 1998) and manufacturing implications (Skipworth and Harrison, 2004). While only a hand full of studies have explored the interaction among the supply chain firms such as impact of relationship structures (Yeung et al. 2007) and power structures (Krajewski et al. 2005) on postponement implementation. Yeung et al. (2007) proposed that in case of a balanced supply chain relationship, either speculation (no postponement) or production postponement should be adopted. In their other proposition, Yeung et al. (2007) observed that in the case of an unbalanced supply chain structure, either purchasing postponement or product development postponement have served the players better.

The authors of the study highlighted the need to identify whether region specific or industry specific patterns existed. Secondly the model in terms of its usefulness was more of an academic nature only, since the structure was assessed on the basis of dependence, which for short to medium term is considered something external to an organization’s control. There is no solution for an organization wanting to move from one postponement strategy to another.

RESEARCH PURPOSE

The purpose of this study is to develop a conceptual model for aligning supply chain strategies in US textile and apparel industry for postponement application.

The study would help practitioners identify requirements from their supply chain structures based on their postponement strategies and would aid them in make necessary changes in order to better align their supply chain structure to the support the application of a particular postponement strategy.

RELATIONSHIP STRUCTURE

CLASSIFICATION SELECTION

The relationship typologies presented in the literaturecan be categorized into two types. One which categorizes the relationships in terms of qualitative variables such as poor relationship, bilateral relationships etc (Tangpong et al 2008, Humphries et al 2007, Donaldson and O’Toole 2000, Ring & Van de Ven 1992), while the other which categorizes relationships in terms of content variables, for example, contractual, administered (Rinehart, 2004), coordination (Duffy 2008) and Type I, Type II (Lambert et al, 1996). Content based typology was selected for this study because of its objectivity which would make its practical interpretation easier and measureable. Of the three typologies falling in the content category (Rinehart, Lambert, Duffy), Lambert’s typology was selected to categorize the relationships for this study as it had more details in terms of relationship codification process.

METHODOLOGY

Given the preliminary stage of research in the postponement and supply chain area, qualitative research method was chosen for this study. Qualitative method of research focuses towards exploring phenomena and theory building where there is a lack of existing theories (Creswell, 2003). Within the qualitative research area, it was decided to adopt the case based research methodology, since the purpose was to develop an understanding and a clear picture of a phenomenon (McCutcheon and Meridith 1993). For a detailed description of methodology and cases refer to Chaudhry & Hodge (2012).

POPULATION

For this study the population was defined as the organizations falling under North American Industry Classification System (NAICS) code 424320 and 424330 which include Men’s/boy’s and Women’s/child clothing and accessory merchant wholesalers. Based on this list, the leading companies on both scales were contacted for developing case studies. Efforts were made to have some diversity in terms of product categories. Based on the principles highlighted by Yin (2009) and the number of cases used by Skipworth and Harrison (2004), it was decided to target developing three to six case studies for this study.

CASE DATA

The interviews were conducted either over the telephone or in person. After the interview, the data was structured in the form of case studies and submitted to the respondent for review and consent. Case briefs are presented next, for detail version refer to Chaudhry & Hodge (2012).

CASE BRIEFS

Company A used a multiple channel sourcing strategy. It sourced its basic jeanswear from South America for which the fabric was sourced from the US. The US supplier worked on JIT basis which was made possible by sharing advance planning with the supplier. For its fashion apparel primarily it used purchasing postponement at apparel vendor stage where as its tier II suppliers fabric mills) used manufacturing postponement by buying material in advance. For new developments product development postponement route was adopted. The feature of this interaction included information exchange at strategic and tactical level, joint planning, advance visibility of requirements, joint problem solving, long terms placements, consumption of unused inventory, open contract type and long term orientation. For company A, its supply chain relationships were found to be as per Lambert's definition of Type II relationships.

Company B operated in the hosiery industry with focus on basic sports socks category. It used manufacturing and logistics postponement for its socks in the basic segment. Company B's relationships with its downstream customers were characterized by information exchange at all levels of management, sharing of forecasts and product reviews, in addition it was linked to its customers' Point Of Sale (POS) data. Company B had made customer focused investment in manufacturing/warehouse locations and technology solutions. Moreover some of its customers had handed over product management responsibilities to company B as well. Company B's relationship with its downstream partners was also found to be close to Type II relationships of Lambert's typology. Although its interaction was more integrated and at a higher level than company A's in terms of informational linkage, yet it was not at Type III level in which different constituents of the value chain operate like one organization.

Company C operated in collegiate logo sock manufacturing business and primarily used manufacturing postponement by purchasing material based on forecast. This was driven by the lead time dynamics in the upstream market. However it had multiple interaction levels with its various downstream customers. With one category it has strategic linkage (Type II) with access to POS data, collocation of analysts, and access to product sales reviews while for other it had an arm's length type of relationship. It also used logistics postponement for one of its major customer with which it had an arm's length type of relationship.

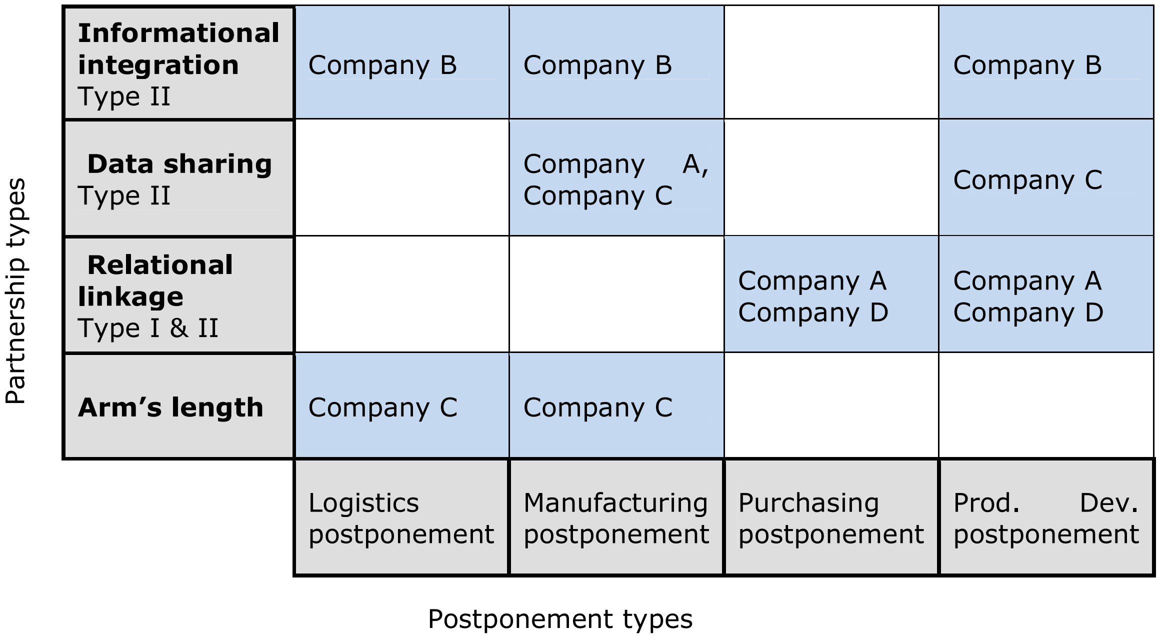
Company D operated in fashion products segment with its upstream vendors primarily adopting purchasing postponement strategy. Since it focused more on new designs it did not adopt higher level postponement in its upstream supply chain. Even for carry over products, it preferred its vendors to purchase material upon order confirmation yet some of its large vendors proceeded with material buying in advance based on the past trends. For new products it used product development postponement. Company D reserved capacities in advance and shared business outlook with its vendors. It provided assistance to its vendors in order to improve their processes and worked only with a limited number of suppliers with relationship categorized as Type I & II.

CROSS CASE ANALYSIS

The examples within the individual cases have been arranged across the axes representing postponement levels and relationship types as shown in Figure 1. The vertical scale of the matrix was slightly changed from the Lambert's scale (Lambert et al 1996) based on the data and represent relationships that were observed in the data sample. Multiple examples of postponement application were found within each company in the sample. The highlighted boxes in the Figure 1 indicate the presence of an example in the data set.

Since most of the relationships fell in Type II category, it was deemed necessary to further differentiate amongst them to make the analysis more objective and clear for the users of the model. Type II relationships were further divided into data sharing and relational types based on the focus of the relationship. For example, company B's relationship was more geared towards information integration whereas Company D's was more commitment and relational based. Similarly data sharing based relationship was further divided based on the mechanism of information exchange. In the case of Company B, data sharing was through technological and POS linkage, whereas for one of the Company C's cases, it was without POS linkage and for Company A, it was in the shape of sharing advance forecasts. This would be useful for the managers while formulating relationships based on postponement strategies or for different categories of products.

Although the interaction for Company A with its vendor was categorized as Type II data sharing yet the actual interaction was quite similar to Company D's example in case if product categories where purchasing postponement is used. Consequently, Company A was placed in the relational linkage category, along with Company D, for purchasing postponement strategy as shown in figure 1.



Partnership types

	Logistics postponement	Manufacturing postponement	Purchasing postponement	Prod. Dev. postponement
Informational integration Type II	Company B	Company B		Company B
Data sharing Type II		Company A, Company C		Company C
Relational linkage Type I & II			Company A Company D	Company A Company D
Arm's length	Company C	Company C		

Postponement types

Figure 1: Case example shown across relationship (modified) and postponement types

LOGISTICS POSTPONEMENT

Analyzing the logistics postponement column, the first row suits ideally for adopting logistics postponement and involves seamless data sharing from the POS location across the supply chain. In the case of Company B's example, the manufacturing and assembly operations were vertically integrated and data was shared across the chain, whereas in the case of de-integrated supply chains, the data must be transmitted to the upstream level in order to service the customers with optimal inventory levels. One important aspect highlighted by the Company B's case was transfer of product maintenance to the vendor and that included self order generation by the vendors in the supply chain without waiting for customer's go ahead. This saves time as well as avoids duplication of efforts. Moreover Company B had made investment in setting up distribution centers to cover their downstream market. In terms of investment it would be pertinent to highlight that the size of an organization and its turnover plays an important role in determining the extent of investment. Company B's size and turnover made it economically feasible for it to invest in technology and infrastructure. On the other hand, for Company C or any organization of its size or smaller, investment in POS linkage might not be feasible based on the cost benefit analysis.

Moreover the power structure in the value chain also impacts the choice of postponement strategy, for example, in Company C's case, its customer, the mass merchant had the clout to enforce its policies and made Company C adopts logistics postponement without the required data sharing with greater probability of increased mismatch cost.

For less fashion and more commodity type products having stable demand, data sharing without technological integration can also deliver although with certain demand and supply mismatch costs attached. The lower two boxes would be sub optimal with chances of obsolescence and stock out costs in addition to inventory carrying costs.

MANUFACTURING POSTPONEMENT

Analyzing the manufacturing postponement column based on the data, seamless data sharing from the POS location across the supply chain, suits ideally for adopting manufacturing postponement. In case of Company B's example the manufacturing and assembly operations were vertical, whereas in other case of de-integrated supply chains, the data must be transmitted to next tier at upstream location in order to gain advantage of data sharing and servicing the customers with optimal inventory levels. Similar to the logistics postponement case, the transfer of product management and maintenance to the vendor supported this strategy. For commodity type products that have some fashion content, such as new colors or design modifications, data sharing without technological integration (POS access) can also help to adopt manufacturing postponement although with certain demand and supply mismatch costs attached. However, in the case of Company C, where the products had some fashion content and manufacturing had to be initiated after the order placement, data sharing enabled better forecasting for raw material procurement. However for certain smaller customers which buy directly and do not have regular requirements, for example college teams or clubs or small institutions, they would always have an arm's length relationship with their product source while the source would still work on manufacturing postponement strategy.

Similarly in case of Company A, with an extra tier in their supply chain as opposed to the cases of companies B & C, it shares advance forecast based on the sales data with its vendors. This allows its vendors, especially upstream fabric manufacturers to make preparations earlier. The second round of forecast triggers production at tier II level where as the tier I waits for the actual purchase orders. However purchase orders are still based on forecasts and in most of the case ahead of the selling seasons. This highlights two aspects, one which is the lead time and transit time, which in Company A's case is greater than company B & C's case and hence require them to initiate production earlier. Secondly the data has to be shared with tier II vendors as well in order to cut down the time, because if tier II vendor would start after receipt of final purchase order, the lead time would increase with little advantage in terms of added market information. Company A adopts manufacturing postponement in its supply chain, whereas if individual tiers are analyzed, tier II proceeds with forecast and has the goods ready to ship once it receives the purchase order thus adopting logistics postponement at tier II level, where as tier I postpones manufacturing till they receive the purchase orders. While all this is still ahead of actual selling season so the whole process is based on forecast with perhaps the final shipping (from regional warehouses to individual stores) based on following some actual sales trends. However a POS linkage for the supply chain partners and shifting of product planning and management activities upstream (apparel manufacturers) can help reduce the time to market and reduce supply chain mismatch costs, but only in the case where the vendors have the capability to turn around the orders within the selling season.

PURCHASING POSTPONEMENT

Analyzing the purchasing postponement column, there were only two examples in the relational box for company D and Company A. One reason of having limited examples could be the limitation of the study method of having a limited sample size. The other reason could be that this interaction presents the most optimal strategy for the product categories under consideration. In terms of product category, both company A and D use purchasing postponement predominantly for products which have new designs or specifications (apart from the case where Company D uses purchasing postponement for carryover products) and have short life cycles generally spanning one seasonal cycle with little chances of product replenishments within the season. For both companies, even their tier II vendors begin production after the issuance of final purchase orders. Any other strategy under these circumstances would be sub optimal. For example following a purchasing postponement strategy for products with a life cycle of one season and having POS access for the vendors or sharing POS data in any other way (top two boxes of purchasing postponement column) would not add to supply chain's capabilities unless the vendors have the capability to furnish replenishments within the season based on the purchasing trends. One example is of Zara which uses a vertically integrated structure to follow the strategy of within season replenishments (Ferdows et al,. 2004). Looking at purchasing postponement case in isolation, where the vendor is not providing any other service such as VMI for any other category of products, POS access with technological investment would mainly go unused.

The third option in this column, i.e. arm's length relationship, could still work in this case and in the short term could seem more lucrative because of minimum relation building efforts. However on the down side there could be issues of quality and consistency which can cost a lot, especially for world class brands. Moreover other hidden costs such as vendor search costs, monitoring costs, and poor quality costs could overtake the costs of maintaining a relationship based strategy. In addition, there could be chances of lack of capacity availability for products requiring specific physical and technical capabilities. However there is a need to further explore the above argument.

In the case of commodity natured products, having data sharing relationship would demand the adoption of manufacturing or logistics postponement strategy. However the box representing the arm's length relationship can deliver in case of low value commodity products because of lack of any special technical requirements. On the other hand, high market value brands would still operate in the relational strategy area even for commodity products in order to maintain quality of products as well as their brand reputation.

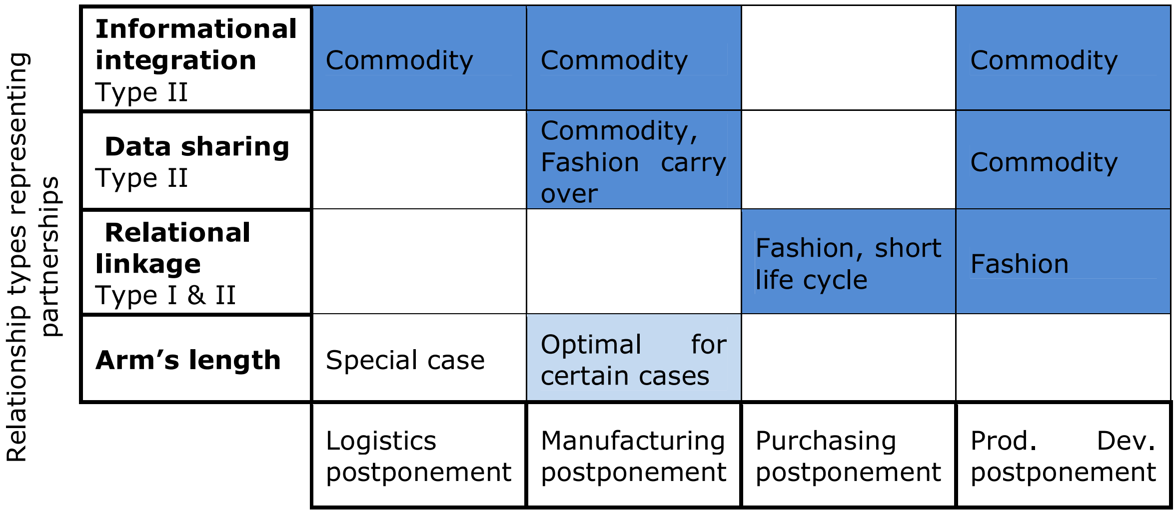
PRODUCT DEVELOPMENT POSTPONEMENT

The product development postponement column has companies in commodity type business adopting Type II data sharing relationship across the supply chain, while fashion oriented product makers adopting a more relational based strategy. One reason for this diversion in strategies could be the particular business dynamics for certain categories. There seems to be more delegation of product development in case of commodity businesses like hosiery examples in this data whereas in the case of fashion categories the designing functions still seem to be governed by the channel leaders, the brand companies. Another possible reason could be the location factor, since the hosiery organizations were based in the United States with more access to the US market trends and knowledge of tastes where as the vendors in fashion categories were from Asia and the geographic and cultural barrier might be an impediment in the eyes of the brand organizations with regards to market understanding. However it would be interesting to see how these brand organizations manage their commodity, for example hosiery, businesses. Based on the data, since company A and D did not have POS linkage with their vendors, they would still be in the relation and product development postponement interaction area. The reason for this could be the lack of technological linkage as pointed out by the respondents or the policy of the channel leaders to control the designs and the designing process. Further research could answer these questions. However the arm's length relationship strategy would be sub optimal in case of product development since the brand owners (commodity as well as fashion) want their vendors to actively participate in the process by presenting designs to their design teams.

In addition an active participation by a vendor during the design process helps reduce the time to market (Cooper, 2001). However there is a need to further explore the pattern of exchanges in the product development column based on product type, location and organizations size and strategy.

PROPOSITIONS

Figure 2 presents the propositions for relationships types that best support postponement strategies for different categories of products based on the length of their life cycles. These propositions are based on the methodology adopted and the data collected for this research.



Informational integration Type II	Commodity	Commodity		Commodity
Data sharing Type II		Commodity, Fashion carry over		Commodity
Relational linkage Type I & II			Fashion, short life cycle	Fashion
Arm's length	Special case	Optimal for certain cases		
	Logistics postponement	Manufacturing postponement	Purchasing postponement	Prod. Dev. postponement

Postponement types

Figure 2: Conceptual model showing postponement types across partnership types

The highlighted boxes of the matrix indicate a successful implementation of a particular postponement strategy based on the collected data. Different product categories appear along different postponement strategy columns, however the product development postponement column has all categories of products since there is some product development or at least some product enhancement being carried out for all categories of product at any stage of product life cycle. This development goes on simultaneously with the regular product sourcing and manufacturing activities for the existing products and once development are finalized the initial flow of orders in generally managed under purchasing postponement strategy. Based on this argument, if only the first three types of postponement are considered, namely logistics, manufacturing and purchasing, where some processes are based on forecast while the rest are postponed, there is a shift from informational linkage to relational linkage as postponement shifts from logistics towards manufacturing as shown in Figure 13 which shows the successful cases of postponement implementation. Similarly the data set for this study suggests that commodity type products are better managed by having informational linkage across the supply chain with delegation of product management functions to the vendors, whereas the fashion category products require a more relational management of the supply chain.

CONCLUSION

The level of postponement is driven by the type of the products and the position of the organization in the value chain. The postponement applications are supported by most suitable supply chain structures that are warranted by the dynamics of a particular value chain. The postponement applications include logistics postponement mainly for commodity type products such as socks, manufacturing postponement for commodity as well as fashion carry over products and purchasing and product development postponement for fashion and new products.

The conceptual model presented in Figure 2 highlights different supply chain relationship scenarios for logistics, manufacturing and purchasing postponement strategies. As new products are introduced, they can be better managed by adopting purchasing postponement strategy since at that time very little information exist on downstream demand. However as the product moves along the life cycle curve towards maturity stage and transform into commodity type products, they can be supported by adopting manufacturing and logistics postponement strategies, which require the value chain to have access to the latest sales data and trends. However, products which have a short life cycle and are phased out after one season and are managed by placing only one order prior to the actual selling season, access to sales data would not add much and would be better supported by adopting purchasing postponement strategy requiring relational linkage among the partners.

AREAS FOR FUTURE RESEARCH

The sample included organizations towards the downstream end of the value chain and lacked evidence from the upstream players in the value chain such as the fabric and yarn manufacturers. However, the model would still be helpful for the upstream members in understanding postponement dynamics in the downstream part of the value chains. Moreover the data did not cover the other product categories such as women legwear, outdoor specialty clothing, childwear, etc. which could have different dynamics in terms of implementing postponement strategies. Some boxes in the interaction matrix were empty, i.e. there was absence of any data in certain relationship and postponement interaction areas. This could be due to the limitations of methodology or sampling or due to the sub optimality of the said interaction. However further research would be needed to prove either of the propositions. Moreover there was no Type III relationship encountered in the study, further research could be carried out to classify the relationships in the textile and apparel value chain or to assess the reasons of non existence of certain types of relationships.

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DIFFERENTIATED STRATEGIES FOR THE MANAGEMENT OF SUPPLY CHAINS IN THE HOME APPLIANCES INDUSTRY

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ABSTRACT:

The increasing dynamics and complexity of today's supply chains resulted in having the differentiation and optimization of supply chains as survival needs to firms. Firms need to select from a wide variety of developed approaches to manage their supply chains, such as lean, agile, leagile, Supply Chain Operations Reference-model (SCOR®) framework and many other detailed models and methodologies. In this paper, a business case study is conducted to answer the research question: "*How can the agility best fit within the supply chain strategies?*" This business case study is applied on Delta Electrical Appliances (DEA) Company, a member of "Olympic Group", the Egyptian market leader of home appliances.

This research contributes to literature by developing the DESC (Differentiated enlightened Supply Chain) framework that consolidates necessary analysis in order to discover the scope and priorities of the supply chain from multiple perspectives. It is a guideline for the enlightened differentiated supply chain management. Through this, every different supply chain is managed differently to serve for different order winning criteria that are considered from multiple perspectives.

The research concluded that in such significant and rapid changes in the requirements of different products and markets, Differentiation is the clue to satisfy customer requirements and firms' competitive position. It is to manage different priorities differently. There are neither lean nor agile companies. Rather, every different supply chain needs to be managed differently according to its current order winning criterion. Also, the research concluded that Postponement strategy is highly recommended for firms in competitive environments with high market dynamics. The research pointed out that in order to avoid misleading results, data must be refined before the analysis starts. This requires three main actions. The first is to "*Run the analysis ONLY on active products, i.e. remove the discontinued products*". The second is to "*Disregard the periods affected by exogenous factors if they have a medium to long term effects*". The third is to "*Neutralize the market fill quantities in the analysis*".

Keywords:

Supply chain strategies; Agile supply chain; Lean supply chain; Decoupling point; Differentiated enlightened Supply Chain.

1. INTRODUCTION:

Customers are not usually so patient to wait for a product lead time that the organization needs to take to procure, make and deliver finished product. There is a significant need for agile supply chain management as a key strategy for competitive advantage in dynamic markets.

Order winning criteria is not the same for all the products of a company. It actually varies according to the product itself, its stage in product life cycle and its target market. Based on this fact, every different supply chain has different order winning criteria. Accordingly, the best strategy varies according to each supply chain. There is no single best strategy that can be applied to all of the company products. The problem of long lead times can be significantly solved through agile supply chains. There are many approaches to create agility in supply chains, some of them can effectively fit the supply chain strategy and some others do not.

The main research question of this paper is "*How can the agility best fit within the supply chain strategies?*" There are some other questions derived from this main research question such as: Is it agile supply chain, Lean/JIT system or should it be hybrid concept (Leagile)? If it is the leagile, where to allocate the decoupling point before which the system would operate with the agility and after which it would be JIT? What is the best strategy for each supply chain of DEA Company?

2. LITERTURE REVIEW:

The topic of '*Agility*' has been attracting the attention of many researchers and it formed a repetitive recommendation of many business researchers to all corporations to create agility in their supply chains. Basically the research on this topic focuses on three main areas. The first discusses the definition and description of the term '*Agility*'. The second investigates the benefits the organizations enjoy from creating agility. Finally, the third area studies how corporations can create agility within their supply chains.

2.1. Agile Supply Chain - Conceptual Definitions

Many studies have attempted to provide a conceptual definition of organizational agility. The idea of manufacturing flexibility was extended into the wider business context and the concept of agility as an organizational orientation was initiated by Nagal and Dove (1991). Later, Christopher and Towill (2000a) confirmed the argument that "A key characteristic of an agile organization is flexibility".

Venkatraman and Henderson (1998) represented three elements of *virtual organizing* as an assessment of the agile capabilities of a supply chain. Later, Christopher and Towill (2000b) confirmed the argument that "A key characteristic of an agile organization is flexibility". Naylor et al (1999) related the agile and lean paradigms to supply chain strategies. They emphasized the features of Leagile as a combination of the lean and agile paradigms within a total supply chain strategy. This is achieved by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the marketplace.

Christopher (2000) described the agile supply chain by four distinguished characteristics. First, the agile supply chain is *market sensitive* to quickly respond to customer requirements. Second, it is information based through *virtual supply chain* - rather than inventory based - which assumes access to information, knowledge and competencies of companies through the Internet. Third, it has *process integration* that allows collaboration between buyers and suppliers. Fourth, it is *network based* in a way that leverages the respective strengths and competencies of the network partners to achieve greater responsiveness to market needs. Similarly, Hoek et al (2001) identified four dimensions of agile supply chain practices. The first is *customer sensitivity*. The second is the *network integration* between all nodes in the chain. The third is *process integration* so that core modules of products can be delegated within networks of agile competitors. Finally, the fourth element is *virtual integration*.

Kehoe and Boughton (2001) discussed the *capabilities* of an agile supply chain in terms of two dimensions; *information reach* and *range of activities* covered by networking amongst companies. They concluded that an agile supply chain should extend to the highest levels on the dimensions of *reach* and *range*. At the highest levels of attainment of the two dimensions, the conduct of internal operations will be transparent to suppliers and customers. Also, local teams of employees can think globally and take virtual initiatives with teams in other companies within the supply chain. Closely related to the characteristics of the agile supply chain, the dimension of *process based* supply chain agility were defined by Ghatari et al (2009) through a framework for understanding process based agile supply chains (PBASC).

On a different related research area, the distinction or integration between leanness and agility presented a wide area of discussions. Researchers were divided into two groups, some made a distinction between lean and agile approaches as a selected strategy for building market winners (MW) or market qualifiers (MQ) like Goldman et al (1995), Mason-Jones et al (2000) and Christopher and Towill (2000b). Contrarily, the following researches started to look at the 'leanness' and 'agility' as not mutually exclusive paradigms and may be married to advantage like Aitken et al (2002) and Yusuf et al (2004). While Towill & Christopher (2002) concluded that it is not "lean *or* agile", rather it is the careful selection and integration of appropriate aspects of these paradigms belonging to the particular supply chain strategy. One may well find the lean and agile paradigms operating at different times but in the same place, or operating at the same time in different places within a supply chain.

2.2 Agility in supply chains – Benefits of having it

Organizations that created agility in their supply chain enjoy many benefits such as shorter lead time and meeting customers' requirements (Christopher, 2000). Agility has become more critical in the past few years because most supply chains are incapable of coping with emergencies that have became frequent like the terrorist attack in New York in 2001 and the SARS epidemic in Asia in 2003, threat from natural disasters, wars and computer viruses. No doubt, agile supply chains quickly recover from sudden setbacks (Lee, 2004).

Mason-Jones et al (2000) concluded that classifying supply chain design and operations enables matching the supply chain type according to marketplace need. It enables the application of lean principles, agile principles and leagile principles according to the real needs of a specific supply chain. Aitken et al (2002) in a case study on a lighting company concluded that, in order to compete in volatile markets, to be lean is not enough. 'Lean' and 'Agile' paradigms may be married to advantage. Visibility of demand, flexible and quick response, synchronized operations and organizational agility are each necessary, not just sufficient condition for international competitiveness but must be integrated into the agile enterprise. Also, Aitken et al (2003) introduced a product classification system at which products are segmented into clusters based on market demands which are influenced by both lean and agile thinking. Such classifications result in decreasing costs, increasing sales volume and increasing customer service levels in relation to order cycle times, product development lead times and variety.

The increasing selectivity by end customers is a differentiating feature of business in the 21st century. So, value streams need to be adapted to meet this latest challenge (Childerhouse and Towill 2006). Moreover, over the past two decades, globalization has resulted in a highly competitive business environment. The turbulent markets in the 21st century highlighted the need for more competitive enterprise strategies. Efficiency alone is not enough. Speed, quality, flexibility and responsiveness which are key components of agile capabilities are necessary to meet the unique needs of customers and markets. Enterprises benefit from having such characteristics by expecting uncertainties and enabling rapid changes to achieve greater responsiveness to variability in their business (Baramichai et al 2007). Finally, agile supply chains impact the business performance and affect business strategy. It responds to rapidly changing, fragmenting global markets by being dynamic, context specific, growth-oriented and customer focused (Ghatari et al 2009).

2.3 Agility in supply chains – Methods and Supporting Approaches

All definitions indicate that organizational agility is a multi-dimensional concept that involves several diverse aspects of an organization. This can be seen as the prescription for organizations to create agility in their supply chains. To achieve agile supply chain Mason-Jones et al (2000) consolidated the rules for simplifying and streamlining material flow into four powerful sets of Material Flow Control Principles. First is the selection of good decision support systems. Second is slashing of material flow and information flow lead times. Third is the widespread provision and integrity of operations information. Finally the fourth is the elimination of redundant echelons. To the same objective Christopher and Towill (2000c) created an *Integrated Agile Enterprise Enabling Model*. Lee (2004) summarized the method to create agility in the supply chain to continuously provide supply chain partners (suppliers and customers) with data on changes in supply and demand so they can respond promptly.

Product variety/volume predictability matrix was introduced by Aitken (2000). He concluded that companies need to manage their supply chains through four strategies. All are related to this matrix. The four strategies to the focused factories are *MRP* (Material Requirement Planning), *Kanban*, Assemble-To-order and design-To-Order. Aitken et al (2002) argued that "*lean methodologies can be a powerful contributor to the creation of agile enterprises*." Also, Towill & Christopher (2002) studied these "lean" and "agile" paradigms in terms of space-time commonalities and proposed a logical sequence for organizations to pursue from identifying the market "winners" and "qualifiers" for each market segment through allocating appropriate/feasible decoupling points in the supply chain toward establishing performance metrics to encourage the alignment of marketing and supply chain strategies.

Aitken et al (2003) proposed a flow diagram of the decision processes to match between supply chain strategy and the stage of product life cycle. The focused demand chains are designed to maximize Order Winner (OW) and Market Qualifier (MQ) objectives for each of the four product clusters (MRP, KANBAN, Assemble-To-order and Design-To-Order). Also, at a generic level there is no single supply chain strategy that is applicable to all products' life cycle stages. Rather, each stage has a significant impact on the strategy, especially in relation to supply chain management. As a product proceeds through its life cycle, demand characteristics change. There has to be a consequential requirement to change the supply chain strategy to maintain competitiveness. "*Hence the direct relevance of the focused supply chain in optimally matching product to pipeline. Analysis of the key order winner (OW) and market qualifier (MQ) characteristics during each stage of a product's life cycle facilitates the identification of supply chain engineering requirements* (Aitken et al, 2003)".

Closely related to the Market-Orientated supply chain, Childerhouse et al (2002) introduced an integrated framework for the development of *focused demand chains*, through which the particular *product classification system* utilized five parameter (duration of life cycle; time window for delivery; volume; variety; and variability, with the acronym DWV[3]) schemes. Later, Childerhouse and Towill (2006) positioned the move of each supply chain towards seamless Market-Orientated supply chain within the Integration/Orientation Matrix. The main concept of this matrix is that it defines the *Level of Integration* of each supply chain (To-Be) based on the *degree of market orientation*. Then this ideal situation is compared with the actual (As-Is) to define gaps. This matrix representation helps in both targeting and positioning value steams as an aid to matching them to real-world requirements.

A major strategy to create agility is the postponement strategy through a decoupling point. Yang and Burns (2002) introduced a framework of postponed manufacturing and its impact on global competitive performance. Closely related to how to create agile supply chain is how to marry the lean and agile paradigms. Childerhouse et al, (2002) concluded that lean precedes agile. This is because real and effective change requires the mapping and understanding of all the relevant business processes in the value chain from customer need identified to customer need satisfied. Another tool that can be used to successfully transform a business toward agility is the "*Agile Supply Chain Transformation Matrix*" that was developed by Baramichai et al (2007).

3. RESEARCH APPROACH:

A Descriptive, Single, Intrinsic case study is used to answer the research question. The work is based on the *Supply Chain Excellence (SCE)* methodology with some customization to ensure wider exploration of the improvement opportunities and optimal decisions of DEA Company. The *SCE* is a proven business improvement *methodology* based on the SCOR®-model. This process reference model has been developed and endorsed by the Supply Chain Council as the cross-industry standard *diagnostic tool* for supply chain management. SCOR® enables users to address, improve and communicate supply chain management practices within and between all interested parties. The use of *SCE* methodology with some customization resulted in creating a new model in this paper that is divided into four phases: Educate, *Discover/Analysis*, *Design* and *Develop.*

Narrative data is collected by interviews with relevant managers to analyze and determine narrative outputs like DEA SC business scope. Also Historical data is collected and used for quantitative analysis like categorizing the final products into RRS (Runner, Repeater and

Stranger) families according to their behaviour. This case study consists of phase zero plus three phases (see figure 1) with fourteen kinds of analysis and actions:

Phase 1: Discover/Analysis phase:

1. Business Scope Diagram that is a flow chart that determines the DEA SC to represent *Customers*, *Key nodes* (A node represents a logical or geographic entity in the supply chain) and *Suppliers* of DEA organization.
2. DEA SC Definition Matrix that helps to define the number of the supply chains in relation to its customers and products or services.
3. Historical sales volumes analysis over the past 5 years to calculate demand using the *12 months moving average actual sales* forecast method.
4. Analyzing the sales volume of the last 12 month to categorize the *final products into RRS families* according to their behavior.
5. Analyzing the actual sales history to identify the *Product Life Cycle (PLC) stage* that each product belongs to.
6. Applying *DWV*^{3} analysis for each product to develop the focused demand chains.

Phases 2: Design phase:

7. Identifying *order winning criteria* for each product based on its position in the PLC stage, RRS matrixes and SCOR criteria.
8. Drawing the *"As-Is" Input/Output tables* of DEA SC functions. They include all data gathered during meeting with all the company staff. They were arranged according to IT system analysis as: Business Process/Input/Output and Filling.
9. Drawing the *"As-Is" Work/Information Swim Lanes* of all processes of DEA SC as a diagnostic tool used by SCOR to define the "As-Is" situation for the entire supply chain. It helps in defining the supply chain disconnections and visualizes the flow of information, documents and processes.
10. Linking each process to its related SCOR metrics. In SCOR model, the level-1 metrics are called *Strategic metrics* or *Key Performance Indicators* (KPI's) and they are ten metrics. While level-2 metrics are called "Diagnostic metrics" and they are 36 metrics. They measure a part of the SC and/or a part of the strategic metrics and provide direction to where problems originate. All metrics beyond level-2 are called level-3 metrics and they are more than 500 SCOR metrics. These metrics serve as further diagnostic tools for level-2.

    During this stage of the case study and after drilling down the metrics up to level-3, a voting session was held to rate the criticality of each level-3 metric to the performance of DEA processes. Nine managers participated in this rating session. Rates are ranked from lowest (1) to highest criticality (5). All Level-3 diagnostic metrics with a rate of 3 or higher are critical metrics which DEA must track for improvements; they are key success metrics.

Phase 3: Develop phase:

11. Assessing Inventory Management using the *X-Y-Z analysis* of Raw Material Inventory value, the *A-B-C analysis* of Raw Material Consumption and the *lead time analysis*.
12. Setting the production plan per family using MS Excel solver to minimize the average projected available balance of Finished Products by changing the MPS (Master Production Schedule) cells.

13. Calculating the finished products safety stock (SS) level and the MPS.
    - Target opening safety stocks of finished products are set to cover 10 sales days for Runner products, 7 sales days for Repeater products and 5 sales days for Stranger products.
    - DEA planning team breaks the monthly finished products families' forecast into weekly demand equally and gets the opening balance of the month under consideration. Then DEA planning team calculates the MPS and PAB (Projected Available Balance) according to the following equations:

      PAB = Previous PAB + Scheduled Receipt + Planned Order Released

      - Gross Requirements.

      MPS = Gross Requirements - Scheduled Receipt - PAB + Safety Stock.
14. Applying improvement policy of SS for each RRS family refers to the desired service level for each of them.
    - RRS classification of the new introduced products is determined by the analysis of the last 12 month sales. New policy of SS is applied for each RRS family to refer to the desired service level for each of them.
    - Planned safety stock in days of coverage is a function of RRS classification of the new introduced products, ABC/XYZ classifications, Standard deviation of demand during replenishment lead time, and Z value which corresponds to the desired service confidence level. Confidence level of SS is set to be 95% for runners, 92% for repeaters and 90% for strangers.

4. RESULTS AND IMPLICATIONS OF THE RESEARCH

This research differentiated DEA supply chains after applying three types of analysis on DEA's historical sales volumes. The first is Runners/Repeaters/Strangers (RRS) analysis. The second is Product life cycle (PLC) analysis. The third is Duration of life cycle, time Window for delivery, Volume, Variety and Variability (DWV^3) analysis for each product. Then this research linked DEA processes to their related SCOR Key Performance Indicators (KPI's) to define the critical success factors for DEA. All of these kinds of analysis are consolidated in one matrix to illustrate the differentiated supply chain strategies bases on different order winning criteria for each of DEA products.

The most significant results of this research were its contribution to the literature by developing the DSCM (Differentiated Supply Chain Management) framework, illustrated in figure 1. It consolidates the necessary analyses at its first phase to discover the scope and priorities of the supply chain from multiple perspectives. This paves the way for differentiated supply chain management, through which every different supply chain is managed differently to serve for different order winning criteria that are considered from multiple perspectives. Second phase of this framework includes the "As-Is" analysis to assess the current status of the supply chain, measure its performance with respect to the preset priorities and then benchmark the performance against competitors and best in class performance. Finally, the third phase of this framework develops the guided performance in optimizing the planning process for finished products and raw materials.

The applied Raw Material inventory analysis (*X-Y-Z* Inventory value *analysis*, *A-B-C* Consumption *analysis* of Raw Material and *lead time analysis*) revealed that the company has high value items (X) in its lowest consumption items (C). This indicated that DEA Company holds significant obsolete stock value. A recommendation was given to DEA Company to write off its obsolete stocks to improve its financial performance. Also, this work recommended inventory decisions for DEA like using Kanban, vendor Managed Inventory (VMI) or MRP systems based on each group position in the *X-Y-Z*, the *A-B-C* and *lead time* matrixes.

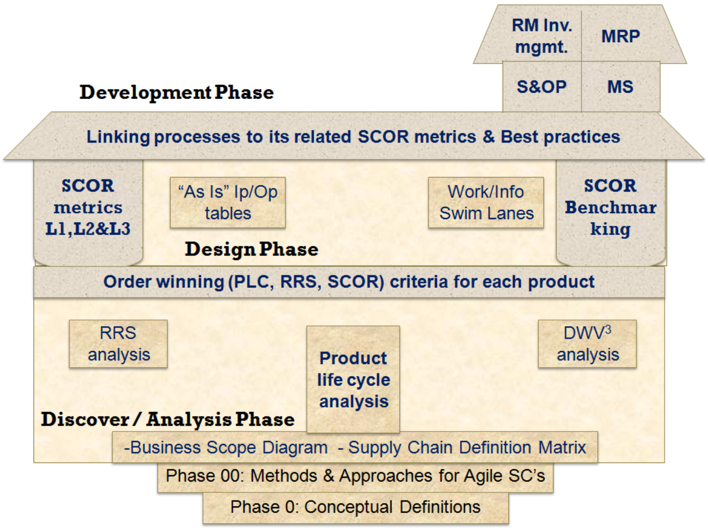

Figure 1: DESC (Differentiated enlightened Supply Chain) framework

Finished products Safety Stock (SS) at DEA was neither fixed static level nor ratio of past actual sales volume. Rather it is a ratio of the demand in a certain coverage period of the sales forecast. This complies with the essence of keeping SS to protect against the uncertainty of demand (and/or supply) of future periods. SS is calculated by the required consumption for a certain number of days into the period ahead. The number of days is determined according to the RRS categories of the finished product. This method adjusts for demand seasonality of white goods.

Implementation of this case revealed positive outcomes in exploring the improvement opportunities of DEA and achieved significant performance improvement of the following: Defining key success factors and business priorities; Readiness for benchmarking performance and setting targets; 13% savings in purchasing cost of raw materials and components; 17% reduction in days of On-Hand inventory from 120 to 100; 4% reduction in working capital due to categorized SS policy; Increase in product availability from 98% to 99.5%; And also increase in suppliers' schedule adherence from 91% to 97%.

5. CONCLUSION AND PRACTACAL IMPLICATIONS:

This research concluded that in such significant and rapid changes in the requirements of different products and markets, differentiation is the clue to satisfy customer requirements and firms' competitive position. It is to manage different priorities differently. There is neither lean nor agile company. Every different supply chain needs to be differently managed according to its order winning criteria. Also it concluded that postponement strategy is highly recommended for firms in competitive and highly dynamic markets.

This research recommended that supply chain strategy needs to be dynamically adapted to the changing order winning criteria. The marketplace Order Winners (OWs) and Order Qualifiers (OQs) are dynamic for any specific product as it proceeds through its product life cycle. Therefore, the production and manufacturing processes must also dynamically adapt to best service these changing marketplace conditions. The basic elements of a supply chain are then re-configured to better match the marketplace.

The research highlighted that in order to avoid misleading results; data must be refined before running the analysis. This requires three main actions. The first is to r*un the analysis ONLY on active products, i.e. remove the discontinued products*. The second is to d*isregard the periods affected by exogenous factors*. The third is to n*eutralize the market fill quantities in the analysis*.

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A CLASSIFICATION OF DIFFERENT STRATEGIC ROLES OF LOGISTICS

- EXTENDED ABSTRACT -

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Introduction

In recent years the strategic importance of logistics has been well recognised in literature. It has been revealed that logistics can contribute to a company’s overall profitability and growth, and hence be the foundation for a sustainable competitive advantage (Mentzer et al., 2004; Hult et al., 2007, Sandberg et al. 2011; Sandberg & Abrahamsson, 2011). Beside “production-oriented” or “market-oriented” companies, there are also empirical examples of companies that can be labelled “logistics-oriented”, e.g. Wal-Mart, Dell and Hewlett Packard.

To further advance the knowledge about the linkage between logistics and strategy, logistics scholars have started to go beyond logistics literature and use strategic management theory as a means to better explain and understand the strategic role of logistics. For instance, competitiveness through logistics has been described from the Industrial Organisation (I/O) framework (Persson, 1991) and the Resource Based View of the Firm (RBV) (Mentzer et al., 2004; Olavarrieta & Ellinger, 1997), as well as dynamic capabilities (Esper et al., 2007; Sandberg & Abrahamsson, 2011). Also from the other way around, strategic management research has started to acknowledge the importance of logistics and supply chain management (SCM) as a means to achieve competitive advantages. In terms of methodology, the literature incorporates conceptual papers as well as case studies and statistical studies.

Overall, the above mentioned literature provides us with a vast amount of information about the strategic role of logistics. However, as already stated by Persson (1991): “To understand the important and changing role of logistics in any company, it is insufficient to state that logistics has an important strategic impact.” (Persson, 1991, p. 1) To be able to develop beyond the statement that ‘logistics contributes to corporate strategy’, it is necessary to, in a more systematic way, distinguish between different strategic roles.

In this conceptual paper, we develop and describe three principle roles for logistics to play for a company’s sustainable competitive advantage. Based on how logistics as a function interplay with - and is positioned against - other functions in the company three generic roles are identified: (1) Logistics activities *alone* constitute a sustainable competitive advantage, (2) Logistics activities *together* with activities from other functions constitute a sustainable competitive advantage, and (3) logistics activities *enable* other company functions/activities to form the basis for a sustainable competitive advantage. These three types have previously been discussed in different ways in literature, however so far not been developed and explained and contrasted against each other in an explicit manner.

Research methodology

This conceptual paper starts with the need for a more comprehensive classification of different roles of logistics in corporate strategy. With more than 20 years of research on strategic matters of logistics, our department have gathered relevant literature, published own literature, and worked with a vast amount of empirical data where a common denominator has been to investigate and illuminate the strategic importance of logistics. Through an iterative process and discussion with colleagues, the three generic roles of logistics have emerged. Foundation for the classification is how the logistics function is related to other functional areas in the company. In line with supply chain management literature that stresses functional integration, and a development towards more cross-functional research on company performance, a positioning of logistics towards other functions is crucial for the understanding of how logistics contributes to corporate strategy.

The literature included in this study has mainly been taken from our department's previous work on the logistics role in business strategy. Important criterion for our selection has been a more extensive argumentation about the impact for corporate strategy in the research. Papers typically discussing a strategic level of SCM in general terms without explicitly treating the question of competitive advantage and/or corporate strategy have been outside the scope for our selection. In addition, papers not addressing logistics issues explicitly have been neglected.

Our paper does not claim to be exhaustive when it comes to literature – there are indeed a vast material published. Rather, this paper seeks to demonstrate – through a classification - that there are different strategic roles of logistics.

A classification of the role of logistics

The three roles of logistics (labelled alone, together and enabler) are in this chapter described and exemplified. Figure 1 illustrates how the logistics function is positioned in relation to other business functions, examples of competitive strategies that can be achieved based on the functions, and the ultimate strategic condition, i.e. sustainable competitive advantage.

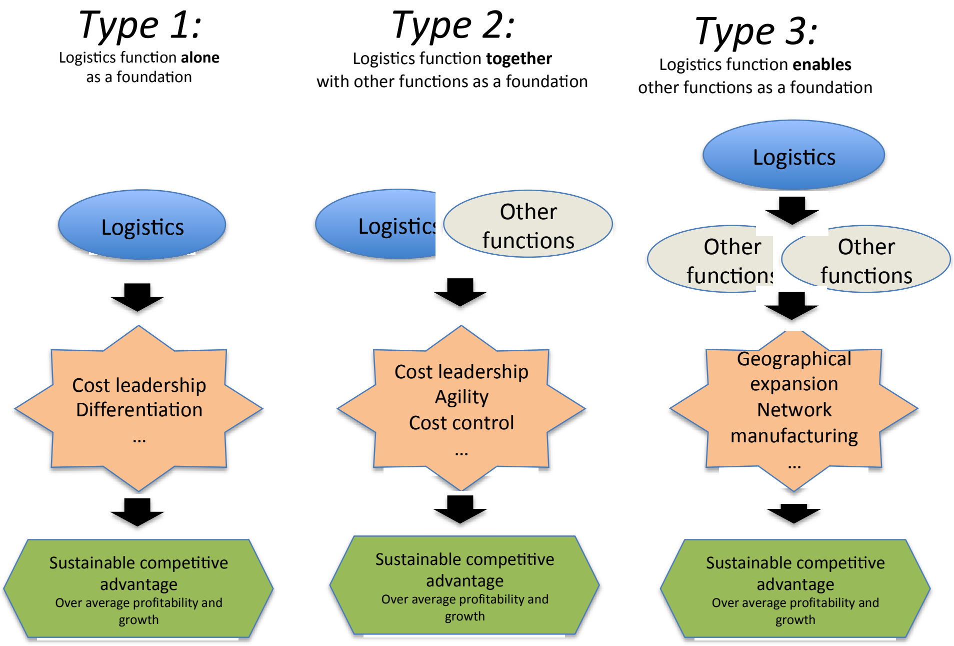

Figure 1: Three types of the logistics role

Type 1: Alone

Considering the first type, there is research claiming that competitive strategies, such as cost leadership and differentiation strategies (e.g. Persson, 1991), may be enhanced by the logistics function alone. In literature there is research stating the importance of logistics as a whole, as well as research claiming certain components of logistics to be the foundation for competitiveness (Mentzer et al., 2004). For instance, Olavarrieta & Ellinger (1997) argues that a company's 'logistics capability' is valuable, scarce and difficult to imitate in line with the resource based view of the firm. In a similar vein, also based on RBV, Stank et al. (2005) identify customer focus, time management, integration, information exchange, and evaluation as the key capabilities of logistics. Esper et al. (2007) identify based on earlier research customer focus, supply management, integration, measurement, and information exchange as important logistics capabilities. These capabilities may in turn be the foundation for a variety of competitive strategies.

Type 2: Together

In accordance with SCM, where logistics is incorporated as an important cornerstone, research enlightens several examples where the logistics function is closely intertwined with other business functions. The functions together form the basis for competitive strategies such as cost advantages or flexibility. Most explored are probably the interfaces between logistics and production, and logistics and marketing (e.g. Gimenez & Ventura, 2005). In addition, the IT function is often closely connected to logistics. Recent research shows that a very complex, over time developed, tight connection between the day-to-day logistics processes and in-house developed IT system could be valuable, rare and difficult to imitate (Barney, 1991) and thus the foundation for a sustainable competitive advantage (Sandberg & Abrahamsson, 2011). In common for this type is the strong dependence between the participating functions, without the other function(s) no competitive strategy can be achieved.

Type 3: Enabler

The third strategic role of logistics builds on the fact that logistics may have an indirect impact, via other functions, on competitive strategies. In some cases logistics may simply be considered as having a supporting, secondary role to strategy. Typically, the logistics function is not considered best practice, for instance on the world class logistics scale developed by Bowersox et al. (1999). However, it may have a facilitating, enabling role for other functions that in turn provides the basis for competitive strategies.

As an example, Sandberg (2012) investigates purchasing groups with a centralised logistics platform. The existence of such a platform enables among others access to suppliers and their products, and ability to focus on core competence (i.e. sales activities) for the individual dealers (stores). The research demonstrates a situation where logistics in itself may not be the most effective or efficient tool upon which a sustainable competitive advantage is built. Rather, it is logistics' ability to support other functions that may be seen as the major contribution from logistics.

Overall, typical competitive strategies found in literature for this type are geographical expansion, network manufacturing/assembling strategies, and new purchasing strategies.

Discussion

Based on literature from strategic management theory as well as logistics this article elaborates a more comprehensive view on how logistics can contribute to a company's sustainable competitive advantage. For academics, and practitioners, this research provides an overall starting point for how to understand and analyse the role of logistics in a company. Although very simple, the classification enables a more focused discussion on the role of logistics and its multiple purposes.

From a research methodology and –design viewpoint, this research provides us with several insights, including:

The *unit of analysis* becomes critical for a proper illumination of the linkage between logistics and strategy. If the unit of analysis is too narrowly defined, e.g. the logistics function, two out of three roles may be difficult to find. Therefore, a more holistic approach is needed when exploring the strategic role of logistics.

In order to detect the different roles of logistics, the *theoretical framework* used must be able to cover all three roles. Whereas the industrial organisation (I/O) and the resource based view of the firm (RBV), which are the most dominant strategic management theories used for explaining the strategic importance of logistics, can help to reveal the two first roles (alone and together), the third role (enabler) may be difficult to identify with these theories. The enabler role may be better captured with logistics literature, for instance the logistics platform approach (Abrahamsson et al., 2003) or the Strategy-Structure-Performance framework. Stock et al.'s (1998) research on how logistics contributes to new geographically dispersed manufacturing strategies and organisational structures is another example. In conclusion, there is no single theoretical framework in existing literature that covers all the strategic roles of logistics that are possible.

Further studies should incorporate more theoretical perspectives, as a means to further enrich the knowledge about the strategic role of logistics.

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TRENDS FOR THE FAST MOVING CONSUMER GOODS SUPPLY CHAIN IN 2030 - A MULTI-STAKEHOLDER DELPHI SURVEY

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INTRODUCTION

Supply chains in the fast moving consumer goods industry have experienced significant change since new Benetton, Zara and WalMart showed how innovative supply chain concepts can contribute to performance. They also revealed that flexibility and investments at the right point of time are essential in fast changing environments. In recent years strategic plans have become more informal, goal focused and less specific (Courtney et al., 1997). In times of high uncertainty and complex challenges a company monitoring trends and detecting weak signals in the business environment can better prepare for the future while managing everyday business.

Many researchers are concerned with the current situation of the consumer goods industry, its retailing structure and the respective supply chain. However, the dynamic nature of the industry with its direct exposure to changing consumer demands and underlying social trends makes it very probable that the coming decades will bring just as much change as the past ones. To realize this is important for all actors involved in the supply chains of the fast moving consumer goods sector. It is crucial for a company's long term survival and competitiveness to be innovative and adaptive (Laakso et al., 1998, McGrath and Ming-Hone, 1996) and companies preparing for the future are substantially more successful than those who do not keep scanning their environment (e.g. Ansoff et al., 1970, Miller and Cardinal, 1994). To our knowledge no academic research papers methodically analyzing possible long-term trends in the fast moving consumer goods industry have been published yet.

In our research we aim to find out which trends are likely to be most influential in the future of the consumer goods supply chain. For verification of the prevalent trends we used the Delphi method, soliciting the opinion of 81 designated experts of the sector and its supply chain.

SURVEY PROCESS

The real-time Delphi technique is a development of the classical paper based Delphi developed in the 1950s by the RAND Cooperation (Dalkey and Helmer, 1963). The real-time Delphi applied for this survey is an online variant that equals the methodology described by Gnatzy et al. (2011). In the conducted real-time Delphi, 16 projections were presented to a panel of experts. They were asked to evaluate each projection according to its estimated probability of occurrence (EP) on a scale from 0-100 %, its impact on the industry (I), and desirability of occurrence (D), both on a 5-point Likert scale. For each dimension the experts had the possibility to provide arguments. In our online based real-time Delphi, the participant receives direct feedback about the assessments of the other experts. Besides quantitative data the participant has the possibility to access the qualitative arguments the other experts provided to support their evaluations.

The projections the experts were asked to assess were developed in a phase based process (von der Gracht and Darkow, 2010). In an intensive desk and database research relevant trends were detected, taking into consideration the STEEP factors (social, technological, economic, ecological, and political) (e.g. Wright and Goodwin, 2009) and the five forces model by Porter (2008). Subsequently a review of the findings aimed to concentrate on the most relevant driving factors for consumer goods supply chain in 2030. On their basis the projections were developed. The total number of 16 projections complies with the principle of a small number of projections aiming at a high response rate and a great number of properly filled in surveys (Parenté and Anderson-Parenté, 1987).

Projection number	Projection for 2030	Short title
1	New forms of media and advancements in technology have improved the supply of the buying public.	New media/ technology
2	The range of products in the store-based retail market has strongly decreased in comparison to 2010.	Decreased assortment
3	The development of age-based, differentiated consumer goods and related services has become a decisive competitive advantage in the consumer goods industry.	Age-differentiated products
4	Store-based sales of dry goods (washing detergents, cleaning agents, cosmetics, nappies, etc.) have been displaced by e-commerce sales.	E-commerce
5	The demand for sustainably produced and distributed consumer products (socially and ecologically friendly) has increased disproportionately.	Sustainability
6	Customers increasingly expect consultative and innovative value-added services from consumer goods manufacturers.	Value-adding services
7	Brand loyalty for consumer products has strongly increased compared to 2010.	Brand loyalty
8	The expertise of consumer goods manufacturers in developing innovative and strong brands has become more important than production and distribution.	Brand innovation
9	Close collaboration of consumer goods manufacturers, retailers and logistics service providers has become an essential prerequisite for market success.	Cooperation
10	Customers' requests for customized consumer products have strongly increased since 2010.	Individualized products
11	Store-based retail shops have increasingly been adapted into 'concept stores' for testing products and consultation.	Concept stores
12	The supplementation of store-based retail with e-commerce solutions has led to innovative sales and distribution models.	Innovative distribution/ supply
13	Automated ordering and direct deliveries of convenience goods to households has been established comprehensively.	Automated ordering
14	Inner-city supply is still not an unconquerable hurdle for the retail market and logistics service providers in 2030.	City supply
15	Through the joint application of intelligent IT systems (RFID, location-based services, etc.), the collaboration among consumer goods manufacturers, the retail market and logistics service providers could be revolutionized.	IT cooperation
16	Statutory provisions have led to a higher level of standardization in loading equipment and packaging in the consumer goods industry.	Regulation

Table 1: Final projections

EXPERT SELECTION

Besides the design and development of the projections, the selection of the relevant experts is a crucial determinant influencing the reliability of the research results (Møldrup and Morgall, 2001, Welty, 1972). In the selection of the experts we concentrated on the six relevant groups for the consumer goods industry, namely the producers of consumer goods, retail companies, universities, consumer research, logistics and IT providers, consulting, and politics and associations. The aim was to include different perspectives on the future of the consumer goods industry as a diverse background of the experts is supposed to increase accuracy in group decisions (Preble, 1984). To contact designated experts only, the focus was on chief executive officers, decision makers in strategy development, category management or logistics departments. The largest share was formed by producers of consumer goods with 23 participants representing 29 % of the total participating expert group. Second largest group came from the retail companies (15 participants, 18 %), and consulting (15 participants, 18 %) followed by logistics and IT providers (14 participants, 17 %), politics and associations (5 participants, 6 %), and academia (10 participants, 12 %). Because 30 (Parenté and Anderson-Parenté, 1987, Skulmoski et al., 2007) or even 20 (Akkermans et al., 2003) participants are regarded the minimum number of participants, 81 participating experts is an adequate panel.

ANALYSIS OF QUANTITATIVE DATA

In a first step, we analyzed the quantitative data obtained from the real-time Delphi. In terms of descriptive statistics, we calculated the mean values of the assessments for the expected probability of occurrence, the impact and desirability. We obtained information whether the occurrence of an event was considered as probable (improbable), high (low) impacting, and desirable (undesirable). To check whether the Delphi succeeded in supporting the process of consensus finding among experts we compared the evaluations of the first and final round and used the conversion rate as an indicator. The standard deviations for the EP in both rounds were compared as a reduction of the standard deviations can be considered as convergence of opinion and as an approximation towards consensus (Rowe and Wright, 1999, Schmidt, 1997). Additionally we calculated the interquartile ranges (IQR) of expert’s assessments, a method accepted for consensus measurement (De Vet et al., 2004, Scheibe et al., 1975). The convergence and the consensus are indicators of certainty of the experts regarding their assessments given in the survey.

ANALYSIS OF QUALITATIVE DATA

In a second step, the qualitative analysis, we analyzed the 1,197 written arguments, often written in complete sentences containing several criteria. For every projection and category the arguments were aggregated and analyzed. We divided the arguments in the criteria which were named and summed up, which argument was named by how many experts. To avoid bias the sorting was done by two different researchers (Corbin and Strauss, 1990). After the independent sorting the results were compared and summing up under different criteria or categories was discussed until an agreement about the categorization could be achieved. This procedure enables us to identify the criteria mentioned most frequently. This compilation enriched the discussion among the experts and subsequent workshop sessions.

RESEARCH RESULTS

An overview of the data obtained by the real-time Delphi is presented in Table 2. Regarding the probability of occurrence, over all 16 projections a decrease in the standard deviation can be observed. It means that the standard deviation for the evaluation in the first round was larger than it was in the final round, when the Delphi portal was closed. This is an indicator for a convergence of the participants’ opinions due to the controlled feedback of statistical data and experts’ arguments.

No.	Short title	EP Final	EP First	I	D	IQR	CV
1	New media/ technology	80	80	4.1	4.0	15	-7.9%
2	Decreased assortment	39	42	3.7	2.5	30	-7.6%
3	Age- differentiated products	76	74	3.9	3.7	20	-5.0%
4	E-commerce	35	38	3.5	2.5	20	-7.7%
5	Sustainability	78	77	4.2	4.3	20	-9.7%
6	Value-adding services	60	60	3.7	3.4	25	-6.5%
7	Brand loyalty	42	46	3.8	3.1	20	-13.8%
8	Brand innovation	68	66	3.8	3.6	30	-6.5%
9	Cooperation	82	81	4.2	4.2	10	-6.6%
10	Individualized products	69	68	4.0	3.1	20	-5.1%
11	Concept stores	42	45	3.4	2.6	20	-5.9%
12	Innovative distribution/ supply	76	75	4.0	3.8	20	-4.7%
13	Automated ordering	55	55	3.9	3.3	30	-3.6%
14	City supply	43	46	3.1	3.7	40	-10.5%
15	IT cooperation	69	66	4.0	4.1	20	-9.6%
16	Regulation	59	59	3.6	3.5	20	-4.6%

EP= Estimated Probability of occurrence (0-100%) I= Impact (5pt.-Likert scale)
D= Desirability (5pt.-Likert scale) IQR=Interquartile range (≤25 equals consensus)
CV= Convergence rate (≤ 10 % equals moderate convergence)

Table 2: Delphi results

CLUSTER ANALYSIS

Several authors found it reasonable to cluster the projections along their probability of occurrence and their impact in order to derive appropriate strategies (Ogden et al., 2005, Akkermans et al., 2003, Rikkonen et al., 2006). To receive reliable clusters for the small sample we conducted a cluster analysis using ward linkage with the squared Euclidean dissimilarity measure with standardized z-scores. The distribution of the 16 projections along these dimensions can be visualized in a scatterplot (von der Gracht and Darkow, 2010). Entries labeled with dots are projections where consensus was reached while entries labeled with diamonds correspond to dissent projections. Additionally the entries are numbered according to the listing of projections in Table 1.

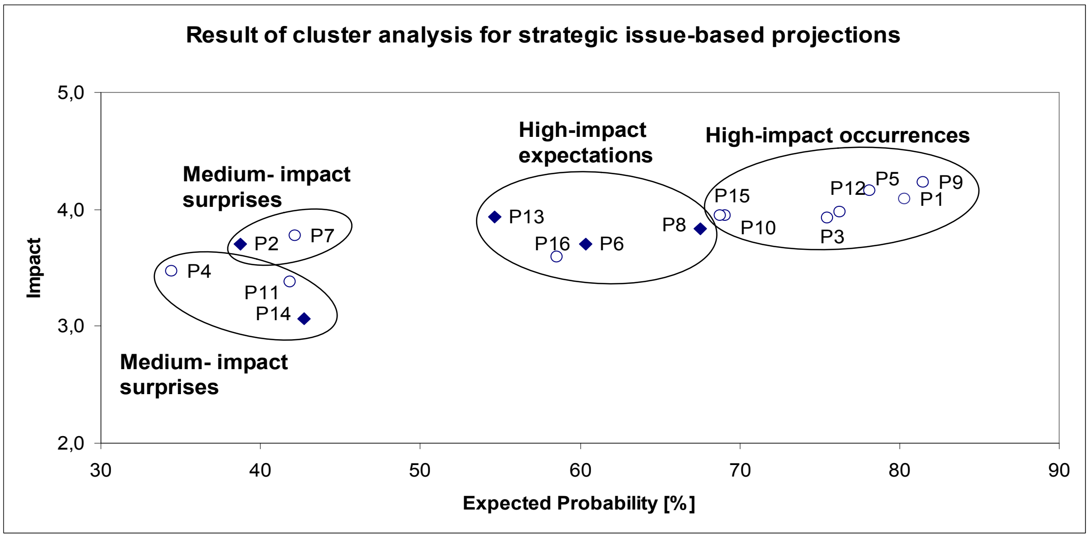

Figure 1: Clusters

This scatterplot visualizes that the projections can be clustered in four categories, namely high-impact occurrences, high-impact expectations, high-impact surprises, and medium-impact surprises. High-impact occurrences are estimated to be likely to occur and to have a high impact on the industry, while high-impact expectations are estimated to have a medium likelihood and high impact. High-impact surprises are not likely to occur but would have a relatively high impact, while medium-impact surprises are regarded as neither probable nor momentous.

COMPARISON OF THE GROUPS

In order to identify differences among the groups' expected probability of occurrence, impact and desirability, we tested all issues for significant deviations by applying a Kruskal-Wallis one-way analysis for variance (because the vast majority of the underlying data was not distributed normally) and afterwards using the ANOVA method on significant results and a Gabriel post-hoc test. Considering that one characteristic of the Delphi method is the convergence of the participants' assessments, only the experts' initial assessments were used in order to assure the independence of the observations. Overall, three projections were found to carry a significant group bias in either of the surveyed dimensions (see Table 3). Applying the Gabriel post-hoc-test to these results only revealed significant differences between explicit groups for the desirability values of collaboration. Manufacturers and retailers expressed a higher desirability of occurrence for the issue collaboration than academics. This indicates a potential difference in the perception of the benefit collaboration might have for the different parties. While manufacturers and retailers are more optimistic about collaboration, the academics seem to have a diverging perception and are less enthusiastic.

No.	Short title	Dimension	Kruskal-Wallis	Anova
4	E-commerce	Impact	Sig. = 0.018	F (5, 75) = 2.966, p = 0.017
9	Collaboration	Probability	Sig. = 0.050	F (5, 75) = 2.595, p = 0.032
9	Collaboration	Desirability	Sig. = 0.030	F (5, 75) = 3.735, p = 0.004
11	Concept stores	Desirability	Sig. = 0.036	F (5, 75) = 2.511, p = 0.037

Table 3: Comparison of stakeholder groups

DISCUSSION

Cluster analysis shows that experts expect mainly two aspects to prevail in consumer goods supply chains. cooperation among supply chain partners is expected to increase, as is product differentiation. Further interpreting the results of projections 1 and 12, cooperation will occur at the same time that a spreading multitude of retailing and supply channels bolster the efficient provisioning of the population. This stands in contrast to the expectation of (Ganesan et al., 2009) that an increasing use of alternative retailing channels by manufacturing companies will harm the relationship between them an the retailers. This rather indicates realization of prospects of larger profits by joint performance (see Yan, 2008) analogous to (Ganesan et al., 2009) qualification of the above expectation.

Interestingly, according to our group comparisons, participants directly involved in the supply chain are the most optimistic about future collaboration, whereas experts from academia and administration take a more pessimistic view on the future development of collaboration in the consumer goods supply chain. Especially administrative experts seem to have a negative view. The projections with a significantly lower probability of occurrence assigned by them are exactly those associated with increasing cooperation among supply chain partners. The most optimistic about cooperation are retailers, assigning projection 9 a probability of almost 90%. Retailers being the first mover for cooperation, having to motivate and coerce suppliers into policy changes has already been observed by (Siemieniuch et al., 1999). However, this does not seem to be an indication of conflict between retailers and manufacturers, because the manufacturers' expectation for projection 9 is still very high. Furthermore manufacturers express a significantly high desirability for the projection. The retailers significantly lower desirability for an increased utilization of technology in cooperation (projection 15) could point towards an hesitance of sharing information with supply chain partners and thus could be a slight indicator of possible conflict. Retailers also deem the increasing reliance on concept stores even less likely than the rest of the Delphi participants and they express an especially low desirability of e-commerce marginalizing staionary retailing for dry products. Overall the benefits of supply chain cooperation paired with an increase in multchannel retailing, that leaves a functioning and comprehensive staionary retailing structure intact, seem to outweigh the threat of full-scale vertical competition for players in the consumer goods supply chain.This finding also holds true, when the perseptions of manufacturers and retailers are directly compared. Only the manufacturer's higher perceived probability that brand innovation will be more important than distribution and production hints that the rise of retailing brands (as an answer to direct channel retailing) is on the mind of the manufacturers.

MANAGERIAL IMPLICATIONS

Our research provides twofold contributions for managerial usage within the consumer goods industry. First our real-time Delphi survey provides input for the initial steps of strategic planning as we provide a possibility to identify issues and judge their impact and urgency (Korpela and Tuominen, 1996). Companies should adress the projected futures in the environmental sectors critical to the company in order to develop their own strategy and to engage in long-range planning activities to prepare for future developments (Flint et al., 2005). The cluster analysis of the projections along the estimated probability of occurrence and the impact reveals the issues which were regarded to be of highst probability and impact in the consumer goods industry in 2030.

Taking our clustering of the projections into consideration leads to the conclusion that the emerging opportunities for the consumer goods sector are likely to lie in the cooperation between manufacturers and retailers, the usage of new media and technological developments – not only for provisioning of consumers, but as well for cooperation along the supply chain – and socially and ecologically compatible goods. Moreover, products and services are estimated to be individualized and differentiated by age. It has to be kept in mind, that these issues are not definetly becoming reality, but are still to unfold (Ansoff, 1980). They are rather likely to occurr and as their occurrence would have a high impact on the consumer goods sector, consideration of these issues is crucial for the identification of new business opportunities so that the required capabilities to profit from the upcoming chances can be developed (Bergman et al., 2006).

Nevertheless, strategists should not leave the other clusters without regard as they might be less likely and of lower impact but are not impossible to become reality. That is why strategists should develop alternative strategies, in case that the company recovers changes towards one of the projections that are not within the high-impact occurrence cluster (Armstrong, 1982). For the recovery of changes, a continuous monitoring in terms of the strategic issue management, that focusses on the detection of weak signals should be implemented (Camillus and Datta, 1991, Ansoff, 1980).

From the group comparison managers can learn about different stake holder's views of the future of their industry. Especially the relatively negative view on supply chain collaboration of the groups not directly involved in the industry should be taken into account by companies. This could indicate some hidden stumbling blocks or even be an early indicator of differences between industry and politics. Yet overall the group comparison should also be taken as a further building stone in the trust that has apparently been developing among supply chain partners and the relatively few differences found among groups indicate that all partners are moving in a similar direction.

CONCLUSION

The data obtained from the real-time Delphi for the consumer goods industry in 2030 discloses valuable insights for strategists in the consumer goods sector. We were able to present twofold contribution to the deficient research focusing on long-range developments. Our cluster analysis enabled us to provide a basis for the identification of relevant futures within the industry. We clustered the projections into four groups, that are high-impact occurrences, high-impact expectations, high-impact surprises, and medium-impact surprises. We found from the high-impact occurrencess cooperation to be the leading trend for 2030. As the projections within this cluster are likely to occur and have a high impact on the industry, they should be considered in the strategy development process of a company. The comparison of the group emphasizes the necessity of a differentiated treatment of the data used for strategy development as there are significant discrepancies between the assessments of different stakeholders. Futhermore, the insights on differences can be used in the communication and negotiation process to strengthen existing bonds and overcome remaining barriers.

However, there are some limitations to our research. The number of projections presented to the experts was limited in order to achieve high response rates and to avoid drop-out. As the consumer goods is a broad and complex industry, there are more driving factors than can be covered by one survey. In future research, further topics influencing consumer goods industry like the importance of innovative marketing e.g. product placement in the media or guerilla marketing, packaging sizes, or product and country specific market conditions could be covered.

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WAYS TO DEVELOP A ROBUST SUPPLY CHAIN

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ABSTRACT

This paper aims at describing how robustness of the supply chain can be created on each management level. In today's globalized world networks become more and more common, but simultaneously more complex. Dealing with uncertainties and risks respectively solving them becomes a crucial aspect for withstanding competition and in best case for generating competitive advantage.

A first key to achieve robustness on strategic level is to choose the right linkages in the supply chain and to ensure proper communication within the supply chain. To minimize risks multi-sourcing is a way to reduce dependencies and to be able to react flexible on day-to-day variations. From a tactical point of view synchro- and multimodal transportation are solutions to ensure on-going processes in the network, therefore stabilizing the supply chain. Hereby, simulators can help to plan and design the network. Moreover on operational level the flow of goods can be ensured by the using intelligent cargo. There are fewer fluctuations and due to the interaction and problem solving behavior of the individual intelligent cargo items there is stability added to the whole supply chain.

INTRODUCTION AND STATE OF THE ART

The recent natural disasters in Thailand and Japan had fundamental impacts on to the manufacturing industries leading e.g. in the electronics sector to short supply of key components and thus subsequently to the delay of the introduction of new products and the manufacturing of existing products; e.g. the price for hard disks increased by 100% due to these problems. For Sony, for example, the flood disaster in Thailand caused delays in the production of the NEX and Alpha cameras and lead to a loss in net income of 25 billion yen (233 million euros). Individual components have not been available, and new product introductions had to be postponed (Sony Corporation 2012). If you consider that the flood in Thailand has led to damages of 50 billion dollars and the tsunami in Japan to damages of 210 billion dollars, imagine how immense the economic impact must have been (RP Online GmbH 2012).

It clearly demonstrates that in the today's global distributed economy and supply networks disruptions on natural, social or political level can have a profound impact on the supply chain and thus on the companies involved in them. Therefore a paradigm shift is immanent, leading from today's highly optimized and lean supply chains to supply chains that are more robust in order to prevent disruptions of the supply chain due to uncontrollable events. Unfortunately, the reduction of the vulnerability of the supply chain leads at the same time to higher costs. However, taking into account the costs that a total drop-out of the supply chain incurs to a company, the costs to make the supply chain more robust are clearly justified. Measurements taken to enable robust supply chains can be categorized in three layers; strategic, tactical and operative measurements. In this Article there will be different measures on these levels described, based on different possibilities to secure the supply chain. A holistic framework will be proposed which can be used to secure supply chain robustness while at the same time to ensuring logistics operations that are environmental-friendly.

The major goals of Supply Chain Management (SCM) during recent years have been in general the optimization of costs, the implementation of JIT concepts and diversification to maximize the supply chain surplus (SCS). But "at the same time the vulnerability of supply chains to disturbance or disruption has increased. It is not only the effect of external events such as natural disasters, strikes or terrorist attacks but also the impact of changes in business strategy”(Christopher 2005, p. 233). However, vulnerabilities are located on the strategic, tactical and operational level of the Supply Chain (SC).

Especially, in the last decade of the last century Just-In-Time practices, Global instead of Local Sourcing as well as Single Sourcing became more and more popular. Companies have chosen to centralize their factories and to focus them on the production of fewer products at a location, but a consequence is that the goods have to be transported longer distances to the customer (Christopher 2005, p. 233). The fact of longer distances that a product has to be transported, leads to vulnerability on the tactical level. This vulnerability is the missing strength of a transport network. For example a synchro- respectively multimodal logistic hub does have demonstrably more opportunities for the switch of the transport vehicles. On operational level vulnerability is the missing real-time status information about each individual good of the shipment. One reason for these vulnerabilities is the business thought that a SC has to be more efficient than effective. The following figure will outline some of these vulnerabilities.

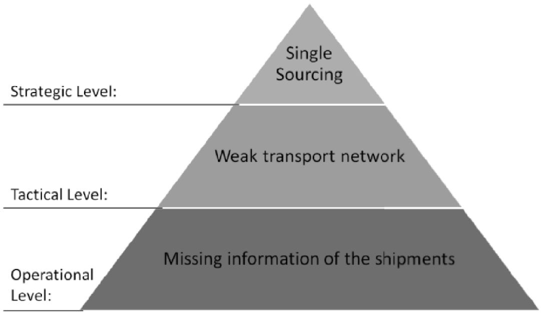

Figure 2 Vulnerabilities

According to these levels it can be stated that the lower the level the more short-term orientated is it. That means decisions on the strategic level are long-term orientated and are of far-reaching impact. Decisions on the tactical level are mid-term orientated and of big impact on the routine business. In comparison to the other levels according to the time factor the operational level is more flexible and has direct impact on the daily business. But every disturbance on each level is cost expensive. For that it is advisable to reduce the disturbances to a minimum.

The following chapters of this paper investigate the various possibilities on strategic, tactical and operational levels which are dealing with long- to short-term disturbances. The aim is to propose a holistic approach to the planning and deployment of robust SC.
In the first part of this paper for robustness and risk management will be given. Subsequently, the problem will be outlined and possible solutions on every level will be provided.

DEFINITIONS

‘*Robust*’ can have different meanings depending on the context. These are model robustness, algorithm robustness and solution (or decision) robustness (Klibi et al. 2008, p. 18). In a broad definition robust is the extent to which the Supply Chain Network is able to carry its functions for a variety of plausible future scenarios (Klibi et al. 2008, p. 18). So “a supply chain is *robust* if it performs well with respect to uncertain future conditions” (Snyder et al. 2003, p. 2). Furthermore, a SC is robust “if it is capable of providing sustainable value creation under normal business conditions as well as major disruptions” (Klibi et al. 2008, p. 18).

A robust SC focuses on a multiple sourcing strategy and synchromodality to create an advantage if one partner fails. In this case a second partner can compensate this failure. Also random and uncertainty will be avoided. Robust emphasizes flexibility and agility and “the goal of *robust* optimization […] is to find solutions that perform well under every realization of the uncertain parameters, though not necessarily optimally in any” (Snyder et al. 2003, p. 2).

Robust focuses on the key word reliability, too. A supply chain is '*reliable*' if it performs well when parts of the system fail – for example, when a distribution center becomes unavailable because of poor weather, natural disaster, etc. (Snyder et al. 2003, p. 2). As noted above, robust optimization is concerned with finding solutions that perform well with respect to uncertain future conditions, while reliable optimization is concerned with finding solutions that perform well when parts of the system fail. In order to develop robust SC a risk management has to be committed in the various stages of the SCM development.

Supply chain risk management

Supply chain risk management is "the part of supply chain management, which includes all the strategies and measures, all knowledge, all institutions, all processes and all technologies that are suited to technical, human and organizational level to reduce the risk to within a supply chain" (Kemmerling 2008, p. 24). The importance of risk management is increasing due to the fact that more and more semi-finished parts of manufactured goods are purchased. So the purchasing process becomes more critical and takes place in a complex environment. A survey of the Fraunhofer Institute for Manufacturing Engineering and Automation shows this shift: In the year 1980 60 % of the production was personal contribution by the company. In the year 2004 the personal contribution in production decreased to 43 % (Schatz et al. 2010, p. 8).

Generally, risk management differentiates risks in five categories. These risks are in the global (Environmental risk), companies' (Process risk), suppliers' (Supply risk) and customers' (Demand risk) environment of a SC as well as the Control risks of the transport flow (Hotwanger 2008, p. 28). The first four risks can be assigned to the strategic level of a SC. On the tactical and operational level are the transport flow risks located which include decisions for the Supply Chain Transport Network Design and the selection of external partner like Service Provider and Carriers. The mentioned risks are visualized in the following SC of figure 2.

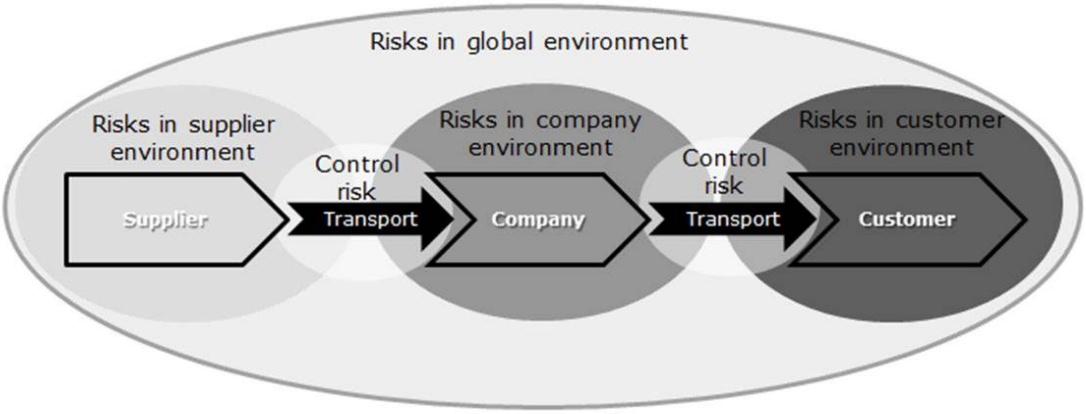

Figure 2: Categories of risk in a SC (cf. Hotwanger 2008, p. 28; cf. Martin 2005, p.238)

However, to develop and deploy a robust SC risks must be avoided and reduced to a minimum. To achieve this goal it is necessary to categorize the risks. Some risks are solvable with an effective safety management and security management. These risks are hardly to influence and preventable. But the risks triggered by natural disasters are unforeseeable and need an effective SC risk management.

According to figure 3, risk management can be divided into three main components: Risks on strategic level, risks on tactical level and risks on operational level. On each level different risks respectively different responsibilities are to find.

The aim of SC risk management is “to help in the understanding of the key risk drivers of supply chains and enable the partners to optimize their internal risk management system – at least developing an understanding of supply chain risks” (Stemmler 2006, p. 210). However, risk management includes activities to identify, analyze and assess, and communicate, as well as control, risks (Stemmler 2006, p. 210).

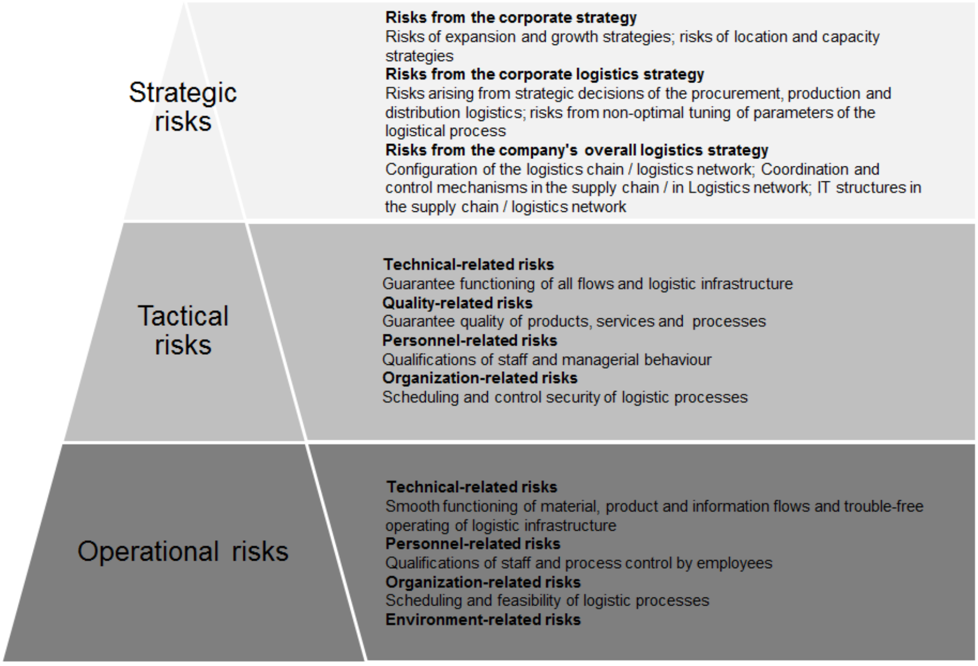

Figure 3: Logistic risks on management levels (cf. Prof. Dr. Jürgen Hoffmann 2007, p. 13)

PROBLEMS AND IMPORTANCE OF ROBUSTNESS ON THE MANAGEMENT LEVELS

Depending on the management level different tasks and issues need to be fulfilled. Accordingly, it is dealt with different problems, but nevertheless the importance of a robust and flexible supply chain can be reflected on each level.

Strategic Level

Most important on the strategic level is the cost-effective design and layout of the entire logistics network and individual logistics systems, aimed at the logistics strategy and its goals (cf. Hellingrath 2008). Moreover on the one hand the evaluations of investment decisions form a main part of strategic work and on the other hand the building of a network by choosing the right partners and linkages as well as the right way and depth of communication is of great importance. Generally, strategies for the corporate company, logistics and overall logistics are mapped out and need to be evident on all management levels through the whole supply chain.

Risks on strategic level influence the whole SC and result from strategic decisions like using JIT concepts, choose for global sourcing and single souring or a combination of it etc. If wrong decisions are taken, they are of far-reaching impact not only for the own company, but for supply chain members, too.

Problems are exemplary finding good partners for the supply chain respectively keep on holding the relationship, profit of a partnership and supply chain integration (both partners) or the up- and downwards information exchange.

Tactical level

On the tactical level the robust supply chain with all strategic decisions is created and executed. Therefore some risk mitigation strategies for supply chains should be kept in mind. For logistic providers it is relevant to achieve increased flexibility in transportation and supply (Wu et al. 2009, p. 46). The problem on the tactical level is that a developed network is situated in uncertain conditions. In addition to it the size of the network influences the dealing with risk. In a bigger network the effects can be more far-reaching, extensive, complex and beyond one's control. In most cases the logistic service provider is working at the hubs with single-modality solutions instead of multi- or synchromodality ones, which would be more flexible.

On this level it is necessary to be either redundant or flexible (Sheffi 2006). Redundancy means to build up safety stocks and a bigger vehicle fleet which is expensive and regarding the product stock it intensifies through the whole supply chain (bull-whip effect). To become more flexible has indeed advantages for logistic providers, suppliers and manufactures. The responding on day-to-day routine's fluctuations can be improved and furthermore the reaction on disruptions is more successful and can lead to competitive advantage.

Operational level

The operational subjects are dealing with the coordination and control of the movements in the supply chain in real-time. So the focus is on smoothly running processes. There operational risks represent the field of the risks associated with the daily business of freight forwarding by the carrier. Due to the fact that a variety of these risks lead to damage of the customer's good or can lead to other liability-related issues, the liability risks belong to operational risks. In addition, all typical challenges of the freight forwarding business arising from the seasonality (utilization rates) belong to operational risks (Huth et al. 2009) of the carrier. The most important risk for the carrier is the transport risk i.e. loss or damage of the goods by damage, accident or other events (Prof. Dr. Jörn Altmann n.d.).
It is important on this level to react and respond quickly on problems which should be kept in mind while designing the network. A strong integration of the supply chain members with improved communication and a high flexibility makes the network resilient and transparent and let the carrier perform best if matters become urgent. By this transparency internal risks are minimized and only external risks gain attention.

SOLUTIONS FOR ACHIEVING ROBUSTNESS ON THE MANAGEMENT LEVELS

On all management levels the achieving of robustness is accompanied by flexibility that needs to be realized in and between the linkages of a supply chain to react best on unforeseen events.

Strategic level

In this level the foundation is laid for a robust SC by choosing for the right design and lay-out of the SC. Choosing not only for the right partners, but also for a suitable number of partners and linkages, is a basic decision of great impact. Moreover the depth of integration and communication are crucial factors.

The decisions must be taken accordingly to the corporate, logistics and overall logistics strategies and be realizable in every level downwards.

It should be kept in mind to stay flexible for reacting on uncertain conditions. So dependency, too less information and too fixed structures should be avoided. Multi-sourcing is an example how a relationship can be built up. In case of the occurrence of problems, e.g. shortness of supplies, another partner can step in.

Tactical level

The risk management and the accuracy how it is carried out have influence on the robustness of a supply chain. For logistic service providers all risks regarding transportation and warehousing and the risk shifting are in focus (Schramm et al. 2008, p. 43). By supply chain integration and the use of external resources it is possible to open new ways of flexibility. Cross-docking is an integrated example how to act flexible and efficient on the day-to-day varieties and how to work in a strong network.

The robust SC is designed on the tactical level. Network simulators may help to plan the SC and to exclude risks from the beginning on. Risks can be found on the one hand in the own company, e.g. too less resources, and on the other hand in the linkages in the supply chain, e.g. not offering multimodal services at a specific hub.

For achieving robustness and resilience, but also flexibility in the supply chain, the usage of synchromodal transportation is a very suitable way. This concept focuses on hubs with multimodal possibilities. Therefore "the concept is synonymous with the creation of an optimum flexible and sustainable transport system in which companies can choose from a range of modalities at any given moment" (Europe Container Terminals 2011, p. 8). The basis for synchromodality is to link inland-terminals via inland shipping and/or rail with deep-sea terminals so that high-frequency links via all modalities become feasible (Europe Container Terminals 2011, p. 8). However, synchromodality "concerns the switching between different forms of transport (truck, barge, airplane, ship, and train) within a strategy of more timely, efficient and environmentally friendly distribution from the major ports – limiting the use of trucks for inland transport" (Van Stijn et al. 2001, p. 1). The application of synchromodality has several benefits. "For example, if certain goods can be transported by barge instead of by truck, this is cheaper and reduces traffic jams and CO2 emission" (Overbeek et al. 2011, p. 33). A further advantage is the fact that the transport failure risks decrease – from now on it is possible to change the modality during the transport. Moreover it is a point of interest to find solutions that are suitable to use across industries. Some users already see the benefits of having a robust supply chain: "To ensure that the Netherlands becomes the world's number one player in logistics (it's now number four, ed.) we need to set clear priorities. As a cross-industry organisation, the Strategic Logistics Platform is ideally placed to do that" (Europe Container Terminals 2011, p. 8).

Achieving robustness and stabilization is hereby a process that can be described with continuous process engineering like the plan-do-check-act model of W. Edwards Deming (Arveson 1998). Firstly, it has great impact how the SC is built up and for which partners and relationships it has been chosen. Synchromodality suppliers should be preferred and "the basic requirements of supply chain partners are: willing to accommodate the uncertainties and variations in each other's Businesses" (Chi 2009, p. 2). Thereby the simulators and planning tools give a first insight in the processes and possible obstacles. Secondly, the partners work out possible solutions and know how to act if problems occur. This includes for example, too, that the hubs are created optimally and usable for multimodality transport. Thirdly, during the running progress continuous communication takes place that strengthen the relations, but has also positive influences on the integration within the SC: "Effective supply chain collaboration is also instrumental in stimulation cross-functional activity within the individual companies, resulting in cross-functional improvements and improved communications between companies" (Emmett et al. 2006, p. 136). These actions within the SC need to be measured through the whole SC and to be evaluated continuously. At last, to stabilize the supply chain network even more it is important to take actions of improvement. This can apply for a single link or several ones of a supply chain as well as for the whole.

Operational level

The aim if this level is to create a transparent network whereby all information needed is available all time and to every member of the supply chain and which results in flexibility. A solution therefore is the usage of intelligent cargo as proposed by the EU FP7 projects like Euridice and iCargo (Baalsrud 2011, p. 1).

The basic idea of intelligent cargo is to implement a platform for software information services in the field of logistics planning tools, which allows providing logistic services for freight transportation on the base of a federal system. The focus is on individual goods and their interaction with different IT systems and users. It is possible to define for all transported goods the same triple information (time, place, status). This means that additional data about a specific cargo item is available compared to already existing tracking and tracing methodologies. Moreover, value-adding services on base of this data can be defined, which enable the individual control of the transported goods within the market. To reach these objectives various emerging technologies exist, mainly including but not limited to the concept of "Service-Orientated Architectures" (SOA) and "Mobile Software Agents" (concept of dynamic, distributed and mission-oriented intelligence).

The concept of a distributed and intelligent platform provides that every article has its own intelligence. On the one hand the locally deployed intelligence is used for the realization of an efficient monitoring and tracking of the goods, but also on the other hand to receive and evaluate other relevant information concerning the goods' transportation in real time. Examples of information of interest hereby may be sensor data, like temperature, or legal data regarding customs. Around these intelligent individual goods an open platform is created to integrate the received information and provided services with existing (legacy) systems and to offer the services using SOA and other ICT systems. Therefore interoperability with a variety of software products based on established standards and technologies is ensured.

All in all there are fewer fluctuations and due to the interaction and problem solving behavior of the individual intelligent cargo items there is stability added to the supply chain. But of course there are other positive aspects that can be mentioned. The efficiency and productivity is increased. By this the environmental impact (ecological foot-printing) is minimized and costs of freight transportations become lower due to better usage of resources (Sternberg et al. 2010, p. 253). Moreover it is possible to handle all operations though one system and to have a good monitoring system (Sternberg et al. 2010, p. 253). The control over transport planning, system integration and the accountability of it becomes possible. Additionally the reporting system can be adjusted to individual and special needs. On the level of individual goods the flexibility is increased and the problem-solving process is optimized (Sternberg et al. 2010, p. 253).

SUMMARY AND OUTLOOK

As shown above the need for robust supply chain is getting more and more immanent as fluctuations and break downs in supply chain have to be coped with in order to meet the time and cost expectations of a highly globalized market. With rising fossil fuel prices the concept of robust supply chains becomes even more attractive, as it is obvious that the concept of robust supply chains lead at the same time to a better utilization of the existing logistics resources.

Since the goal of the industry is still cost reduction, the increased fuel prices will further foster the uptake of robust logistics operations. However the activities described are still very fragmented, by listing today's opportunities it was shown that there are already individual tools available that support the build-up of robust supply chain. However, these tools do not support each other and do not follow an integrated approach. Furthermore, besides the developments in RTD Projects like iCargo (for the operational level), the tools have not been adapted to explicitly cope with the set-up and operation of robustness in supply chains. Thus the next step will be to support the operative level of solutions like the one developed in iCargo with additional tools to enable, in the long run, a coherent holistic approach towards environmental friendly robust supply chains while at the same time guaranteeing the competitiveness of the developed robust supply chain business models.

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HYPER-TURBULENCE AND THE EFFECT OF PRODUCT INNOVATION ON THE MANUFACTURING FIRM'S SUPPLY CHAIN ORIENTATION (SCO)

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ABSTRACT

Manufacturing firms currently operate in a "rapidly changing, hyper-competitive, increasingly global, supply chain era" which has threatened the firm's ability to maintain a competitive advantage (Defee and Fugate, 2010, p.180). Therefore, there has never been a more critical time to strengthen the supply chain and improve product and service innovation to provide a more sustainable business model approach. Historically, when the business environment is characterised as hyper-turbulent, authors propose that firms should respond by focusing on market orientation (Narver and Slater, 1990). In contrast, this study examines the effect when manufacturing firms adopt supply chain orientation (SCO) and innovation orientation (IO) simultaneously. Key findings are amalgamated from interviews with four finished goods manufacturers and the results of two online surveys to provide empirical evidence to better understand the challenges when firms prioritise an innovation orientation during this difficult trading period.

1. INTRODUCTION

The recent economic downturn has had a profound impact on the UK manufacturing sector; this is noted especially in the last quarter of 2008 and the first quarter of 2009 (AIM, 2009; Burns, 2009). Previously, studies have overstated the importance of market orientation (Narver and Slater, 1990), however, more recently, authors also recognise that individually, supply chain orientation (SCO) and innovation orientation (IO) are important for firms to achieve a sustainable competitive advantage (Mentzer, DeWitt, Keebler, Nix and Smith, 2001; Dobni, 2010). Regardless of the strategic orientation adopted by firms, Pearson (1993, p. 242) claims that firms "which are too strongly focused on a single orientation tend to perform poorly in the long run". Building on these studies, this research paper examines the behaviour of four manufacturing firms when trying to adopt both approaches: SCO and IO simultaneously. Utilising a single industry perspective, this study seeks to address the following research question;

RQ1. *What effect, if any, does product innovation have on the manufacturing firm's supply chain orientation during periods of hyper-turbulence?*

2. LITERATURE REVIEW

The review examines two strategic orientations which have recently received an increased level of interest by authors; these include supply chain orientation (SCO) and innovation orientation (IO).

2.1 Supply Chain Orientation (SCO)

Supply chain orientation (SCO) is considered as a pre-requisite to supply chain management (SCM) by managing six flows both inside and outside of the firm (product; services; information; finance; demand and forecasting) (Mentzer *et al*. 2001). SCO is portrayed as a "conceptual umbrella" which is defined by three characteristics: strategic, structural and behavioural (Esper, Defee and Mentzer, 2010, p. 171). Although still regarded in its infancy of development, SCO studies have grown exponentially; it is even argued that successful implementation of SCO could overshadow the importance of marketing (Min, Mentzer and Ladd, 2007). In view of this development, author emphasis has turned towards the firm's internal supply chain to understand the cultural fit of the firm to meet environmental challenges being faced. Mello and Stank (2005, p.534) claim that SCO and SCM are "manifestations of culture" requiring all individuals within the firm to coordinate and collaborate to support the supply chain flows for improved customer value. When the supply chain flows are valued by all individuals in the organisation this becomes cultural; firms which only evidence a supply chain culture to achieve customer value, are implementing a supply chain cultural orientation (SCCO) (ibid.).

2.2 Innovation Orientation (IO)

Similarly to supply chain and SCO development, the concept of innovation is applied in a number of ways to include, organisational behaviour, business model, services, processes and channels of distribution (Wolf, 1994; Zott, Amit and Masa, 2012; Siguaw, Simpson and Enz, 2006). Studies on product innovation appear to fall into two broad research themes: new product development (NPD) (Leonard-Barton, 1992) and new product introduction (NPI) (Katila and Ahuja, 2002). Existing studies indicate different levels of innovation (Chandy and Tellis, 1998) with new products which can be market driven (Day, 1994), supplier driven (Peterson, Handfield and Ragatz, 2005) or knowledge driven (Slater and Narver, 1995). When firms further demonstrate three characteristics: strategic direction, a learning philosophy and functional interaction; they effectively develop innovation orientation (IO) (Siguaw *et al*. 2006). In essence, IO provides the firm with a strategic direction to respond and fit with market challenges (Manu, 1992). Whilst most studies emphasise the positive effect of IO, when additional pressures are created inside of the firm it is possible that IO brings negative consequences for the firm and its internal supply chain (Simpson, Siguaw and Enz, 2006).

2.3 Common Features of SCO and IO

The review establishes that both concepts, IO and SCO require cultural similarities. Organisational learning promotes openness which is a key requirement for SCO (Min and Mentzer, 2004) and similarly, a learning philosophy is a requisite for firms adopting an innovation orientation (Siguaw *et al*. 2006). The review has further highlighted internal integration across the business functions as critical for successful IO and SCO (Siguaw *et al*. 2006; Mello and Stank, 2005). These combined factors: organisational learning and integration form the necessary culture to implement both SCO and IO (Min and Mentzer, 2004; Siguaw *et al.* 2006). Culture is represented by a pattern of beliefs and expectations to produce necessary norms which shape the behaviour of individuals and groups within the firm (Schwartz and Davis, 1981). However, as corporate culture is shaped by the firm's strategic orientations, individual employees can become resistant to change (Barney, 1986, Hofstede, 1988); this point is pertinent when hyper-turbulence severely affects manufacturing firm performance and a new strategic emphasis is required.

3. METHOD

Employing a single industry perspective, a qualitative approach enabled a deeper understanding of the root causes for problems being faced by four UK manufacturers. As listed in Table 1, in total twelve visits were performed between years, 2008 and 2009. These included eight visits to two finished goods manufacturers' sites for interviews and observations. Each visit lasted between ninety minutes and seven hours. Each of the remaining two finished goods manufacturers were interviewed twice by arranging face-to-face interviews at trade shows. In addition, email correspondence was useful from all four manufacturers to receive further feedback and industry reports to support the findings.

DATES	APPROACH	PARTICIPANTS
October, 2008	Site visit to finished goods caravan manufacturer (A)	CEO
February, 2009	Site visit to finished goods caravan manufacturer (B)	CEO/ Commercial Director
February, 2009	Interview, finished goods manufacturer trade show (C)	Managing Director
February, 2009	Interview, finished goods manufacturer trade show (D)	Commercial Director/ Regional Sales Manager
March, 2009	Site visit to finished goods manufacturer (A)	Operations Manager
April, 2009	Site visit to finished goods manufacturer (B)	Managing Director and

		Commercial Director
April, 2009	Site visit to finished goods manufacturer (A)	CEO
July, 2009	Site visit to Finished goods manufacturer (B)	Regional Manager
July, 2009	Site visit to finished goods manufacturer (A)	Logistics Manager, CEO, planning dept, purchasing dept, marketing dept.
July, 2009	Site visit to finished goods manufacturer (A)	Operations Manager, CEO
October, 2009	Interview, finished goods manufacturer trade show (C)	Managing Director
October, 2009	Interview, finished goods manufacturer trade show (D)	Regional Sales Manager
June-July, 2010	Online survey (Survey Monkey) – Industry wide, invitations are sent by email and advertising in an industry journal companies to encourage participation (60 companies invited-38 completed responses)	Industry supply chain members, finished goods manufacturers, component suppliers
July – Aug,2010	Online survey (Survey Monkey) – Customers encouraged to participate by placing invitations on industry blogs and forums, and advertising in an industry magazine (received 217 completed responses)	Customers – all existing owners of products

Table 1: Interview participants for the study

4. FINDINGS

Overall, innovation is accepted by manufacturers A, B, C, and D, as imperative to the future success of the industry. This view is further supported by end customers surveyed who frequently stress the need for radical innovation of products. Different types and levels of innovation are identified during the site visits and interviews held: manufacturers A and B demonstrate radical innovations which require major changes to the firm’s internal operations. In contrast, manufacturers C and D demonstrate incremental changes to individual components and product appearance. However, to address RQ1: What effect, if any, does product innovation have on the manufacturing firm’s SCO during periods of hyper-turbulence; tensions inside of the UK manufacturing firms are identified when trying to simultaneously implement both SCO and IO during periods of environmental instability. These tensions are particularly evident across the core business functions: marketing, purchasing and operations. Concurrent with the claim by Siguaw *et al.* (2006), Table 2 features some negative aspects of IO identified;

PROBLEMS IDENTIFIED
Strategic Change: “the speed of change required to support innovation” is identified as problematic placing enormous demands on business functions and across the supply base to respond quickly enough. Further issues identified include; “the speed of change can increase costs”...”old ideas have to be challenged”...” (Manufacturer, C and D; Industry survey, 2010).
Life cycle: new product introduction (NPI) has a negative impact on existing models, with new models shortening the life cycle of other models, some quickly becoming obsolete (Manufacturer A)
Aftermarket demands increase with product recalls and quality issues for new product ranges (Manufacturer B) “The speed of change can increase costs” (Industry survey, 2010); the faster new products are innovated and launched, the greater the likelihood of quality issues leading to increased costs in product recalls and repairs which causes major flow disruptions (Manufacturer A and B); Danger of damage to consumer confidence (Consumer survey, 2010).
Increased conflict amongst production and marketing functions (Manufacturer A). “the recession costs - in any recession people have to be removed”...”the recession puts pressure on each department and the natural reaction is to concentrate on one’s own department” (Industry survey, 2010)

Table 2: Negative outcomes of innovation orientation (IO)

5. CONCLUSION

During times of hyper-turbulence, the reality is UK manufacturing firms struggle to balance implementation of SCO and IO; this finding challenges Pearson’s (1993) view that firms should adopt more than one orientation. IO is supported by improved organisational learning and requires fundamental changes to the corporate culture; this is considered more difficult when structural changes force high levels of employee redundancy, altering the dynamics of the workforce. Moreover, a change in strategic emphasis triggers uncertainty amongst employees leading to low morale; this change in behaviour affects output in terms of individuals' willingness to cooperate leading to more supply chain flow disruptions. In addition to this, market driven innovation through new product design can become high risk if the new products fail to stimulate a sufficient rise in sales performance. Subsequently, in times of hyper-turbulence, firms need to consider more deeply the level of innovation feasible; for example, it may be more suitable for firms to adopt a supplier driven innovation (Peterson *et al.* 2005) rather than market driven innovation (Day, 1994); in terms of culture, organisational learning takes time for employees to adapt to new ways of thinking (Barney, 1986; Hofstede, 1988). These findings demonstrate that successful innovation has "everything to do with the organisation and attitude" (Hargadon and Sutton, 2000, p. 157). The author recognises the limitations of these findings taken from a single industry perspective; it is hoped that future studies might examine other sectors and further consider the impact of company size, experience and age to further strengthen the research validity.

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LOCATION CHOICE, LOGISTICS AND REMANUFACTURING

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ABSTRACT

Remanufacturing is the process through which value from old products is recovered by replacing and recovering used components to bring such products to a new or like-new state. Remanufacturing has several advantages: extending the total product life-cycle, reduce cost to the customer, and environmental sustainability. Today, both Original Equipment Manufacturers (OEMs) and third parties are engaged in remanufacturing services and closed-loop supply chain activities, investing in site locations throughout Asia. This brings much need foreign investment and technical expertise to a developing region. A case based approach is used to provide the necessary grounded theory for developing a better understanding of the remanufacturing space and location determinants in Asia. We interviewed five transnational enterprises and three third-party remanufacturers on their location choice determinants for remanufacturing activities and their perspectives on remanufacturing. Findings suggest that firms engaged in remanufacturing tend to co-locate facilities with existing production plants, and those investing in new sites for remanufacturing view the regulatory and logistics environment as most important factors. Further, third-party remanufacturers can be an important support for OEMs to start remanufacturing in new locations. Thus OEMs tend to leverage on existing manufacturing facilities or third-party remanufacturers to reduce their cost of commitment in starting remanufacturing at new locations. Our work contributes to the theory on location determinants in that it helps to grow the knowledge on location choice for remanufacturing activities. Results suggest that OEMs and third-party remanufacturers can have collaborative rather than competitive relationships.

Keywords: Remanufacturing, Location choice, Third party remanufacturers, Case

INTRODUCTION

Today, the scope for SCM in the context of environmental sustainability has extended to include the reverse flow of unsold finished goods, parts and packaging materials from the point of consumption back to the organization or to the rework / refurbishing vendors (Rogers and Tibben-Lembke, 2001). With the rise in environmental awareness, many firms have started to reduce waste, recycle, and refurbish their products for a more sustainable future. Governments in many countries are starting to develop clearer and stricter environmental regulations on issues such as the disposal of chemical waste, clean production, and carbon emissions. One key aspect of reverse logistics that is drawing much attention is in the area of product remanufacturing.

Remanufacturing is the process by which value from old products is recovered by replacing and recovering used components to bring such products to a new or near-new state (Lund, 1983). Remanufacturing has several benefits, such as the extension of the total life-cycle of the product, reduced cost to the customer, and is an environmentally sustainable competitive strategy. Compared to the mass-production of new products, remanufacturing faces various challenges such as volume and quality uncertainty of returned goods (Guide, 2000). Previously, most remanufacturing activities were outsourced to a large number of small, third parties (Guide, 2000). Today, many Original Equipment Manufacturers (OEMs) participate in remanufacturing activities due to the advancement of manufacturing technology such as mass-customization technologies as well as the concerns of environmental protection and social responsibility (Martin et al., 2010). Other players such as third-party service providers (3PLs) and third-party remanufacturers are also active in such closed-loop supply chain activities.

While most remanufacturing activities took place historically in the US and Europe, Asia possesses great potential for the future growth of remanufacturing. Asia has become the fastest growing continent, starting from the growth of post-war Japan, to the booming export-oriented four Asian Dragons, followed by the opening of large countries i.e. China and India. MNCs are aware of the importance of Asia as a fast-growth consumer market, forming 25% of global consumption. With the significant increase in the volume of goods returned in Asia, many MNCs have started or are considering setting up remanufacturing activities in the region. However, remanufacturing differs from normal Foreign Direct Investment (FDI) as additional factors such as the volume fluctuation of the returned core products and customer reception to remanufactured products must be considered.

There are several options for an MNC to consider before it begins remanufacturing activities in Asia. It can either choose a suitable location in Asia to start its remanufacturing activities, or outsource to capable local third-party remanufacturers. We thus initiate this study to examine the location determinants in the remanufacturing sector as well as the outsourcing decision. The approach taken is the business-economic one. We view the decision of remanufacturing as primarily a business decision, depending on the profitability of the activity. Besides direct profit motives, firms may initiate remanufacturing due to customer demand or regulatory pressures. While technological feasibility for remanufacturing is a pre-condition, technical factors alone are insufficient for firms to remanufacture. The huge investment for remanufacturing facilities could be risky due to uncertainties in both supply and demand. We thus examine the issue from the manager’s perspective and explore related factors based on management theory, in particular real options theory which examines strategic decisions under high uncertainty (Luehrman, 1998). In all practicality, as countries are eager to attract FDI for economic development and growth, a grounded understanding of the location factors on remanufacturing location would be important for the national development policies of many Asian countries. The study is thus timely for both firm managers and policy makers to better locate and promote remanufacturing in Asia.

LITERATURE REVIEW

The first research issue for remanufacturing is whether it is doable. Guide (2000) summarizes seven criteria for re-manufacturability: 1) product is a durable good, 2) product fails functionally, 3) product is standardized and parts are interchangeable, 4) remaining value-add is high, 5) cost to obtain the failed product is low compared to the remaining value-add, 6) product technology is stable, and 7) consumer is aware that remanufactured products are available. A typical remanufacturing facility comprises three distinct sub-systems: disassembly, processing, and reassembly. The study also presents several characteristics of production planning and control activities in remanufacturing, namely, uncertainty in the timing and quality of the returns, and uncertainty in materials recovered, and reverse logistics. Apart from remanufacturing plants, Prahinski and Kocabasoglu (2006) review and discuss the reverse supply chain processes around five sequential steps: product acquisition, reverse logistics, inspection and disposition, reconditioning, and distribution and sales with various managerial concerns. Competition with new products is another concern (Atasu et al., 2010).

On the choice between “make versus outsourcing”, Martin, Guide and Craighead (2010) used the Transaction Cost Economics framework to explore an OEM’s decision to make or buy /outsource remanufacturing activities empirically. Factors such as asset specificity, intellectual property content, and brand reputation are examined. Ferguson and Toktay (2006) mathematically studied the feasibility of remanufacturing when the remanufactured products compete with new product sales. Their model shows the OEM should choose either remanufacturing or a collection strategy when facing potential third-party competitors. The collection cost, unit manufacturing cost, and the relative willingness-to-pay will affect the

OEM's choice between remanufacturing and the collection strategy (collection of used products but not remanufacturing).

On FDI location, several theories have been proposed to understand the determinants of location and entry mode of international business enterprises. Dunning (1988) suggests that cross border international activities are influenced by three set of factors: host country specific factors, ownership specific factors (e.g. contractual risk), and internalization factors (ability to produce differentiated products), where location factors (host country specific) include market size, country risk and location familiarity. Real options theory suggests that a firm may view its investment as a type of real options to hedge against potential risks beyond its control (Folta, 1998; Luehrman, 1998). If the venture turns out to be successful, it may increase commitment; if not, it can terminate it without much cost. Joint ventures can be seen as a type of real options in FDI (Kogut, 1991). Empirically, various factors such as cost, market size, culture, and technology have been considered in FDI location studies (Tong and Walter, 1980; Barkema et al., 1996; Chung and Alcacer, 2002).

RESEARCH METHODOLGY

As research on remanufacturing in Asia is scant, a qualitative approach is taken. We conduct a multi-case study to better understand remanufacturing activities in Asia and then develop a grounded theoretical framework. We mainly rely on semi-structured interviews for first-hand information from management level professionals. This allows respondents the freedom to share their experience and opinions, but at the same time provides focus and scopes the discussion. Each interview lasts for about 45-60 minutes.

We interview five transnational enterprises (four OEMs and one 3PL), and three Small and Medium Enterprises (SMEs) as third-party remanufacturers. This paper covers their location choice determinants and their perspectives on the feasibility and location of remanufacturing activities in Asia. Among the transnational firms, Company A produces printers and cartridges, and is contemplating its entry into remanufacturing. Company B is a 3PL which provides logistics services for remanufacturers, while Company C is a heavy equipment manufacturer with an established presence in the remanufacturing sector. Company D is in the chemicals sector and processes waste from oil refineries which is reused in other industries. Company E produces high-end servers in the electronics industry. The three SMEs, Companies F, G, and H, are third party service providers specializing in a few specific engineering processes such as laser cladding, vibratory finishing and shot peening. They serve as suppliers in the long remanufacturing processes for other remanufacturers by focusing on specific components or processes.

RESEARCH FINDINGS

1. *Reasons for remanufacturing*

We first examine the reasons for firms to engage or not to engage in remanufacturing. Company A decided not to start remanufacturing due to four reasons, of which the primary one is quality.

> *First is the regulatory concern. In many countries such as India and China, remanufactured goods are not accepted. Legally it is not allowed to put remanufactured parts into a new product, or to replace a remanufactured spare part when servicing a new product under warranty. Second is the brand issue. We are serious about our brand image. Even if we put another brand on our remanufactured products, people will still say that these are our products. As we can't be assured of the quality of the remanufactured products, we can't provide warranty and the product will be our liability rather than an asset. Third is the cost. The cost of product remanufacturing is almost the same as making a new one and it is economically not viable to remanufacture. The salvage cost for the used parts is too high. Fourth is the low customer demand, as we*

> *don't see customer demand for remanufactured products, especially in large markets like India and China. We have done internal studies on the issue, and the conclusion is always the same. The central issues are quality, brand, cost and demand. We just don't know how to control the quality of the remanufactured products and how to be sure that it can last.*

In contrast, Company C is quite successful in remanufacturing. Some of its operations in Asia are fully dedicated to remanufacturing.

> *We see the need for remanufacturing and its market potential. We can help our dealers by offering better products to them. It is rooted in our culture to treasure the close relationships with our independent dealers (they are allowed to sell other products but not competitors' products). As the dealers are close to our end customers and are in charge of servicing, remanufacturing gives them an option to improve their performance. Normally after a product reaches the 2nd or 3rd round of repair, the repair cost would be too high for the dealer. Now they can choose to send the product back to us for remanufacturing, and get a remanufactured product at half the price of a new product. At the operations level, we sell remanufactured products with the same warranty, performance specification, expected life, and price. But dealers who return old products to us and meet the minimal specification requirement can get a 50% credit, meaning that they can buy the remanufactured product at half price. Dealers know our specification requirements and 98% of the returned used products can get full credit after an inspection process.*

In the case of Company C, the remanufactured products are sold under the same warranty and quality. Some remanufactured products are better than new products made a few years ago as more advanced technologies are employed for its remanufactured products. While Company A is worried about quality, Company C sees remanufacturing as a service to its dealers and customers who want the same quality but at a cheaper price. From the experience of the two companies, we can see that the first key issue on remanufacturing is quality.

While remanufactured products are largely sold to the same group of customers through its dealers by Company C, remanufactured products are sold to a different set of customers by Company E.

> *Our remanufactured high-end servers are mainly sent to developing countries due to their price advantage. There are two types of remanufactured products, those refurbished with warranty and those without warranty. Nevertheless, all remanufactured products are tested and assembled similar to new ones. We started remanufacturing when there was sufficient demand (target customers are willing to buy) and supply (returns of used products) for the business. We don't see competition between new and remanufactured products as they belong to different generations with different functionalities. There is a market for servers running on older technology and customers who value a lower price tag in developing markets.*

In the case of Company E, remanufactured products are deemed less advanced due to technological progress. Thus they are targeted to a set of more price-conscious customers. We must understand the context of remanufacturing as it can be sold to either the same customers with the same functionality or different customers with lower performance requirements or expectations.

Based on his experience with high-tech OEMs, a senior manager's observations in Company B on the feasibility of remanufacturing are as follows:

> *In my opinion, remanufacturing is good business if the production or sales of the product satisfies one of the following three conditions:*
>
> *a. The product is leased (e.g. heavy equipment or photocopiers). When the lease expires, the product is returned and refurbished for the next lease.*
> *b. The sale model contains trade-in of used products.*
> *c. Product design is highly modular so that the defective parts can be easily replaced and the repaired products can function similar as the new (more applicable to high-tech electronics products with significant commercial returns).*
>
> *The remaining value in the returned products is the critical factor. You have to justify the cost of returning and remanufacturing products. As a rule of thumb, the refurbishment cost ought to be less than one-third of the original manufacturing cost in order to make remanufacturing profitable. For example, a PC motherboard costs over $100, and the cost of refurbishment should be less than $30. Similarly, a recycled product cannot be refurbished more than 3 times before scrapping.*

The first two, in the above three conditions, guarantee a sufficient volume of used products, which is critical in remanufacturing. Company C also allows its dealers to return used parts in exchange for remanufactured products, and Company E started remanufacturing only after seeing a sufficient volume of returned products. Another critical factor is the remanufacturing cost. Though, for spare parts, the remanufacturing cost can be as high as for a new product, it is still feasible due to the limited supply of new spare parts. Company H, who mainly serves clients in the oil and gas industry, observes the following:

> *The strong demand for remanufactured parts is partly due to the difficulty in getting new parts. It is often not easy to locate inventories as spare parts in the oil industry are specialized and produced in very low volumes. Though the remanufacturing cost is almost the same as the production cost of a new part, it is still economical to do so as this reduces the replacement lead time. Sometimes the user has no other option except to use a remanufactured part as the spare part is out of stock globally.*

For third-party SME remanufacturers, demand for services is the key factor attracting them to the industry. Thus, technological feasibility is the basis when choosing to remanufacture, followed by customer demand, cost, and ready supply of used products.

2. Location for remanufacturing activities

On locating the remanufacturing facilities, firms consider many factors. For Company C, the primary concern is government support (both regulatory environment and financial incentives), followed by logistics capability and R&D ability.

> *Many developing countries are not supportive of remanufacturing. They are very suspicious about importing used products from other countries. They fear that their land will be filled with industrial garbage. To export used parts to our facility in such a country for remanufacturing, we have to do the cleaning here, and imports to the country must go through two rounds of inspection by customs officers in the two countries, and the remanufacturing process is video recorded by customs to ensure that the imported item are remanufactured and not dumped. The perception of Country Z (the country Company C invested without existing manufacturing facilities) on remanufacturing is very different. We get support from its government to set-up the remanufacturing facility in the form of both grants and tax incentives. Customs is very friendly to us to move used products in and out of the country.*
>
> *For our customers in the region, this country is the ideal location to process used products. Besides it is well connected to all different locations in the region, it is also well linked to all our main manufacturing locations globally, and so it is easy for us to*

> *send partially processed used products to other locations for further remanufacturing. We are also able to source for some spare parts locally for the remanufacturing process. The skilled labour force and R&D facility are additional advantage as the profitability of remanufacturing is largely dependent on technology and skilled labour. Most employees in our plant are high-skill workers.*

From the above discussion, an important location factor is proximity to customers. Since Company C has many customers in Asia, it makes economic sense for the firm to start remanufacturing in Country Z rather than sending the used parts back to the US. Though having a location advantage, its manufacturing facility in an Asian country is not suitable for remanufacturing due to the existing regulatory restrictions. For most firms, the location choice of remanufacturing is closely related to their existing manufacturing facilities. For example, Company E located its remanufacturing facility in Country Z to be close to the manufacturing facility. When the volume of used parts is low, using existing facilities make good economic sense. Companies H and F adopt a similar strategy.

Company D, a player in the chemicals sector, has another remanufacturing consideration.

> *We chose* Country Z *as a location for the plant mainly to be close to its customers as 70% of our plan's production is for the local market. Also, some of our supplies are by-products of other firms which are often too cheap and heavy for transportation, we have to locate near these suppliers.*

The close proximity to key suppliers is a location factor for Company D. This may be important for some industries when the supplies (could be used parts or other additional inputs) are bulky or hazardous, making long-distance transportation infeasible or costly.

3. Feasibility of outsourcing remanufacturing

Another issue explored in this study is third-party outsourcing. Historically, third-party firms were doing the remanufacturing before the involvement of OEMs (Guide, 2000). With the participation of OEMs in remanufacturing in recent years, OEMs can choose to either compete against third-parties (Ferguson and Toktay, 2006) or collaborate with them (Martin et al., 2010). From our interviews with the OEMs, those who have not initiated remanufacturing such as Company A are strongly against third-party remanufacturing, while firms with remanufacturing experience are amenable to collaboration. For example, Company C has collaborated with third-party SMEs as suppliers in its remanufacturing process. Further, when the volume of used parts is low, OEMs prefer to outsource some processes to third-parties to reduce the capital investment. Quality-validated third-parties can reduce the OEMs' capital investment in remanufacturing and give them the flexibility of commitment later. Company G made the following comments on Company C:

> *The cladding process we are doing is a common process and most MNCs including Company C have the capability to do it. However, they may outsource it due to demand uncertainty and we can thus share their risks in the case of a demand surge.*

Table 1 summarizes the responses of the companies on their remanufacturing strategies.

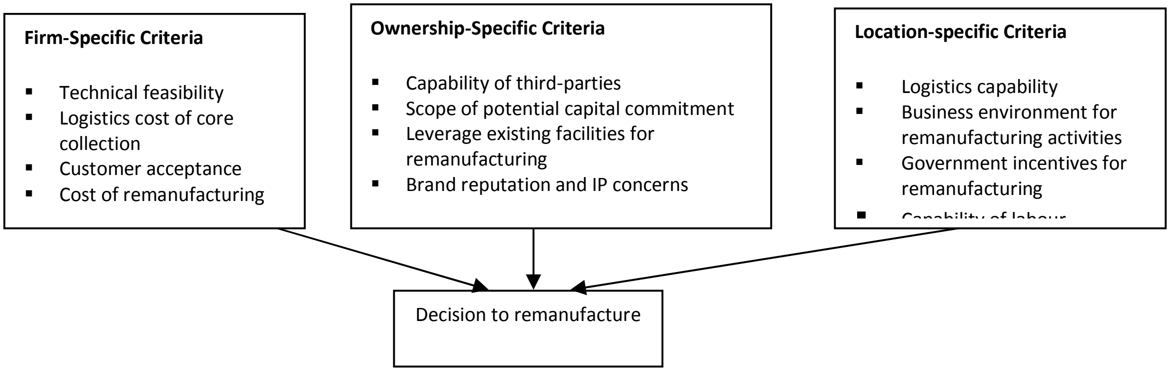
	Company A	Company C	Company D	Company E
Procurement	Only displayed goods or defective goods are returned to dealers	Sent back by dealers		Acquired from the market or returned by customers
Location Factors	High costs	Logistics connectivity, R&D capability	Proximity to customers, logistics capability, efficient customs	Presence of existing facility, logistics connectivity
People & Training			High labour costs	Training of workers on old technology
Technology		Acquire technology to do third party remanufacturing		No additional investment required
Market for remanufactured goods	Small market size for remanufactured goods			Price sensitive customers use old technology
Outsourcing Potential	Quality and brand name concern prevent outsourcing	Validate third party manufacturers to ensure quality		Prefer to in-source to protect brand names
Costs	High costs make remanufacturing infeasible			Only high value products is feasible for remanufacturing

Table 1: Responses from transnational firms on their remanufacturing activities

RESEARCH FRAMEWORK

Based on above field interviews, we develop the following framework with three groups of factors as determinants for a firm's decision on starting remanufacturing activities in a specific location. The first issue is whether to initiate the remanufacturing activities, the second is where to locate the remanufacturing facilities, and the third is whether to do the remanufacturing by itself or outsource to capable third parties.

Figure 1: Framework for decision to remanufacture



Based on this framework, we propose three propositions for further empirical validation.

Proposition 1: *Firms engaged in remanufacturing will tend to locate facilities with existing manufacturing facilities.*

Given the uncertainty of customer demand as well as the volume of returned used products, firms are concerned about the profitability of remanufacturing operations. Remanufacturing is a promising concept for firms to demonstrate social responsibility but the business viability is highly uncertain due to various external factors. According to real options theory, the optimal strategy firms should choose is to invest a small amount first but keep the option of future commitment open. Thus leveraging existing facilities can significantly reduce the setup cost and allow for economics of scale from existing operations. Company E is one such example where the returned volume has been high enough to initiate remanufacturing.

Proposition 2*:* *The regulatory and logistics environments will play a critical role especially when firms locate remanufacturing facilities in new sites without the support of existing manufacturing facilities.*

When a firm chooses to locate its remanufacturing operation in a new location, it must have significant advantage over existing manufacturing sites due to the great uncertainty of remanufacturing. Regulatory or logistics factors will be critical to offset the disadvantage of high production costs. Company C is one such example as the firm chose Country Z over the country with existing manufacturing facilities for its regulatory and logistics competency advantages.

Proposition 3: *Third-party remanufacturers can be an important support for OEMs to start remanufacturing in new locations, especially when OEMs initiate remanufacturing without the support of existing manufacturing facilities.*

As mentioned, an OEM faces much uncertainty when starting its remanufacturing operation in a new location. According to real options theory, the firm should make a small commitment at first and increase its commitment in the future if it turns out to be successful. Due to the complexity of the remanufacturing processes, a small commitment means much outsourcing. The OEM would outsource most remanufacturing activities to existing third-parties for flexibility and reduce its cost of commitment. Third-party remanufacturers in the new market are thus more likely to be collaborators rather than competitors as they can share the risk and reduce the OEM’s cost of commitment. In our field study, Company C is one such example as the firm engaged multiple local SMEs. Even for processes such as cladding which it is capable of doing itself, Company C outsourced to a third party SME to reduce its investment in Country Z at the start.

Conclusion

Remanufacturing is an interesting research topic given the increasing concern on the sustainability of modern-day production processes. From an Asian perspective, our work contributes to the field with multiple case studies of various industry players. Applying real options theory, we show that OEMs tend to leverage on existing manufacturing facilities or third-party remanufacturers to reduce their cost of commitment in starting remanufacturing at new locations. Our study shows that OEMs and third-party remanufacturers can have collaborative relationships instead of the commonly assumed competitive stance. Further empirical work to test the propositions from this study will be conducted. The framework summarized from the study can also guide further investigations. This paper provides a practical understanding of the remanufacturing sector in Asia and the factors which affect the location decision and remanufacturing strategies of OEMs. It will assist managers and decision makers in transnational enterprises to design appropriate logistics related solutions for remanufacturing.

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MEANINGS OF VALUE WITHIN LOGISTICS & OPERATIONS MANAGEMENT: CONSTRUCTING THE TOWER OF BABEL?

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ABSTRACT

This is a conceptual paper that explores the origins and current conceptualisation of the concept of 'value' and 'value add' within Logistics and Operations Management. It is presented as a catalyst for discussion at the Symposium in Cape Town.

INTRODUCTION

The terms 'value' and 'value add' have long been a salient feature of the vocabulary of management (Neap & Celik, 1999). Van de Ven (1992) in his reflection upon the nature of the strategy process muses that the term 'process' is one of the most widely used words in the management lexicon. In his article he develops three interpretations (models) of the concept of process that are most widely used within the management and organizational literature. He subsequently argues that the interpretation of the term process that is adopted by a researcher influences the research questions that they ask, the methods they employ and consequently the contribution that they make to theory. Van de Ven's article has left an indelible impression upon the minds of the authors of this paper, as we have reflected from collective experience that the terms 'value' and 'value add' can perhaps be added to 'process' (and 'system') as among the most frequently used and ill-defined terms in common currency within organisations today.

If true, what are the implications for both research and practice within Logistics and Operations Management? Surely the concept of value is of fundamental importance to our current conception of the supply chain, and also to the Contemporary Operations & Management Paradigms (COMPs) such as Lean Thinking (Womack *et al*., 1990; Womack & Jones, 1996) and Agility (Goldman & Nagel, 1993; Christopher *et al*., 1999; Harrison & van Hoek, 2002), that have come to underpin the supply chain concept? Do all parties conceive of value in the same way when they communicate? Are we indeed all 'singing off the same hymn sheet' or are we building a Tower of Babel when we invoke the value adding concept as a guiding principle for process and supply chain improvement?

This paper marks the start of a conceptual project that will attempt amongst other things to characterise how the concept of value has evolved; how it is currently conceived; how it is measured; and how it can be added, maximised, grown or used as a directional influence for improved supply chain and organisational performance. This clearly implies a significant undertaking as even a cursory examination of the literature reveals that the depth and breadth of material related to this subject matter is 'vast'. The aim of this conference paper is therefore merely to initiate the process of further examination of this oft invoked concept. We would stress that the following content is the authors' first tentative step in this exercise. This is a discussion paper and is not considered to be a comprehensive, academic review of the subject matter. We hope this provokes discussion at the Symposium in Cape Town.

VALUE THEORY WITHIN PHILOSOPHY AND SOCIOLOGY

Value Theory could be considered the collective term for the various conceptions developed by academics to aid understanding of what, and to what extent, items are valued by different stakeholders and groups under different circumstances. Any attempt to build a literature map on this topic rapidly establishes that value as a subject matter has a long lineage of study across a number of social science disciplines; most notably Philosophy, Sociology and Economics.

The earliest conceptions of value can be traced to Philosophy, and particularly its sub-disciplines of Ethics (morality and the principles of right and evil conduct) and Axiology (the nature of values and value judgements). For example, Plato distinguished between instrumental and intrinsic values in his 'Republic' in circa 380 B.C. Sociology is a younger discipline than Philosophy, with the term itself being coined by the philosopher Auguste Comte in his 1822 work entitled *Plan of the Scientific Works Necessary for the Re-organization of Society.* However, since the inception of Sociology Value Theory has been a theme of its study, where it has been manifested in particular with the study of the personal values that are held by different social communities, and how those values modify under different influencing conditions. For example, significant contributions have been made in this area by notaries such as Emile Durkheim (collective consciousness as a moral force that binds the individual to society), Talcott Parsons (the functional prerequisites of a society's survival) and Karl Marx (the capitalist bourgeois class extract surplus value from the workers).

ECONOMIC THEORIES OF VALUE

A number of theories of value have been developed within Economics to explain the exchange value (price) of a good or service, whereby value is linked to price via the mechanism of exchange between a buyer and a seller. Such theories can be divided into two categories. The first of these is *intrinsic*. Intrinsic theories are characterised as premising the price of a good or service upon objective criteria. For example, neoclassical economics suggests that the value of a good/service is the price it would yield in an open market and is determined by the demand for that good/service relative to its supply. The *Cost of Production Theory of Value* could be classified as an intrinsic theory as this holds that value (price) of a good/service is the sum of the costs of its production (labour, capital, land and taxation). The second category is *subjective*. Subjective theories of value use non-objective criteria to explain the price of a good/service. For example, the *Labour Theory of Value* that is associated with the work of Karl Marx suggests that value (price) is a function of the labour needed to produce or obtain it. Another subjective theory is the *Utility Theory of Value*. This suggests that the value (price) of a good or service is explained by the utility/ usefulness/ degree of satisfaction that is derived by the consumer from the consumption of it (assuming that it is in limited supply), and that marginal utility can be used to explain buyer purchase decisions between alternative offerings.

In summary then, such theorising within Economics has developed a useful and specifically defined vocabulary of terms. It also provides a further useful distinction between *value in exchange* (ie price) and *value in use* (ie utility), whilst *value added* (per unit) is defined as the sale price of that good/service minus its production cost.

It is interesting at this point to examine the conception and communication of value outside the discipline of Economics and within the general management literature. Is there a single conception in common currency? If so, is it derived from Economics or is it something else?

VALUE WITHIN THE GENERAL MANAGEMENT LITERATURE

Perhaps the most widely conveyed and influential invocation of the concept of value within the general management literature has been Michael Porter's (1985) *Value Chain Analysis*

(VCA) model. Porter suggests that a preliminary step to understanding strategic capability is the identification of the [nine] separate *activities* that add perceived value and cost to [any] product or service in a business/ customer value delivery system (Gilbert & Strebel, 1991 cited in Mintzberg & Quinn, 1991, pp.82-83). Porter identifies the five generic *primary activities* of any organisation. These are Inbound Logistics, Operations, Outbound Logistics, Marketing & Sales and Service. He also identifies four generic *supporting activities* in his framework: the Firm's Infrastructure, HRM, Technology Development and Procurement. Porter's conception of customer value is the perceived stream of benefits that accrue from obtaining and using that product or service. Value is measured by total revenue, which is a reflection of the price a firm's products command in the marketplace and the number of units sold. Porter's conception of value clearly encompasses both value in exchange and value in use, and is rooted in the Economics conception of the *Utility Theory of Value*. His VCA model provides a useful framework for exploring this issue further. This model highlights that exchange takes place between the seller's primary Marketing & Sales [activity] and the customer's supporting Procurement [activity]. How, then, is value and conceived within these two organisational functions?

Turning first to Marketing & Sales and we determined to review the official definition of value by the Chartered Institute of Marketing (CIM); the professional body in this field. Interestingly, the terms *value add* and *added value* are used interchangeably, with the latter established as being the most common (Chartered Institute of Marketing, 2012). Added value is defined as *'The increase in worth of a product or service as a result of a particular activity - in the context of marketing, the activity might be packaging or branding'* (op cit.) To cast further light on the Marketing conception of value we turned to what many consider to be the seminal Marketing textbook: Kotler (1994) suggests that the concept of customer value is the guiding concept within Marketing because it is this concept that determines which firm's offering the customer chooses to purchase of the alternatives available (p.8). Kotler defines value as '...*the consumer's estimate of the product's overall capacity to satisfy his or her needs.'* (*Ibid*.). Customers therefore buy from the offering that represents the highest customer delivered value '*[which is defined as] the difference between total customer value and total customer cost. And total customer value is the bundle ,of benefits customers expect from a given product or service.'* (p.36). It is this conception of value that has placed an emphasis on competition based upon differentiation rather than price within Marketing, and the concomitant development of the concept of *value-based pricing* (whereby the pricing point is a function of the buyer's perception of value rather than the seller's cost of production). Based upon the above definitions, it seems that the notion of value within Marketing is conceived of as **value in use** and is derived from the subjective *Utility Theory of Value* within Economics.

The Chartered Institute of Purchasing & Supply (CIPS) also maintain an official dictionary of terms. As per CIM, the terms 'value added' and 'added value' are used interchangeably, although in the case of Purchasing it is the former that seems to be the preferred term. Here, value added is defined as ' *The increase in realisable value resulting from an alteration in form, location or availability of a product or service, excluding the cost of the purchased materials and services'* (Chartered Institute of Purchasing & Supply, 2012)[1]. Further review of the related terms 'value analysis' and 'value engineering' reveals that these activities involve '*[examination of the] factors affecting the cost of a product or service in order to devise a means of achieving the specified purpose more economically at the required standard of quality and reliability'* (op cit.). A review of contemporary Purchasing & Supply text books corroborates these interpretations. For example, Cousins *et al*. (2008) don't specifically define value, but do provide a table that lists the activities (practices or traits)

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[1] Citing Compton, KH and Jessop, D. (2001). *The Official Dictionary of Purchasing & Supply: Terminology for Buyers & Suppliers,* LBP Publications.

that the Purchasing function can undertake to add value to its host organisation (pp.150.151). This table differentiates between strategic activities such as 'supplier relationship management' and 'customer satisfaction', and tactical activities such as 'contract negotiation' and the 'provision of commercial acumen'. The prevailing Purchasing conception of value therefore differs from Marketing. Its heritage is again clearly traceable to Economics, but this time as intrinsic, value in exchange.

VALUE WITHIN LOGISTICS AND OPERATIONS MANAGEMENT

It is useful at this point to briefly consider the conception of value in the remaining primary activities of Porter's (1985) VCA framework; namely Logistics and Operations. Adopting a similar approach to the above, the authors sought insight into the definition and conception of 'value' and 'value added' from official glossaries and key text books within these fields. The findings were illuminating.

Turning first to Logistics and we found for example that neither Chopra & Meindl (2007) nor Crocker *et al*. (2012) had a definition or reference to either 'value' or 'value add' in their index; although the former did summarise Porter's (1985) VCA concept to highlight the importance of Logistics as two of his five primary activities. Rushton *et al*. (2004) do overtly address 'value added'. They state that '*[The traditional view has been] that the functions within logistics are merely a cost burden to be minimised regardless of any other implications*' (p.10) but that the different elements of logistics could add value to a product as it is made and distributed to the final user, and should not be conceived merely as adding cost. They do not define what 'value' is, but instead list examples of *value added logistics services*. These are specialised or niche services, time reliable services, assembly, repacking, refurbishment and packaging returns (pp.62-63). This citation of traits and practices in lieu of definition is teleological in nature reflects the approach adopted by Cousins *et al*. (2008) in the Purchasing texts above.

Of the Logistics texts reviewed, Coyle *et al*. (1996) had the most extensive coverage of this topic area. They state that '... *efficiency, effectiveness and differentiation represent three important ways in which logistics creates customer value ... [which must be] viewed from the customer's perspective [as it is this perspective that is the most important]*' (pp.548-549). The authors continue to summarise the findings of a research project into logistics quality, satisfaction and value that was sponsored by the Council of Logistics Management (CLM) in the USA in 1995 (*Ibid.)*, and also summarise Porter's (1985) VCA work in the same manner as Chopra & Meindl (2007). Similarly to *Rushton et al*.'s (2004) list of value added logistics services, Coyle *et al*. (1996) list the *value adding strategies* (activities, practices or traits) of the Logistics function (pp.578-580). Again, neither 'logistics value', 'value' nor 'value add' are specifically defined and we are left to interpret meaning. Scrutiny of the listed value adding strategies however reveals that 'value' is conceived as cost reduction via an emphasis on the systematic reduction of transactional activities. Hence it is again conceived as value in exchange.

We then turned our attention to Operations Management and undertook a similar exercise using three of the most commonly used text books in Operations Management courses within UK Business Schools. The first of these was Slack *et al*. (2001), which surprisingly had no index nor glossary reference to either 'value' or 'value add'. It did however discuss the topic of *value-based approaches to quality* that stated that '... *quality should be perceived in relation to the price [paid]*' (p.555) - reflecting a subjective, value in use (utility) conception of value. The only other related value topic discussed in this text is Value Engineering (VE). On this topic the authors indicate that the purpose of VE is to eliminate all costs that don't contribute to the value and performance of that product or service, and this is achieved by examining the function and cost of each individual element of the product to establish whether the same function can be achieved at a lower cost via reduction in the number of components, use of cheaper materials or simplification of the process (p.136). This is indicative of value in exchange.

The second Operations Management text was Greasley (2006). Again, no index nor glossary reference to 'value' was offered. However, Greasley does address the concept of 'value added' and he relates this to the Value Chain concept, which clearly paraphrases Porter's (1985) original work. Value added is defined by Greasley as '*[being used to] denote the amount of value a process creates for its internal or external customer. The set of process used to create value for a customer is often called the Value Chain. [It] includes primary processes that directly create the value the customer perceives and support processes that assist the primary process in adding value*.' (p.11).

The third text was Russell and Taylor (2003). This was the only one of the three to have an index entry for 'value'; of which it stated that '*[The purpose of Operations Management is] to ensure that the transformation process is performed efficiently and that the output is of greater value than the sum of the inputs. Thus the role of operations is to create value.'* (p.3). They elaborate upon their definition of the transformation process which '...*can be viewed as a series of activities along a value chain extending from supplier to customer. Any activities that do not add value are superfluous and should be eliminated.'* (p.3).
Yet again, 'value' is un-defined. However, later in the text the authors cast further light on their conception of this when discussing VE; the purpose of which is explained to be the elimination of unnecessary features and functions in product designs with the goal of improving '...*the ratio of value to cost for ... by either reducing the cost of each item or increasing its worth'* (p.90). Therefore according to both Slack *et al*. (2001) and Russell & Taylor (2003), the 'Value' in the Value Engineering (VE) context equates to price, and VE itself is conceived of in an **intrinsic, value in exchange** conception of value.

VALUE FRAMEWORKS AND METRICS

A number of value frameworks have been established to reflect the complexity of meaning implied in the above discussion. For example, Bowersox *et al*. (2000) suggest that there are three customer value perspectives: *efficiency value* that is achieved via low price; *market value* that is achieved via product/service variety, convenience and other positioning strategies; and *relevancy value* that is customer-segment specific and achieved by providing the previous two when, where and how the customer wants it. An alternative framework is provided by Zeithaml & Bitner (2000, cited in Bicheno, 2004, p.14). They suggest that there are four meanings of value: *value is low price* (lowest price is best); *value is whatever I want in a product or service* (the 'classical' Marketing approach - focusing on benefits not price); *value is the quality I get for what I pay* (if I pay more, I expect more); and *value is what I get for what I give* (an evaluation of all benefits versus all sacrifices).

This plurality of meaning has also been reflected in numerous attempts to conceive of a value metric or equation to guide the acquisition and retention of competitive advantage, and it is useful to briefly review this concept in order to contextualise the following discussion on Lean Thinking and Agility. We are aware of a number of such metrics, not all of which are presented here due to space constraints. For example, the consulting firm Coopers & Lybrand suggest Value = (Product Quality x Service)/ (Price x Time) [2]. By contrast, the European Efficient Consumer Response (ECR) movement considers Value = (Quality x Trust x Variety x Service) / (Response Time x Price)[4]. Arguably the most commonly known such equation is provided by Johansson *et al*. (1993 cited in Naylor *et al*., 1999), who suggest that Value = (Quality x Service)/ (Cost x Lead Time). Such value metrics therefore recognise that value is a complex amalgam of factors that are both intrinsic and extrinsic to the selling firm, and cost [reduction] is but one of these factors.

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[2] No reference available to the authors.

There are two other points of note with these metrics. The first is that all such value metrics/ equations are remarkably consistent in structure and belie their conceptional origin in the Economic theories of value discussed earlier. The second point builds upon this observation of consistency: In all of the metrics with which we are aware, *Quality* and *Service* are uniformly listed as factors in the numerator. Likewise, both *Price* (or Cost) and *Time* (meaning lead time) form the main factors listed in the denominator of the equation. It seems that to the architects of these metrics, Cost and Quality are analogous to Hill's (1993) *qualifying criteria,* whilst the *winning criteria* are to be found in Quality and Service. The logic implicit in these value metrics would seem to be contrary to the conception of lead time reduction as an order winning criterion originally espoused by Stalk & Hout (1990), and which forms an underlying tenet of Lean Thinking and similar COMPs that are premised upon the competitive advantage derived from the swift and even flow of material within the supply chain. Were all these architects Marketers?

CONCLUSIONS & FUTURE RESEARCH

This discussion paper represents the first tentative step in a wider ranging conceptual project that aims to explore the conception, communication and execution of the concept of 'value' and 'value add' within the fields of Logistics and Operations Management. After first briefly summarising the evolution of Value Theory within the disciplines of Philosophy and Sociology, this paper then summarised the various theories of value that have been developed within Economics as a means of contextualising the application of these theories within the wider management literature. Using Porter's (1985) well-known VCA model as a framework, the official glossaries & dictionaries of the relevant professional bodies in conjunction with the key text books of each of the primary activities (fields or functional areas) depicted in Porter's model were then analysed.

A key finding of this analysis suggests that the terms 'value' and 'value add' are a locution within both Logistics and Operations Management that lacks specific definition. Instead, definitional rigour tends to be replaced by the axiomatic or the teleological appeal to established practices within these fields. Further scrutiny of such practices however, reveals that the conception of value within both Logistics and Operations Management is similar to that within Procurement; namely that it is clearly derived from an intrinsic Economic theory whereby value is conceived of as value in exchange; being a function of the difference between cost and price. As a consequence of this stereotypical value conception, the production-oriented fields of Purchasing, Logistics and Operations Management seem to have embraced competition based upon price as the primary means of achieving competitive advantage. The origins of Lean Thinking in the Toyota Production System have been well documented. Might this explain why so many Lean implementations adopt an introspective waste/cost reduction focus rather than adhering to the first Lean principle of conceptualising value from the customer's perspective (Womack & Jones, 1996)?

By contrast, Marketing seems to have adopted the notion of value in use (utility) from Economics as its guiding conception, and hence stressed competition based on various forms of differentiation in order to express this utility. Might this explain the traditional 'rivalry' between Marketing and the production and distribution functions in many firms? A number of the key architects of the Agility COMP in the UK have a strong background in Marketing. Might the stereotypical Marketing conception of value in contrast to that of the production-oriented functions therefore explain the ongoing tension between the adherents of the Lean and Agile COMPs; or at least inform this debate?

When a number of value metrics/ equations were subsequently analysed to explore further this complexity of meaning it was found that their architects conceived of Quality and Service as being the 'winning criteria' (numerator), with Price and Leadtime as the 'qualifying criteria' (denominator). To the authors this seems to translate crudely into the numerator equating to value in use, with the denominator equating to value in exchange.

It seems possible to conclude that at the moment, the practioners and academics operating in the value chain and supply chain are speaking in many tongues when it comes to the primary and guiding concept of 'value'. There is a great danger that we are constructing a Tower of Babel when we try to construct efficient and effective supply chains. Clearly, greater clarity is required and this train of research affords the promise to yield significant contributions to knowledge and practice. Our immediate future research will focus on addressing the methodological weakness inherent within this paper by conducting a comprehensive and structured critical review on the topic of value within the Logistics and Operations Management literatures. Following this, a similar comprehensive analysis will be conducted on the way in which value is conceived and utilised within the COMPs that underpin the supply chain concept. This will start with Lean Thinking and Agility, but will also include other contemporary COMPs such as the Theory of Constraints, Six Sigma and Systems Thinking. We hope to be able to construct a hymn sheet that we can all sing off!

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LONG-TERM SUPPLY CHAIN DEMAND MANAGEMENT: A STRATEGIC FACTOR FOR SUSTAINABLE SUCCESS

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ABSTRACT

Purpose:
The purpose of this paper is to discuss the challenges in supply chain demand management and highlight why demand management is key to sustainable success of a supply chain. Furthermore the paper will give insights into what requirements are important for different types of supply chains. These requirements are evaluated and sorted by an ANP application.

Keywords:
Demand Management, Supply Chain Management, Forecasting, Process Management, Analytical Network Process

INTRODUCTION

As the world seemingly accelerates in terms of changing (global) threats and opportunities, sustainable success becomes more and more an objective within the strategic function rather than a given fact. Today, companies need to adapt quickly to trends that are not a result of an evolutionary process but of a sudden and spontaneous development. Traditional key factors for success like financial resources, production technology or economies of scale undergo a shift to include the companies' ability to adapt and to initiate strategic change before competitors and right on time for the customer. One way to achieve flexibility is sufficient foresight within the supply chain regarding trends and changes around customer needs as well as the correct communication thereof. A robust long-term demand planning process that monitors environmental changes and draws the right conclusion regarding potential implications will improve a company's strategic position.

The purpose of this paper is to discuss the challenges in supply chain demand management and highlight why demand management is key to sustainable success of a supply chain. Furthermore the paper shows what requirements are needed in different business environments and that the requirements differ for various supply chain types.

LITERATURE REVIEW

The importance of accurate demand planning on a long term scale is immense and quite sufficiently proved. If future customer demand is not anticipated accurately and the supply chain not adjusted to it, the company's performance will inevitably decrease. Future demand is influenced by new trends and changing environmental requirements, necessitating adjustments not only in supply chain design but also the demand planning process. Decisions such as the building of new office capacities or the extension of a company's portfolio become high risk investments, if the future developments are not sufficiently forecasted (Günther, 2005; Ghiani et al., 2004). High competitiveness means low divergence between supply and demand, more responsiveness and efficiency as well as ultimately improved customer satisfaction (Kilger and Wagner, 2008; Marbacher, 2001). Hence, a structured long-term demand planning process is crucial to the quality of the forecast and thereby a company's performance.
Figure 1 exemplifies how demand planning with its various shades and time horizons interrelate with each other and which departments need to be included within the process to achieve optimal planning results.

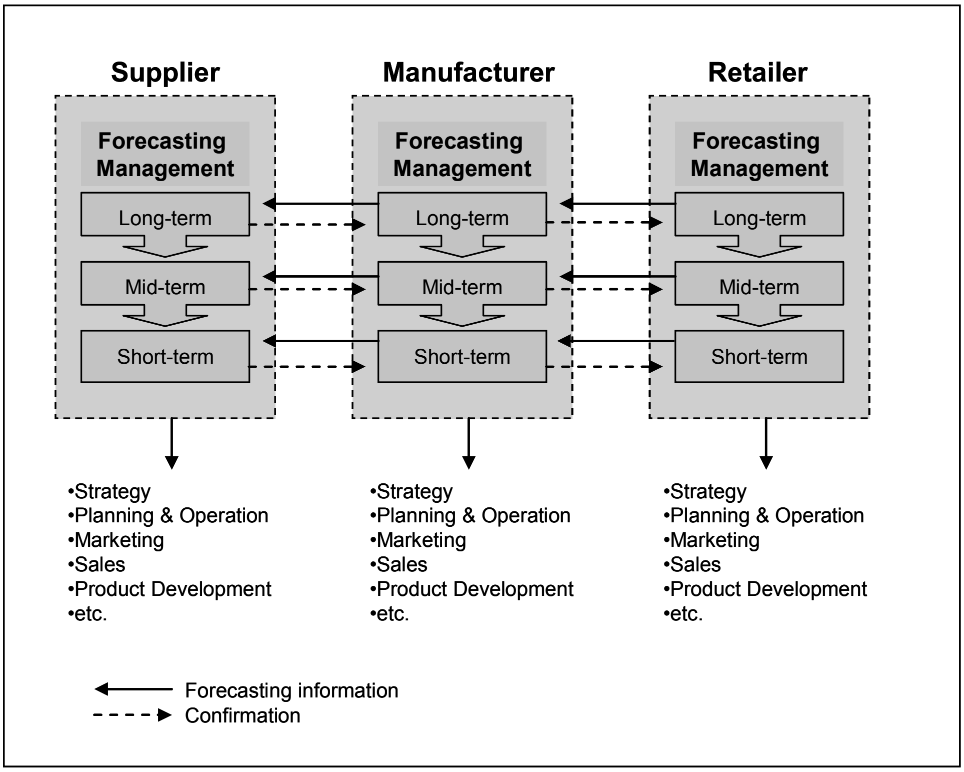


Figure 3: Exemplified Collaborative Forecasting Process Applying Upstream Planning

Although the term implies differently, a supply chain is much less a one-dimensional chain, than a complex net of interdependent elements (Voss, 2007). This paper therefore uses the definition of Christopher which defines supply chains as a network "of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer" (Christopher, 2005). Supply chains extend from the raw material to the ultimate customer, linked by material, financial and information flows.

In literature, various approaches can be found to define supply chain types. For example, Fine (1998) connects supply chains to product types, which are either integral or modular with respect to sourcing. Integral products contain strongly linked components which can be used for many aspects and usually need geographical proximity. Modular products are loosely connected, can be substituted and have standardized interfaces (Corsten and Gabriel, 2004). Analogical to the different product types, an integral supply chain and a modular supply chain is distinguished. Lejeune and Yakova (2005) differentiate communicative, coordinated, collaborative and co-opetitive supply chains, which mainly highlight the elementary relationships between the many supply chain actors. In literature the approach from Vonderembse et al. (2006) is widely known which links the supply chain to the demand of its end product. High predictability of demand with simultaneous high demand volume defines a lean supply chain, where low costs and high flexibility are the most important factors. Low predictability of demand with low volume defines agile supply chains, usually linked to new products or new markets. A combination of both types leads to a hybrid supply chain. As this paper examines the long-term demand processes within companies, the definition of Vonderembse et al. (2006) shall lend the foundation for the results of the study.

RESEARCH APPROACH AND METHODOLOGY

In order to master the selection of key criteria, an accurate multi-criteria decision analysis (MCDM) has to be conducted. MCDM solves decision problems that include multiple and conflicting purposes (Arbel and Vargas, 1992). In the operations research discipline there is a variety of MCDM methods, the suitable method for this research paper is the analytical network process (Saaty, 1990; Saaty, 1996). The analytical network process provides a more generalized model (Saaty, 2005) than the analytical hierarchy process without making assumptions about the independence of the criteria at different levels of the hierarchy and also of the criteria within a level (Saaty, 2001; Mls and Gavalec, 2009). The analytical network process was designed and shaped by Saaty in 1990 (Saaty, 1990) and has to be seen as an extension of the analytical hierarchy process (Saaty, 2004). The analytical hierarchy process (Saaty, 1980) solves multiple criteria problems in a hierarchical structure. In contrast, the analytical network process solves multiple criteria problems as well, but in a network structure (Saaty, 2001; Meade and Sarkis, 1998; Sarkis, 2000; Sarkis and Sundarraj, 2002). This soft research method is a decision-supporting method that integrates qualitative and quantitative data for prioritizing alternatives when multiple criteria have to be considered or for evaluating complex multiple criteria alternatives (Saaty, 2001). In selecting decisive criteria for developing the concept of fourth-party humanitarian logistics (4 PHL), basic steps have to be applied (Saaty, 1996; Meade and Sarkis, 1998; Saaty, 2001; Thakkar et al., 2005; Shyur, 2006; Jharkharia and Shankar, 2007; Tsai et al., 2007; Peters, 2008; Peters and Zelewski, 2008; Sevkli et al., 2008):

1) The model and structure have to be designed and the problem has to be formulated; the analytical network process model and structure is based on a literature review and an expert interview regarding humanitarian logistics practices; the expert interview support has to be applied to classify the crucial criteria and to build the upper level of the analytical network process model; identification of clusters and nodes.
2) Paired comparison of each criterion by the humanitarian logistics experts to determine the importance and relevance of the criteria in order to achieve the objective. For this comparison, a ratio scale of 1–9 is applied to compare any two elements. 1 indicates equal importance whereas 9 indicates overwhelming dominance. Within the comparison matrices, it is assumed that, for each component, it takes inner and outer interdependence.
3) A component in each hierarchy is able to use some or all components of the previous components as the basis for conducting the evaluating operation.
4) It is able to change the absolute and numerical scales into the ratio scale despite conducting the comparison assessment.
5) After conducting the paired comparison, it is possible to use the positive reciprocal matrices to handle the follow-up process.
6) The preference relations conform to the transitivity, i.e. A is better than B, B is better than C, then A is better than C, but also the useful step of components can be obtained by the weighting principle.
7) Every element that appeared in the hierarchical framework, whether or not its advantageous degree was small, will be regarded as relating to the whole evaluation framework but with the independent from a non-check hierarchical structure.

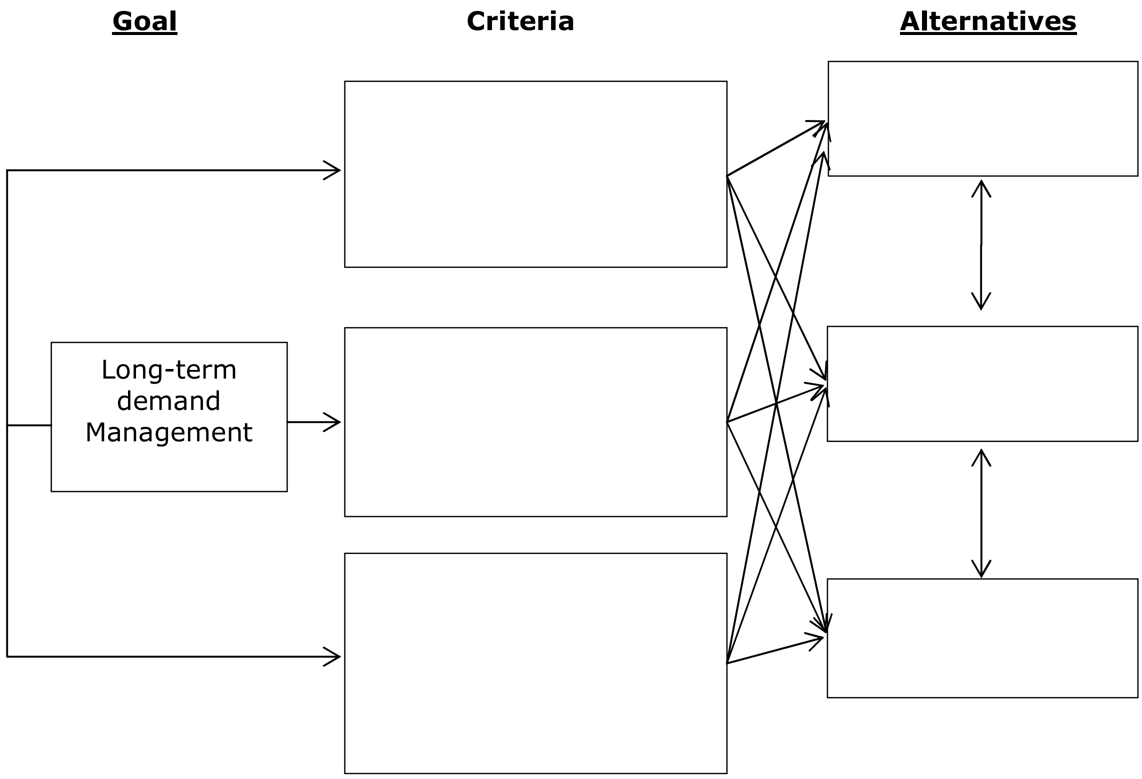
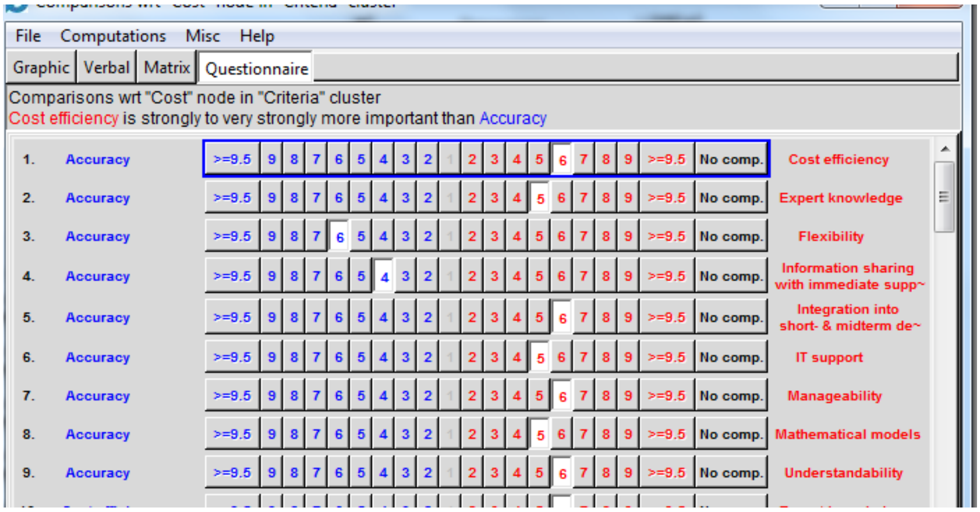


Figure 4: Analytical Network Process Structure

DATA COLLECTION AND RESEARCH RESULTS

The needed data for the ANP simulation were collected by questionnaire through pair-wise-comparison. Different experts from energy industry, logistics provider and chemicals industry were asked to compare two elements with respect to another inducing factor in the network using a point scale that demonstrate equally importance as well as high importance. Furthermore in the second part of the questionnaire the experts were asked about the general meaning of long-term management in the present and future, they were asked to prioritize relevant criteria to show the relevance of short-term management as well as long-term management a 8 point scale ranging from 1 (no importance) to 8 (high importance). It should be also mentioned by a determination of high inconsistencies over the pair-wise-comparisons were revised and moderated by the authors. The results of the second part of the questionnaire are interesting. The results of analytical network process which were calculated by using the software super decisions software will be presented.

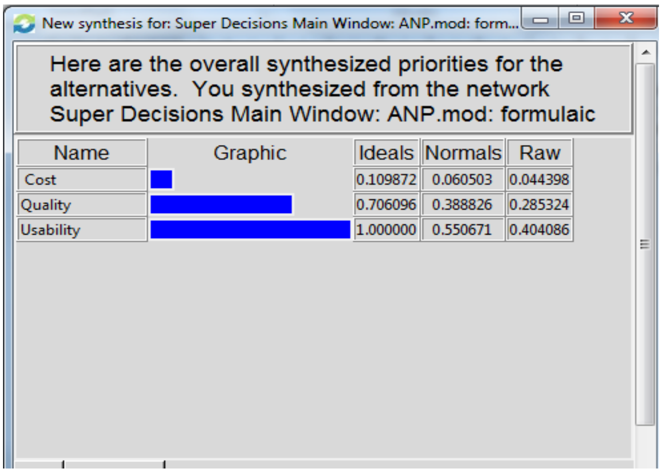
In following table a sample of the questionnaire of the SuperDecision software is shown, where the three clusters and 15 nodes were compared with each other with respect to influences on long-term-management.



Comparisons wrt "Cost" node in "Criteria" cluster
Cost efficiency is strongly to very strongly more important than Accuracy

Figure 5: ANP questionnaire

The rating of the alternative can be adapted from overall synthesized priorities which are presented in following figure. The preferences values are in three different modes such as ideal, normal and raw. The raw values are directly adapted from the super matrix, ideal values are the raw values multiplied by the cluster weight and the normal values are obtained by normalizing ideal values as to sum up to 1.



Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: ANP.mod: formulaic

Name	Graphic	Ideals	Normals	Raw
Cost		0.109872	0.060503	0.044398
Quality		0.706096	0.388826	0.285324
Usability		1.000000	0.550671	0.404086

Figure 6: Preferences of Alternatives

The preference with the highest importance for the experts is usability, whereas quality follows as second most important and the factor cost on third place. When comparing the results with the size of the company, it has to be noted that experts from large companies (>499 employees) assess the importance of costs in the long-term planning process lower than those experts working in mid-sized companies (>49 employees). In general, all experts see a very high importance of long-term demand planning in the near term as well as in the short term. The same applies for the short-term demand planning process. The average accuracy of current long-term demand plan is medium (5.5 on a scale from 1 to 8), implying that there is room for improvement.
The following requirements can be extracted from the questionnaire:

1. Integration into short-term and midterm demand management process, IT support, manageability, mathematical models and understandability are most important for the experts when referring to the aspect usability.
2. When referring to the preference 'quality': Information sharing with immediate suppliers and customer, integration into short-term and midterm demand management process, understandability.
3. When referring to the preference 'costs' the following requirements are of high relevance for the experts: usability, flexibility, information sharing with immediate suppliers, understandability and manageability.
4. Requirements such as expert knowledge, cost effectiveness, IT-support are less important compared to other requirements

The expert's requirements for a long-term demand plan are consistent throughout the three sectors energy, transportation and chemicals. Deviating patterns can only be found when comparing the outcomes to the size of the expert's company: A tendency for experts from smaller companies to evaluate costs higher than experts from large companies can be extracted.
In order to analyse the type of supply chain, the questionnaire included questions around the predictability of demand and the demand volume with regard to the current status as well as the future assessment as those factors are decisive to describe an agile, lean or leagile supply chain according to Vorderembse et al. (2006). The following findings need to be noted: 57% of the experts asses the predictability of demand for the next three years as difficult. 42% of the experts asses the predictability of the long term demand (>three years) as easy. 85% of the experts assessed the demand volume for the next three years as high. 42% of the experts assessed the demand volume on a long-term dimension as low. This leads to the following understanding:

- 42% of the supply chains are of the lean type
- 14% of the supply chains are of the agile type
- 28% of the supply chains are of the hybrid type

Interestingly enough, 42% of the supply chains undergo a change in demand volume in the long run. Hence almost half of the supply chains that were included in the study change their typology slightly, becoming hybrid in the light of changing environmental requirements.

CONCLUSION

The results of the study show that the strategic importance of the long-term demand process is firmly integrated into the companies mind set. Demand planning on a strategic basis is equally important to companies as for example short term demand optimization. Additionally, research showed that the most important factor for a long-term demand plan is its usability. The demand plan should be easy to understand and feasible to integrate into mid-term as well as short-term processes, especially when T support is given and mathematical models used for its compilation. Additionally, costs do not seem to play an important role when designing the long-term demand plan, which is opposing results of other studies e.g. Mentzer and Moon (2005). One reason for that may be that the ANP method requires the knowledge of experts, who obviously evaluate the importance of their work field especially high. Furthermore, this study interviewed experts coming from a disproportional high amount of large companies (86%). Mid-sized companies tend to value cost efficiency higher, hence implying that requirements towards long-term demand planning depend on company size. It was also shown that supply chain types change over time, hence also implying changes in requirements for long-term demand planning. A more detailled evaluation of differences in requirements beyond the highlighted increased cost emphasis should be subject to further research initiatives. In the end, demand planning on a long-term basis is of paramount importance as it influences a company's flexibility and adaptability to the changing world and thus enables sustained competitive advantage.

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BUSINESS CONTINUITY MANAGEMENT:
EXPERIENCES FROM THE 2011 THAI FLOODS

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ABSTRACT

Business continuity has now become a key management paradigm. The purpose of this paper is to explore the development of a continuity model that incorporates business continuity management and humanitarian logistics concepts. This proposed model will then be tested against continuity practices that occurred during the 2011 floods in thailand. Even though the literature on business continuity management is well developed, the case of floods affecting business continuity has been less researched due to its un-predictable nature and related to humanitarian logistics issues.

1. Introduction

The worst monsoon floods to hit Thailand in decades have crippled the country's international trade and national economy as rushing water prevented workers from reaching their offices, warehouses were flooded and factory production stalled. The latest Thai government estimates suggested as much as 1.5% could have been wiped off GDP growth for 2011 (NESDB, 2012) because of the floods, which have already killed almost 300 people and affected more than two-thirds of the country's provinces.

The water has cut off areas north of Bangkok, including a number of major industrial centres located near the former capital of Ayutthaya, and output has been brought to a halt. Toyota, Honda, Ford and Isuzu have suspended most or all of their car assembly operations in Thailand during that period. This suspension has international ramifications because of the country's role as a regional automotive hub.

Thailand is also estimated to supply around 60 percent of the world's hard-disk drives. SeaGate Technology and Western Digital Corp have been among a host of major electronics and semi-conductor makers to suffer and that output has fallen because of the floodwaters, either because locally sourced parts were not available or because factories had become inaccessible. Roughly 14,000 factories have been affected by the country's worst flood in 50 years.

However, according to the Journal of Commerce (2011), these types of disasters will not fundamentally change the design of existing supply chains as affected companies will focus more on contingency plans, supplier risk management and business continuity management for their operations.

The rationale behind this argument is based on the fact that the affected companies have chosen the production locations for economic reasons and that cannot easily be changed because of natural disasters. The affected firms will have to reflect on what has happened and their operating procedures.

The purpose of this manuscript is to develop a business continuity model (BCM) from the literature that takes into account humanitarian logistics practices with actual BCM operations during the flood crisis in Thailand. A local retailer was selected to reflect the context.

2. Literature Review

Business continuity has now become a key management paradigm. A number of business continuity models have been proposed in the literature (Gaddum, 2002; Herbanne et al, 2004; Low et al, 2010). Business continuity management mostly focuses on minimising the business effects of natural or man-made disruption. The framework for business continuity management (BCM) can be divided into different evolutionary stages with different operating protocols depending on business size, type of industry, location, and crisis severity. This would suggest that there is no single generic business continuity model as highlighted by Gaddum (2002). However, it was observed that most business continuity management models could be divided into 3 distinct stages or phases. This is illustrated in Table 1.

Table 1 Business Continuity Models

Stage	Component	Description	Source
Preparedness	Risk identification and Evaluation	Identifying the category and severity of potential risks towards the organization	)Gaddum, 2002; Gibb & Steven, 2006; Low, 2010)
	Business Impact Analysis	Identifying the effects that organization may encounter in case of crisis	
	BCM strategy Determination	Determining the strategy and resources applied in case of crisis, for instance, personnel, Information Technology, data system, constructions, location and supplier.	(Elliot, 2002; Gaddum, 2002; Gibb & Steven, 2006; Low, 2010; Vancoppenolle, 1999)
	Understanding and Training	Generating understanding of persons related to BCM Strategy and holding the required training based on the targeted plans.	()Business Continuity Institute, 2002; Castillo, 2004; Gibb & Steven, 2006; Herbane, Elliott, & Swartz, 2004)
	Monitoring	Catching up with updated data and appropriateness of BCM Strategy as planned for various situations.	(Gibb & Steven, 2006)
Implementation	Transfer risk	Transferring tasks to operational supporters in order to reduce risk	(Castillo, 2004)
	Coordination and Communication	Coordinating and communicating with related persons both inside and outside the organization	(Gibb & Steven, 2006; Herbane, Elliott, & Swartz, 2004)
Development	Review and Control	Review actual operation in comparison with targeted plan as well as outcomes of various operations	(Gibb & Steven, 2006)
	Development	Making the development and future plans based on under-crisis operational evaluation results.	(Gibb & Steven, 2006; Herbane, Elliott, & Swartz, 2004)

Source: The Authors

However, a literature of the BCM field is not sufficient to understand how firms would develop, implement and control business continuity. There are similarities between BCM and humanitarian logistics albeit on a different scale. It was therefore necessary to better understand the linkages between BCM and humanitarian logistics.

The purpose of humanitarian logistics is to be able to provide aid to affected areas and there exist humanitarian logistics deployment models which could also be of reference to BMC model development. Traditionally humanitarian logistics can be divided into 3 different stages, namely *the pre-crisis stage*, which requires well-organised preparation in terms of assistance, public utility, and cooperation for potential crisis; *the under-crisis stage*, which requires the most urgent assistance to the sufferers; and *post-crisis stage*, which requires the review of past crisis, the planned corrective actions, and the future operational plan in case of crisis reoccurrence. Table 2 provides a description of the main humanitarian logistics models.

Table 2 Humanitarian Logistics Models

Stage	**Component**	**Description**	**Source**
Preparedness (**Pre-crisis stage)**	Existing problems analysis	Analysing the cause of effects to sufferers, for instance, vehicles, routes, donation and assistance distribution; including various required systems.	(Kovács, 2007; Hwang, 1999; de Silva, 2001)
	Planning of inter-cooperation among various divisions	Making the co-operational plans among related divisions in charge of providing the assistance to the sufferers in terms of responsibilities and relevant system	(Kaatrud, 2003; Tomasini, 2004)
	Evaluation Plan	Making the evaluation plan before disaster happens	(Barbarosoglu, 2002; Kovács, 2007; Hwang, 1999)
		Preparing the essential resources such as doctor, medicine, food, drinking water, and temporary shelter	(Dignan, 2005; Murray, 2005)
	Information System	Managing information for the sufferer in need	(Long, 1997)
		Managing goods procurement to assist sufferers systematically and promptly	(DeJohn, 2005; de Silva, 2001)
Immediate Response (Under-crisis stage)	Response of Demand	Managing the assistance in terms of time, location, and the required quantity of commodity	(Beamon, 2004; Murray, 2005; Long, 1997)
	Supply Management	Checking the quality and safety of supplies donated to the sufferers	(Chomolier, 2003; Murray, 2005)
	Transportation Management	Managing the commodity delivery to the sufferers in terms of vehicle, fuel, route, and transporter	(Garry, 2005; Leonard, 2005; Sullivan, 2005)
		Packing the food and necessary commodity by using preventive and convenient packages for the sufferers	(Long & Wood, 1995)
Reconstruction (Post-Crisis Stage)	Past Crisis Review	Analysing the cause and problem of operation arising during the crisis period	(Thomas, 2003)
	Future Plan Determination	Making the operational future plan by considering the past crisis	(Thomas, 2003)

Source: The Authors

It was interesting to note that there exist many similarities between the existing BCM and humanitarian logistics models and a combination of both fields could provide a more comprehensive framework when dealing with disruptions. Table 3 highlights common areas between BCM and humanitarian as well as identify components specific to each field.

These differences occur because of the difference in application scope. BCM will focus on how firms will be able to maintain their business activities in time of crisis while humanitarian emphasise a more macro-picture of the situation.

Table 3: Combining BCM & Humanitarian logistics models

Stage	**Component**	**Description**	
Preparedness	Identification and analysis of potential risks	Identifying and analysing the potential risk format and severity of the event that may affect personnel and organization	Business Continuity Model
	Impact Analysis	Identifying the potential effects in case of crisis in terms of operation, personnel, and property	Business Continuity Model and Humanitarian Logistics Model
	Determining strategy	Determining required strategies and resources in case of crisis, for instance, documents and equipment removal before crisis occurrence, under-crisis operation, and restoration	Business Continuity Model and Humanitarian Logistics Model
	Planning of inter-cooperation between related divisions and personnel	Making plans between related divisions both inside and outside the organization to mutually take systematic actions	Humanitarian Logistics Model
	Understanding and Training	Making good understanding of related persons both inside and outside the organization with regard to various strategies and holding the training and rehearsal for consistent understanding	Business Continuity Model
	Monitoring	Updating the information and strategy suitable for changing situations	Business Continuity Model
Implementation	Analysis and evaluation of customers' demand	Analysing requirement of customers for place and time of delivery that may vary	Humanitarian Logistics Model
	Transfer risk	Transferring tasks to operational supporter in order to reduce the risk	Business Continuity Model
	Coordination and Communication	Coordinating and communicating with related persons both inside and outside the organization	Business Continuity Model
Development	Review and	Searching for existing problems	Business

	Control	causes in the operation and comparing the actual operation with the targeted plan as well as various operation results	Continuity Model and Humanitarian Logistics Model
	Development	Making the development and future plans based on under-crisis operational evaluation results.	Business Continuity Model and Humanitarian Logistics Model

Source: The Authors

3. Methodology

This study is exploratory and based on a single company case study. The purpose of the case study is to try to understand the actions of the flood affected firm in implementing their BCM. Yin (1994) suggested the following framework for case study research, the basis of which is a matter of knowledge acquisition and accumulation through the observation of real events. The key question was on how the local retailer was able to implement its BCM strategy during the 2011 flood crisis. This retailer has a national network with over 6,000 stores around the country.

4. Findings

The BCM model utilized by the observed modern trade retailer does follow the generic framework of: Preparedness; Implementation and Development. Hereunder, are the details for each BCM stages:

4.1 Preparedness

This modern trade retailer has given considerable thoughts to risk management approaches in order to secure their business continuity. These assessed risks were not just based on natural or man-made disruption but also on their location. The respondent basically used the traditional quantitative analysis to measure the level of risk exposure (R) from the calculation of two dimensions: risk probability (P) and impact of risk (I); by using an equation of $R = P \times I$ (Waters, 2007). This approach enabled the retailer to have an initial grasp of the risk issues at stake that will impact their business continuity. According to the retailer, three main risk dimensions are considered in their BCM model. These dimensions are: Natural Disasters, Riots and Economic Crisis. It is interesting to note that natural disasters and riots share the same level of impact while the economic crisis has the highest level of impact. It is possible that because of the events that has occurred in Thailand, over the 5 past years, riots and natural disasters have a not so dissimilar impact on the business of this retailer. However, the economic crisis is still considered the highest risk dimension even though probably almost impossible to mitigate. However, the 2011 floods level represented a new challenges as the retailer's traditional flood related BCM model focused only on certain locations that were usually affected by floods on a yearly basis. This meant that for flood risk, the retailer had a "single impact" BCM model. This meant that the flood impact was usually limited to one store in a particular location. The "single impact" BCM could not handle the 2011 floods due to its higher level of impact, not just on the retailer's stores but also on its suppliers and network access. The retailer had to redefine its flood BCM to respond to "multiple impact". This was done through the development of a 3 dimension preparedness plan that focused store, supply and staff management as described in table 4 hereunder. Each dimension had their respective BCM sub-plans aligned with the overall preparedness plan of the retailer.

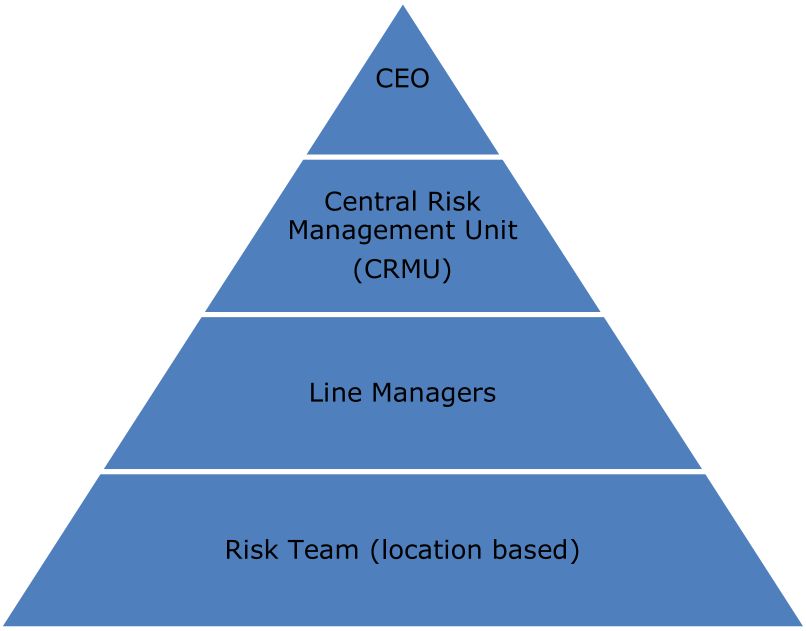
Table 4: Preparedness sub-plans

Store Management	**Supply Management**	**Staff Management**
• Facility Management	• Basic Necessities ○ Dry Foodstuff ○ Temperature controlled items	• Drivers • Warehouse operatives • Cashiers • Suppliers' staff

Source: The Authors

The management of the retailer also established a central risk management unit that included all the related business functions. This was done to improve internal communication and coordination in time of crisis for its nationwide network. Figure 1 illustrates the given structure on how risk is managed in the firm.

Figure 1: Risk management structure



Source: The Authors

The Central Risk Management Unit (CRMU) also has the duty to coordinate with related local and national agencies as well as key suppliers. As an example, fuel delivery to distribution centres will need to be done within a 30 minute window, in case of emergencies, from neighbouring fuel stations. Yearly drills are conducted to validate the said fuel supply agreement.

4.2 Implementation

The 2011 Thai floods created havoc on the retailer's supply chain, not only because it was the worse situation in 50 years but also because of consumers' panic. This consumers' panic created a massive "bullwhip effect" that increased demand to more than 10 times the actual demand. Suppliers could not keep up with the surge in demand as they did not have the necessary contingency plans in place. The impact of the floods can be understood based on 3 key performance dimensions

- *Inventory Level:* The retailer found itself in a stock-out situation due to the surge in demand and the reduced delivery capability of the retailer's suppliers.
- *On-Time Delivery:* During normal time, the actual on-time delivery was assessed at 95% but during the flood crisis this KPI was reduced to 85%.
- *On-shelf product mix availability:* Challenging as product mix requirement varied depending on the flooding stages from before the flood, during the flood and after the flood.

In order to maintain business continuity, the retailer had to work in an even higher level of collaboration with its logistics service providers. The CRMU has had to manage its daily operational plan in coordination with local and national agencies with the support of its logistics service provider. Information was updated on a real time basis.

4.3 Development

After the flood water has receded, the retailer discovered that over 830 stores were damaged from a total of 6,500 stores. Luckily, because of its "single impact" BCM each individual stores were able to initiate their own recovery procedures. This enabled the 830 stores to return relatively rapidly into the retailer's national network.

The assessment of the retailer's existing BCM showed that even though the retailer had a clearly defined BCM model, the impact of the floods was a lot higher than expected. Resources were therefore not sufficient to mitigate, support relief and accelerate recovery of the retailer's national store network. Table 5 provides further insights on the implementation level for each BCM components.

Table 5: BCM implementation level

Stage	Component	Implementation	Implementation level		
			High	Medium	Low
Preparedness	Identification and Analysis of potential risks	✓	✓		
	Impact Analysis	✓			✓
	Determining strategy	✓		✓	
	Planning of inter-cooperation between related divisions and personnel	✓	✓		
	Understanding and Training	✓	✓		
	Monitoring	✓		✓	
Implementation	Analysis and evaluation of customers' demand	✓			✓
	Transfer risk	✓		✓	
	Coordination and Communication	✓		✓	
Development	Review and Control	✓	✓		
	Development	✓	✓		

Source: The Authors

It was observed that the weakest level in terms of BCM implementation were the impact analysis and the analysis of customers' demand. This directly affected the capability of the retailer's BCM model as the overall performance was dependent upon its weakest level. This observation is consistent with general supply chain theory where the overall performance of the supply chain is dependent upon its weakest link.

5. Summary

After the floods, the Thai Government took the initiative to establish a strategic committee for water resources management (SCWRM) but currently the guidelines for flood prevention are still fuzzy. This will requires companies to even focus more on the BCM models in order to mitigate any risk that may arise from new floods in the coming years in Thailand.

Since the retailer does not know how the national flood prevention plan is going to be implemented it will have to rely on its BCM model. A combination of "single impact" and "multiple impacts" plans will have to be developed based on the lessons learned from the 2011 flood crisis.

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BASES OF SUPPLIER SEGMENTATION: PERSPESCTIVES FROM SMALL-MEDIUM SIZED ASIAN GROCERY RETAILERS IN MELBOURNE

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1. INTRODUCTION

In marketing, segmentation is a common means of dividing customers into homogeneous groups for purposes of understanding and servicing the needs of different customer segments. Though less well developed in supply management, segmentation has also been used by large buyers to segregate the heterogeneity of their supply bases into categories with the aim of managing their relationships with different suppliers strategically. A considerable number of supplier segmentation bases have been employed in extant supply management literature to develop directional models, offering prescriptive insights into the strategic planning of supply management activities. The majority of these bases, however, are predetermined, based on either a logic for classification or the tenets of some well-developed theories, e.g., transaction cost economics and resource based view. Very little attempt has been made to explore factors underpinning the adoption of different segmentation criteria based on empirical data.

This study investigates factors contributing to supplier segmentation in supply management. Rather than focusing on large buyers, which has been the preoccupation of supply management research, this study explores supplier segmentation bases from the small retailers' perspective. Specifically, it examines how small-and-medium Asian grocery retailers (SMAGRs) in Melbourne segment their suppliers, identifying the bases they use and the reasons they choose to adopt those bases.

2. LITERATURE REVIEW

Supplier segmentation has been extensively studied in the last two decades (see for example Dyer et al., 1998; Kaufman et al., 2000; Caniëls & Gelderman, 2007), albeit some still regard it "to be in the early stage of providing a coherent strategic intent behind supplier assessment" (Day et al., 2010, p. 625). The needs for supplier segmentation are many. Cost saving is a major driver, since matching purchasing needs to appropriate suppliers, controlling relationships, stimulating completion can help reduce procurement cost (Cunningham, 1983). Limitation in resources is another. Consequently, a firm must allocate its scarce resources to managing those supplier relationships which generate the highest returns (Choi & Krause, 2006). Risk management and avoidance of supplier opportunism is another reason for supplier segmentation (Kraljic, 1983; Stump & Heide, 1996), although the assumption that the relationship between buyer and supplier is built on power and dependency (Dubois and Pedersen, 2002) is regarded as partial (Day et al., 2010). A relatively less investigated motive for supplier classification is value generation through strategic outsourcing. Segmentation enables a firm to leverage its supply management capabilities to exploit strategic opportunities for creating value with suppliers and to form strategic alliance for long-term benefits (Turnbull, 1990; Bensaou, 1999; Sausen et al., 2005).

Day et al. (2010) conducted a thorough review and taxonomy on supplier segmentation and concluded that most of the classifications of suppliers were based on portfolio modelling focusing on the constructs of power and dependence and certain buyer-supplier relational factors. Most of the studies reviewed used a classification schema of two or four categories to form a portfolio of relationship types. Their analysis reveals that the prevalent theory on supplier classification is transaction cost economics (TCE), which provides a foundation for firms to appraise risks arising from supplier opportunism. TCE specifies the conditions under which a firm should manage an economic exchange internally or externally, i.e., through inter-organizational arrangement. It focuses on minimizing the total transaction costs of producing and distributing a particular good or service. These costs are determined by limited rationality, opportunistic behaviour, frequency, uncertainty, and asset specificity involved in the transactions (Williamson, 1975, 1985, 1996). The first two elements are assumptions that underpin the choice of a firm between insourcing and outsourcing. The last three elements are factors or variables that characterize any transaction and affect the transaction cost. In supplier segmentation, TCE helps explain a firm's need to categorize suppliers to minimize the cost of relationship governance and the threat of opportunism (Choi & Krause, 2006). Other management theories such as resource dependency theory, inter-organizational theory, resource-based view, industrial networks and industry analysis have also been applied to account for supplier segmentation. Table 1 categorizes these studies based on the research design and the predominant theoretical basis reviewed by Day et al. (2010).

Table 1: Research design and theoretical basis of selected supplier segmentation studies

	Predominant Theoretical Basis				
Research Design	**Transaction Cost Economics**	**Resource Dependency Theory**	**Inter-Organisational Theory / Resource-Based view**	**Industrial Networks / Industrial Analysis**	**No theoretical basis disclosed**
Survey questionnaire	Dyer et al. (1998); Bensaou (1999); Kaufman et al. (2000); Hallikas et al. (2005); Caniëls & Gelderman (2007)	Caniëls & Gelderman (2007)	Bensaou (1999)	Svensson et al. (2004); Caniëls & Gelderman (2007)	
Case study	Moeller et al. (2000); Nellore & Söderquist (2000); Cox et al. (2002)	Cox et al. (2002)	Moeller et al. (2000); Cox et al. (2000)	Moeller et al. (2000); Cox et al. (2000)	
Secondary data	Tang (1999)	Olsen & Ellram (1997)	Olsen & Ellram (1997)	Tang (1999); Olsen & Ellram (1997)	
No empirical basis disclosed					Karljic (1983); Hadeler & Evans (1994); Steele & Court (1996); Van Weele (2005)

Source: Adapted from Day et al. (2010)

Various segmentation bases have been used in previous studies in classifying suppliers. The segmentation base can focus on the supplier or the product. For the former, an example will be Kaufman et al. (2000) in which two dimensions: (A) technology and (B) collaboration were employed to divide suppliers into four distinct groups: commodity supplier (low A, low B), collaboration specialist (low A, high B), problem-solving supplier (high A, high B), and technology specialist (high A, low B). For the latter, an example will be Tan (1999) who used two key factors: (A) strategic importance of the part to the buyer and (B) buyer's bargaining power to determine supplier relationship. Tan (1999) developed a supplier relationship map in which suppliers are divided into four types: partner (high A, low B), preferred supplier (high A, high B), vendor (low A, high B), and exclusive supplier (low A, low B). Similarly, Svensson (2004) used a dyadic approach and two dimensions: (A) the supplier's commitment to the buyer and (B) the commodity's importance to the buyer to segment the suppliers of a vehicle manufacturer. He developed a generic model of supplier segmentation in which supplier relationships are divided into four types: family (high A, high B), friendly (high A, low B), business partner (low A, high B), and transactional (low A, low B). Once the suppliers are segmented, appropriate strategies and resources can then be assigned to the different supplier categories to develop and manage the relationships with each to meet the needs of the firm.

To segment the suppliers, both qualitative methods, such as case study, and quantitative methods, such as questionnaire survey, have been employed. For the latter, variables are used to represent the dimensions in the segmentation base. Data are then collected through questionnaire survey. Various statistical techniques are then used to aid the classification. For example, Kaufman et al. (2000) used 22 and 26 candidate variables to represent the technology and the collaboration dimensions respectively in the segmentation. They applied correlation analysis, contingency table analysis (cross-tabulation), and analysis of variance (ANOVA) to classify the suppliers into four distinct groups. Factor analysis was also used to assess the presence of latent constructs in the measured variables. Similarly, Svensson (2004) used 18 items to measure the two dimensions used in the segmentation. Both parametric tests, such as Pearson correlation coefficient and paired samples t-test, and non-parametric tests, such as Kendall rank correlation coefficient, Spearman rank correlation coefficient, Sign test, and Wilcoxon matched pairs signed rank test, were applied to aid the classification. More sophisticated tools such as K-means type subspace clustering (Zhang et al., 2006) and S-canopy clustering algorithm (Irfan et al., 2009) have also been applied in supplier categorization.

Despite the abundant research on supplier segmentation and supplier relationship management, most of the studies have focused on large buyers with strong bargaining power (see for example Kaufman et al., 2000; Svensson, 2004). Little attempt has been made to investigate how small and medium-sized buyers segment their suppliers and manage their supplier relationships, which can differ markedly from that of large buyers and the Kraljic’s (1983) portfolio modelling they used. Such a gap needs to be filled to complete the extant literature on supplier segmentation.

3. METHODOLOGY

3.1. Study Methodology

Our objective was to explore how small retailers classify their suppliers in the context of Asian grocery retailing in a western society. Because we were investigating a relatively less well-documented area, we adopted a multiple case study approach (Eisenhardt, 1989; McCutcheon and Meridith, 1993; Yin, 1994), selecting 14 SMAGRs in Melbourne as our cases.

3.2. Case Selection and Data Collection

The 14 SMAGRs in two Asian-dominant suburbs in Melbourne were selected using a theoretical sampling frame to encompass differences in business size (by physical size of shops), location (whether in wet market or in Asian shopping strip of suburb centre), and variety of groceries offered (by range of groceries displayed). Data collection involved several rounds of on-site semi-structured interviews in each case. Unobtrusive observations were also conducted on numerous occasions at each of the case retailers to obtain graphic insights on some of the information provided and to facilitate data triangulation.

3.3. Data Analysis

Data analysis began with a within case analysis of the 14 SMAGRs focusing on the approaches each used to segment their suppliers. This was then followed by a cross-case comparison in which the supplier segmentation approaches employed by each SMAGR were linked to their characteristics: location (i.e., inside a wet market or on an Asian shopping strip), predominant retail strategy (i.e., low price, fast-turnover goods, or product availability), and size (i.e., physical lot size in relation to one another).

4. FINDINGS

The within case analysis revealed six supplier segmentation schema: supplier responsiveness, saleability of goods supplied, variety of brands offered, strength of established relationship, trading term flexibility, and price competitiveness. The six schema reflected six specific attributes of suppliers considered to be of value to the SMAGRs. The results of the cross-case comparison show that the choice of schema is associated with the characteristics of the SMAGRs, including the manner in which the business was established, the size and location of the business, and the strategic retail focus.

Table 2 shows the supplier segmentation schema adopted by the 14 case SMAGRs in relation to their location and strategic retail focus, while Table 3 displays these segmentation schema with respect to the size and strategic retail focus of the 14 SMAGRs.

Table 2: Classification of suppliers based on SMAGR's location and strategic retail focus

LOCATION			
Wet Market	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship. **SMAGR3** Strength of established relationship. **SMAGR10** - Price competitiveness - Brands (popular) Saleability of goods supplied	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship **SMAGR3** Strength of established relationship **SMAGR10** - Price competitiveness - Brands (popular) - Saleability of goods supplied	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship. **SMAGR10** - Price competitiveness - Brands (popular) - Saleability of goods supplied
Asian Shopping Strip	**SMAGR4** - Brands (popular and new brands). - Price competitiveness. - Flexibility in payment terms **SMAGR7** - Price competitiveness. - Saleability of goods supplied. **SMAGR9** - Price competitiveness. - Saleability of goods supplied. **SMAGR12** - Brands (popular). - Price competitiveness. - Flexibility in payment terms	**SMAGR4** - Brands (popular and new brands) - Price competitiveness. - Flexibility in payment terms **SMAGR5** - Price competitiveness. - Saleability of goods supplied **SMAGR6** - Flexibility of payment terms - Price competitiveness. - Saleability of goods supplied. **SMAGR11** - Price competitiveness. - Saleability of goods supplied. **SMAGR12** - Brands (popular). - Price competitiveness. - Flexibility in payment terms **SMAGR13** - Price competitiveness. - Saleability of goods supplied. **SMAGR14** - Price competitiveness. - Brands (popular and new brands) - Saleability of goods supplied	**SMAGR4** - Brands (popular and new brands). - Price competitiveness. - Flexibility in payment terms **SMAGR8** - Supplier responsiveness. - Price competitiveness. **SMAGR12** - Brands (popular). - Price competitiveness. - Flexibility in payment terms **SMAGR14** - Price competitiveness. - Brands (popular and new brands) - Saleability of goods supplied
	Low cost	Fast turn-over	Availability

Strategic Retail Focus

Table 3: Classification of suppliers based on SMAGR's size and strategic retail focus

SIZE			
Large	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship. **SMAGR3** Strength of established relationship.	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship. **SMAGR3** Strength of established relationship. **SMAGR10** - Price competitiveness - Brands (popular) Saleability of goods supplied	**SMAGR1** - Price competitiveness - Brands (exclusive/ nonexclusive) - Saleability of goods supplied **SMAGR2** Strength of established relationship. **SMAGR10** - Price competitiveness - Brands (popular) - Saleability of goods supplied.
Medium	**SMAGR4** - Brands (popular and new brands). - Price competitiveness. - Flexibility in payment terms. **SMAGR12** - Brands (popular). - Price competitiveness. Flexibility in payment terms	**SMAGR4** - Brands (popular and new brands). - Price competitiveness. - Flexibility in payment terms. **SMAGR5** - Price competitiveness. - Saleability of goods supplied. **SMAGR12** - Brands (popular). - Price competitiveness. - Flexibility in payment terms **SMAGR14** - Price competitiveness. - Brands (popular and new brands) Saleability of goods supplied	**SMAGR4** - Brands (popular and new brands). - Price competitiveness. - Flexibility in payment terms. **SMAGR12** - Brands (popular). - Price competitiveness. - Flexibility in payment terms **SMAGR14** - Price competitiveness. - Brands (popular and new brands) Saleability of goods supplied
Small to Very Small	**SMAGR7** - Price competitiveness. - Saleability of goods supplied. **SMAGR9** - Price competitiveness. Saleability of goods supplied.	**SMAGR6** - Flexibility of payment terms. - Price competitiveness. - Saleability of goods supplied. **SMAGR11** - Price competitiveness. - Saleability of goods supplied. **SMAGR13** - Price competitiveness. - Saleability of goods supplied.	**SMAGR8** - Supplier responsiveness - Price competitiveness
Strategic Retail Focus	Low cost	Fast turn-over	Availability

5. DISCUSSION AND CONCLUSION

Among the six supplier attributes, the first three deal more with short-term gains whereas the last three long-term benefits. The former group can also be regarded as tangible value whereas the latter intangible one. To facilitate analysis, Tables 2 and 3 are presented numerically as Tables 4 and 5 to show the counts of the various supplier attributes in each category.

Table 4: Counts of supplier attributes based on SMAGR location and strategic retail focus

	STRATEGIC RETAIL FOCUS	Low Cost	Fast Turnover	Availability	TOTAL*
LOCATION	Attribute of Supplier				
Wet Market	(1) price competitiveness	2	2	2	**6**
	(2) variety of brands offered	2	2	2	**6**
	(3) saleability of goods supplied	2	2	2	**6**
	(4) strength of established relationship	2	2	1	5
	(5) trading term flexibility	0	0	0	0
	(6) supplier responsiveness	0	0	0	0
Asian Shopping	(1) price competitiveness	4	7	4	**15**
	(2) variety of brands offered	2	3	3	**8**

Strip	(3) saleability of goods supplied (4) strength of established relationship (5) trading term flexibility (6) supplier responsiveness	2 0 2 0	5 0 3 0	1 0 2 0	**8** 0 7 0
TOTAL*	(1) price competitiveness (2) variety of brands offered (3) saleability of goods supplied (4) strength of established relationship (5) trading term flexibility (6) supplier responsiveness	**6** **4** **4** 2 2 0	**9** **5** **7** 2 3 0	**6** **5** **3** 1 2 0	

* Figures in bold represent supplier attributes that may lead to short-term gains.

Table 4 clearly reveals that SMAGRs operating in wet market are emphasizing equally on all the three attributes leading to short-term gains. This is understandable as these SMAGRS are mainly vegetable, fish, poultry and meat vendors. Their products are mostly perishable items that cannot be stocked for long period. While prices have to be attractive to customers due to keen competition, the variety of products available and their saleability are also important because of the short shelf lives of these products. It is interesting to note that strength of supplier relationship – an attribute leading to long-term benefit - is also considered important to these SMAGRs. This can be explained by the fact that for quality and perhaps food safety reasons, these SMAGRs might have to source regularly from a few trustworthy and reliable suppliers with whom they have been doing business for a long time. As such, good supplier relationship is considered essential to the continuing success of their business.

In comparison, SMAGRs operating in Asian shopping strip appear to be focusing mainly on short-term gains. They weight heavily on price competitiveness when selecting their suppliers which is the main consideration. Then, they emphasize equally on variety of brands offered and saleability of goods supplied which is the second major concern. They also seek flexibility on payments terms from their suppliers which helps improve short-term cash flow. In contrast, long-term supplier relationship is not essential from their perspective. This is again understandable as these SMAGRs are mostly grocery shops or vendors of household items in the shopping strip. Most of their products are dry goods which have much longer shelf lives. But the product variety is a lot larger than that of their wet market counterparts. Due to limited shop space and operating capital, these SMAGRs cannot stock much and therefore a fast turnover is necessary. Theses business characteristics can account for the prevailing emphasis of these SMAGRs on obtaining short-term gains than long-term benefits from their suppliers.

From a strategic retail focus perspective, regardless of the location of the SMAGRs and their business strategies, the findings show that all the surveyed SMAGRs are emphasizing on short-term benefits as far as selection of suppliers is concerned. The observation is particularly clear with those SMAGRs focusing on fast turnover. Apparently, maintaining cash flow appears to be a major challenge for the SMAGRs in selecting products and their suppliers. This may, to a certain degree, reflect the fierce competition in the trade, hence the pragmatic attitude of the small buyers under surveyed.

Table 5: Counts of supplier attributes based on SMAGR size and strategic retail focus

	STRATEGIC RETAIL FOCUS	Low Cost	Fast Turnover	Availability	TOTAL*
SIZE	Attribute of Supplier				
Large	(1) price competitiveness	1	2	2	**5**
	(2) variety of brands offered	1	2	2	**5**
	(3) saleability of goods supplied	1	2	2	**5**
	(4) strength of established relationship	2	2	1	5
	(5) trading term flexibility	0	0	0	0
	(6) supplier responsiveness	0	0	0	0
Medium	(1) price competitiveness	1	4	3	**8**
	(2) variety of brands offered	2	3	3	**8**
	(3) saleability of goods supplied	0	2	1	**3**
	(4) strength of established relationship	0	0	0	0
	(5) trading term flexibility	2	2	2	6
	(6) supplier responsiveness	0	0	0	0
Small to Very Small	(1) price competitiveness	2	3	1	**6**
	(2) variety of brands offered	0	0	0	**0**
	(3) saleability of goods supplied	2	3	0	**5**
	(4) strength of established relationship	0	0	0	0
	(5) trading term flexibility	0	1	0	1
	(6) supplier responsiveness	0	0	1	1
TOTAL*	(1) price competitiveness	**4**	**9**	**6**	
	(2) variety of brands offered	**3**	**5**	**5**	
	(3) saleability of goods supplied	**5**	**7**	**3**	
	(4) strength of established relationship	2	2	1	
	(5) trading term flexibility	2	3	2	
	(6) supplier responsiveness	0	0	0	

* Figures in bold represent supplier attributes that may lead to short-term gains.

When classified on the basis of the physical size and strategic retail focus, Table 5 reveals that large SMAGRs are placing equal emphasis on short-term as well as long-terms gains when selecting their suppliers. For medium-sized SMAGRs, the emphasis starts to shift more to short-term gains, whereas for small to very small SMAGRs the weight is placed almost entirely on price competitiveness and saleability of good supplied. This suggests that SMAGRs tended to select suppliers based on their operating size, which reflected available capitals. With a relatively lesser pressure on cash flow, large SMAGRs might be able to afford the resources for developing supplier relationships that may add value to the business and help them achieve a sustainable competitive advantage in the long run. In contrast, small to very small SMAGRs are usually operating with limited cash flow and therefore survival is the first priority. As such, their focus was on short-term gains which rely heavily upon price competitiveness and saleability of goods. The small operating capital of these small to very small SMAGRs might also have limited the product range available in their shops hence their lack of emphasis on variety of brands offered by the suppliers. The medium-sized SMAGRs are clearly in the middle range of the spectrum, striking a balance between tangible and intangible gains for their business. The pressure on fast turnover appears to be lesser than that of small to very small SMAGRs. Therefore, their supplier criteria were based more on price competitiveness and range of products available to customers, instead of saleability of goods supplied.

Again from a strategic retail focus perspective, regardless of the size of the SMAGRs and their business strategies, the findings show that all the case SMAGRs appeared to place greater emphasis on short-term gains, rather than long term benefits.

6. LIMITATIONS AND FUTURE STUDY

As with all case studies, this research has its limitations in several areas. The most notable of all is the generalizability of its findings. Being confined to the Asian grocery sectors in Melbourne, the applicability of its findings needs to be tested in other retail sectors and other locations. Research into the supplier segmentation approaches employed by small retailers in sectors like clothing, fashion goods, electronics and electrical appliances would be fruitful avenues for further investigation.

While supplier segmentation is considered the antecedents to developing appropriate supplier relationship management strategies, this study has not explored how the adoption of different supplier segmentation schema is linked to supplier relationship management strategies. This is an obvious extension, which will add value to the findings of the present study.

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AUSTRALIA-CHINA-UK WOOL SUPPLY CHAIN: A STUDY OF SUPPLY CHAIN MANAGEMENT ISSUES

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INTRODUCTION

Australia is the largest producer of wool, producing 21.5% of the world's greasy wool in 2008 (AWI, 2011). In 2010/2011, wool production was forecasted to be 350 million kilograms of greasy wool from 75 million sheep horn. This compares to 73 million sheep horn in Australia, producing 340 million kilograms of greasy wool in 2009/2010.

During the 1980s and 1990s, the Wool Research and Development Council provided millions of dollars of funding for a range of activities primarily focused on farm production research and textile research (e.g. Mullen *et al.*, 1989). Due to lower wool prices during the 1990s, some researchers questioned why Australian wool growers produced wool. In this respect, Quaddis *et al.* (2006) investigated the factors that drive and motivate the Western Australian wool producers. They found that income, input factor and personal motivation are significant predictors of wool production by Western Australian producers.

The traditional markets for Australian wool have been the UK/European markets where a substantial amount of the downstream processing was carried out. However, over the past two decades, China has become a dominant player in the world in terms of both primary processing of greasy wool and a producer of wool apparel subsequently exported to other countries, including the UK. China currently accounts for between 75% and 80% of greasy wool exports from Australia.

Although apparel and textile supply chains have received significant attention over recent years, there has been limited research on the supply of natural fibres and in particular the Australian wool supply chain. This paper contributes to this field by examining supply chain management issues in the Australia-China-UK wool supply chain. Our aim in this research is to identify the key factors that may contribute to the successful integration of the Australia-China-UK apparel wool supply chain. Specifically, our research questions are:

- *What is the current structure of the Australia-China-UK apparel wool chain?*
- *What are the major supply chain management issues in the Australia-China-UK apparel wool chain?*
- *How are the major stakeholders addressing these issues?*

The remainder of the paper is structured with first providing a review of literature. Next a methodology section, followed by results including the use of a rich picture. The paper discusses the findings before concluding with the limitations of the paper and a future research agenda.

LITERATURE REVIEW

Apparel and textile supply chains have received increased attention from academic researchers (see Lowson, 1999; Christopher et al., 2004; Bruce et al., 2004; Chaudhry, and Hodge, 2012), mainly due to the view that they have become increasingly complex and dynamic. Brun and Castelli (2008) consider that the high level of demand volatility, the dramatic shift in the scale and power of major retail buyers in the market, the advent of own brands retail networks, the nature of sourcing and supply chain decisions, which are increasingly global in nature, are just some of the factors that have contributed to their complexity and dynamism and have attracted the attention of the academic world.

As a result of fashion trends changing at a faster pace, long high volume production runs are not required anymore and the focus for responding to consumer demand must be through lead-time reduction (Christopher et al., 2004). In search of flexibility and responsiveness to changing consumer demand, shorter runs are becoming more frequent (Barnes and Lea- Greenwood, 2006).

As such, retailers' success in the market place depends on their ability to identify and monitor demand on a real time basis but also on their ability to adapt to changes in demand and promptly dispatch the right product to the point of sale. Identifying the market needs ('getting the product right') is essential, but in order to achieve a high speed to market, a supply chain able to deliver the product in a timely manner is also required ('getting the response time right'). Supply chain strategies employed within the textile and apparel industry include just in time, quick response and accurate response (Chandra and Kumar, 2000). Bhamra et al., (1998) recommended that the UK industry needed to focus on flexible delivery, reduced stock levels and increased net margins.

In this study our focus is on the supply of textiles and in particular the supply of wool. Textile supply chains have been described as complex and often relatively long (Jones, 2002) with a need to reduce lead times and achieve quick response (Bruce et al., 2004). Products are increasingly sourced globally, but there is still a need for local suppliers (Bruce et al., 2004).

A review of the literature found that very few studies have explored or tracked the wool supply chain. Champion and Ferne (2001), examined communication issues in the apparel wool supply chain with a particular emphasis on the link between wool growers in the state of Tasmania and their downstream wool processors (spinners and weavers) based in Germany and Italy. The primary focus of this study was on communication relating to issues of raw wool quality, especially contamination. They found "while there appears to be an emerging recognition by various members of the apparel wool textile chain of the need for, and power of, improved communication, significant barriers including the presence of 'functional silos' continue to exist." (Champion and Ferne, 2001, p. 254).

Misra and Choudhary (2010) report on the supply chain opportunities and challenges within the Indian rug industry for which wool is a key component. They found some of the issues facing the sector are sporadic market demand, poor planning of resources in weaving and wool production, and the lack of education with many weavers and wool produces leaving the industry. Their case study research investigates the use of information and communication technologies as one way to improve the performance of the rug industry. The results indicate that ICT mediation was successful in engaging customers via the intranet. However, it was less successful in integrating the weavers and producers in the supply chain.

METHODOLOGY

We take an exploratory, inductive approach to this research. Inductive research refers to the actions leading to the development of a hypothesis or set of propositions that can be tested within a specific context (Strauss, 2004). Face to face and telephone interviews were conducted with seven key informants:

- Two executives from Australian Wool Innovation,

- Two executives representing the Australian Council of Wool Exporters and Processors, the Federation of Australian Wool Organisations and the Private Treaty Wool Merchants of Australia.
- The CEO of a Chinese based manufacturer primarily involved in yarn spinning.
- An executive based in the UK from a International wool consolidator
- Owners-managers of a UK based weaver/manufacturer

These interviews lasted from 30 minutes to two hours and where possible were recorded with the permission of the interviewees. A thematic analysis was conducted using the qualitative interview data and identified issues relating to logistics and supply chain management as well as other significant changes that had occurred. This analysis enabled the structure of the supply chain to be developed and key themes to be identified. These themes were then mapped onto a rich picture visualisation.

This rich picture model focuses on the major issues related to the planning and control of the supply chain and its associated operational logistics. It is not meant to be comprehensive, but presents the eight critical 'hot spots' identified by our supply chain diagnostics and interviews.

RESULTS

Australian Wool Supply Network

The wool supply network within Australia has changed significantly over the past few decades. Wool was the predominant source of income on many farming properties until the mining boom in the 1960's. The rise of the minerals industry in the 1960s, which coincides with tough times for agriculture due to the falling price of wool, forced many farmers to shift from wool production to wheat and meat production. Since the mid-1970s farmers have been focussed on producing a combination of wheat, wool and cattle for meat. During tough times, wool share decreased and farmers did not try to sell their wool stocks since they could store wool easily. Until the mid-1980s, annual production of greasy wool in Australia was around 700 million kilograms. It reached a peak of around 1,100 million kilograms in 1989 primarily due to the strong demand in China. At that time wheat and meat prices were also not so good and there was a reasonable reserve price paid for wool. When communism failed in china in 1989, Australia lost over 30% of its market in China.

Over the past two decades, production of wool and wool products has been in decline, primarily due to consumer demand. Price of wool has fluctuated substantially over this time period. Raw wool production in Australia currently amounts to around 350 million kilograms which is worth approximately $3 billion. Recently the market for wool apparel has been changing and there is good demand for Australian wool, even in developing countries like China, Ukraine and India. China has been a major manufacturer of wool products and is now a major consumer as well.

Figure 1 show the key players involved in the Australian-China-UK wool supply network. It consists of over 26,000 wool growers, 30 major wool brokers, around 60 buyers/exporters, 15 private wool merchants and a number of agents. There are only a small number of processors left in Australia. Australian Wool Innovation (AWI) represents the wool growers (see www.wool.com) and is funded by a 2% levy paid by the wool growers. It is primarily responsible for delivering research, development and marketing for the benefit of Australian wool growers. The wool brokers are represented by the Australian Council of Wool Exporters and Processors. The private wool merchants are represented by the Private Treaty Wool Merchants of Australia.

A very small amount of the raw greasy wool is processed in Australia. Much of the processing is now carried out in Chinese plants/factories that undertake scouring (washing and cleaning), top making (producing a thick filament), spinning, fabric making and finally garment making. Between 85% and 90% of the raw greasy wool is purchased through auctions by wool brokers on behalf of buyers/exporters at one of four selling centres located in Melbourne (Victoria), Fremantle (Perth, Western Australia), and in Sydney and Newcastle (both located in New South Wales). Note that around three decades ago, there were thirteen selling centres across Australia. Only a small amount of wool is kept at the four selling centres for the purpose of sampling and testing by the wool brokers/buyers. The remaining 10% to 15% of the wool is purchased by private wool merchants on behalf of exporters or other agents on behalf of domestic processors.

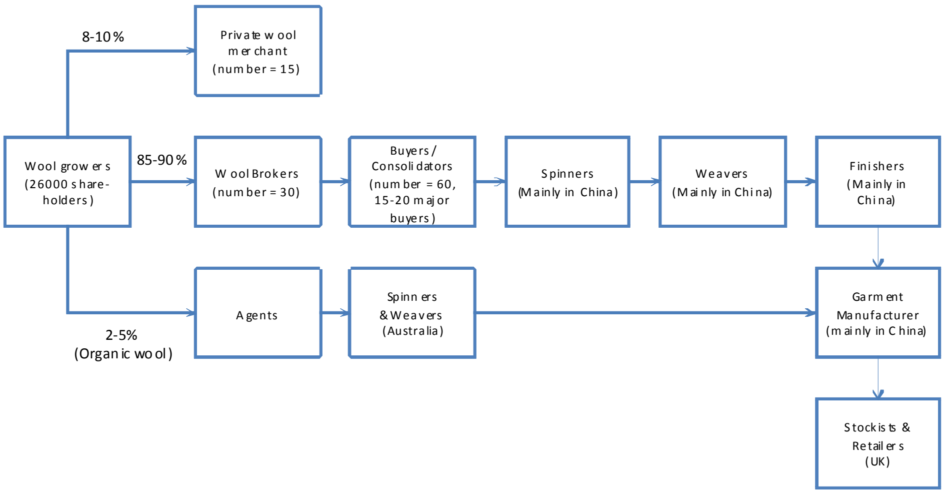

Figure 1. Key players in the Australia-China-UK Wool Supply Network

The actual physical movement of wool is as follows. The wool from the thousands of farms is transported to around 100 wool stores located across Australia where it is categorised and catalogued for the purpose of selling. In New South Wales alone there are 46 wool stores. From the wool centres, the wool is transported to three wool dumps located in Sydney, Melbourne and Freemantle where it is compressed and packed ready for shipping to China from the local ports.

Key Concerns

Figure 2 shows a rich picture representation of the Australia-China-UK wool supply chain, highlighting a number of concerns, or 'hot spots'.

- **Hot spot #1 (low wool prices for farmers)** - Australia maintains its position as the world's leading producer of wool, accounting for 24% of global production and supplying 90% of the wool used in the global apparel market. However, over the past two decades production of wool has been in decline, primarily due to consumer demand. Price of wool has fluctuated substantially over this time period. Nevertheless, the market for wool apparel has been changing recently and there is good demand for Australian wool, but the Australian farmers are consistently feeling the pressure for delivering high quality wool while the sector is primarily price driven. At the same time, China's own wool production is increasing every year, becoming a significant threat.

- **Hot spot #2** (***variability in quality of wool across farmers***) – The quality of wool produced by farmers is determined by its fibre diameter, crimp, yield, colour and staple strength, with the fibre diameter being the most important characteristic in determining quality and price. There is considerable variation in the quality of wool, as well as the yield achieved across different farmers, driven by a combination of factors such as the breeds used, farming conditions, etc. Before it can be used for commercial purposes, wool coming straight off the sheep, known as 'greasy wool', requires scouring, spinning and weaving, and the majority of these activities are performed by overseas processors. Australian farmers sell their wool through auctions to wool brokers, who consolidate volumes on behalf of buyers / exporters, offering high volumes at lower prices and consistent quality.

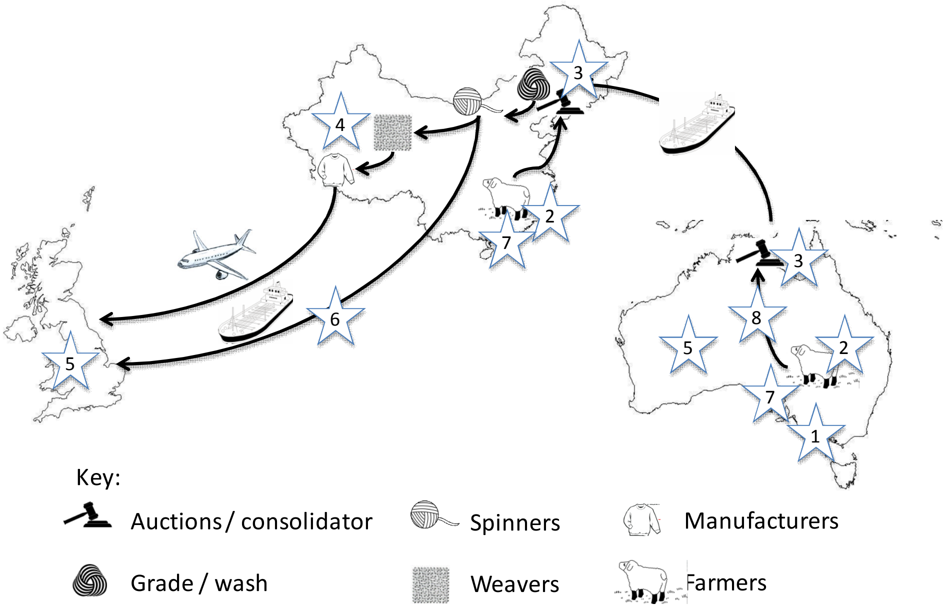

Figure 2. Rich picture representation of the Australia-China-UK Wool Supply Chain

- **Hot spot #3 (brokers focusing on price rather than quality)** – Up to 90% of the greasy wool produced in Australia is sold through auctions by wool brokers. With often too much emphasis being placed on buying the greasy wool at the lowest price, without considering the negative implications that this might have for efficient processing, brokers blend wool from different farmers. This often results in downgrading higher quality wool and ultimately impacts on the quality of the product that reaches the final buyer.
- **Hot spot #4** (**price driven Chinese processors**) – With a large proportion of the supply chain located in China, the sector is confronted by increased competition amongst the many wool processors, textile manufacturers and clothing manufacturers. This has been the result of fluctuations in wool prices, reducing demand from end consumers (not receiving enough orders to remain viable) and the strong Australian currency. The interview conducted with the CEO of a large Chinese wool spinning company highlighted the substantial competition that currently exists in China amongst the many wool processor, textile manufacturers and clothing manufacturers. The current market situation and the lack of transparency along the end-to-end supply chain is considered to be "harmful" to the whole industry. Collaboration between the Chinese manufacturers and the Australian exporters were generally considered to be good. The Chinese company referred to above buys 97%

of its raw wool from Australia. Around 40% of its finished product (yarn) is shipped to the USA, Japan and Europe for textile manufacture, around 30% is sold to local downstream processors who manufacture for overseas customers with the remaining 30% going to domestic consumption.

- **Hot spot #5** (**capacity and capability loss for UK spinners and weavers**) - A key concern identified from the interviews in the UK, but also evident in Australia, relates to the future of the industry. Due to the significant fragmentation of the supply chain, the industry focuses on optimising individual companies' goals, to the expense of a clear understanding of final customer needs. In other words, the industry is not pulling everybody in the same direction. Many of the changes discussed above impact on costs and the ability to attract highly skilled employees to the industry, as well as the ability to sustain business over a long period of time.
- **Hot spot #6** (**long international lead times**) – Within an industry that is significantly affected by the pressure for high fashion items, shorter selling seasons, shorter production runs and more responsive suppliers, long delays along the pipelines carry the significant threat of poor product availability and / or obsolete inventory. The UK companies interviewed were continuously affected by a lack of flexibility from their Chinese suppliers, lack of material availability in the supply chain and significant delays in bringing new products to the market.
- **Hot spot #7** (**lack of visibility and poor use of market knowledge in the SC**) – The Australia–China–UK supply chain is characterised by functional independence, with each participant contributing to the process sequentially. For example, poor visibility was experienced by the wool growers, who at the very least expected to receive two types of information from further downstream: information relating to the grading given to their wool (largely provided by the wool merchants and buyers) and information relating to the marketplace in terms of consumer demand. At the same time, the UK retailers had no visibility as to product availability further upstream and were rarely involved in managing beyond tier one suppliers. The need for synchronising activities up and down the supply chain in order to increase the level of responsiveness was highlighted in all the interviews we conducted.
- **Hot spot #8** (**long internal Australian pipeline**) – The wool pipeline within Australia is considered to be long, involving a number of players. Much of the wool transported within Australia is by road. Note that few decades ago much of the wool was transported by rail. With wool from the farms first going to regional wool stores and then to the three main wool dumps, the cost of transportation and handling has increased, although many farmers have benefitted from delivering their wool to local/regional wool stores. Overall, wool industry costs are related to volumes produced and transported. With the current transportations arrangements in place, it is considered to be adding to the carbon footprint.

DISCUSSION

While the results have highlighted the issues surrounding the Australia-China-UK wool supply chain there were a number of positive developments that should be noted. The level of trust between growers, buyers, sellers/brokers and exporters in Australia is considered to be high. The buyers who purchase many tonnes of wool only see a sample of the wool during auction, trusting upstream chain members to have carried out testing and cataloguing appropriately. Buyers purchase wool which is stored at wool stores and they do not have physical access to the wool other than the samples provided. There appears to be high level of trust in the whole industry. However, problems can arise when one of the parties along the supply chain changes (e.g. a new broker/buyer) resulting in the need to establish fresh relationships which can take time. In the UK there is some good practice between retailers and apparel manufacturers in terms of proving visibility of forecast and actual end market demand. This is then built on in the provision of agreed production volumes and schedules.

A key concern, hotspot #5, identified from the interviews relates to the future of the industry in the UK and Australia. Many in the industry are only concerned about their own well-being. In other words, the industry is not pulling everybody in the same direction. Many of the changes discussed above impact on costs and the quality of the people who work in the wool industry. The industry cannot absorb high quality people. For example Fremantle is a small selling centre and many people who work there are employed on a part-time basis. Over the years the industry has become less attractive for high quality people. In the UK capability and capacity for spinning, weaving and manufacturing, has been lost to the near and far east, in particular to China. There is now an extremely high cost to desire to repatriate the supply chain to the UK.

The findings also confirm the previous limited research in the wool supply chain. The results indicate that the supply chain is still considerably long in terms of distance and time. The supply chain is still dominated by manufacturing being undertaken in China, which as the second largest provider of raw wool after Australia and also being Australia's largest customer for raw wool, is proving to be a major power broker. Internal competition within China has led to price based competition driving down prices in Australia but driving up prices in the UK. The quality of the wool in the final products is also degraded.

CONCLUSIONS

We believe that this is the first study to examine the Australia-China-UK wool apparel supply chain. The study identifies the major issues that impact on the effectiveness of this supply chain and how these issues are being addressed by the key stakeholders involved. This study makes a significant contribution to understanding the complexities of the Australia-China-UK wool apparel supply chain. In particular, it adds to the literature on global supply chain management and the critical factors that enable the development of highly integrated global supply chains.

We have identified the structure and major supply chain management concerns in the supply chain. We have also indentified a trend in Australia and the UK for increased trust and transparency of information. A major hurdle remains visibility in the China segment of the supply chain where price based competition dominates.

This paper identifies the factors that contribute to the effective management of the Australia-China-UK wool supply chain. The findings will be of considerable value to both managers in their decision-making and to bodies such as Australian Wool Innovation in developing its future programs aimed at improving the competitiveness of the Australian wool industry and the global wool supply chain.

Further research will explore the value proposition throughout the supply chain. With China as a major power hub focussed on price this has resulted in poorer quality products for end consumers of the apparels. In the long terms this is unsustainable with customers moving towards apparels with synthetic materials. This will be to the detriment of every stakeholder in the wool supply chain. The research will explore how to drive new stakeholder behaviours so as to ensure increased quality and service to end customers.

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SECTION 2 – SUPPLY CHAIN NETWORKS, COLLABORATIONS AND CULTURE

COMPETITION AND COLLABORATION: A TALE OF TWO PORTS IN CHINA

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ABSTRACT

This paper reports the competitiveness of two adjacent container ports in Asia – Hong Kong Port and Shenzhen Port - as seen by their users. It also investigates how the two ports can work together to turn harmful rivalry into advantageous partnership that will benefit both parties as well as the customers. A self-administered questionnaire survey was conducted to collect the data. Results show that out of the five major factors affecting the users' choice of port, Hong Kong port excels in facilities, services, and management while Shenzhen port surpasses in location and costs. The respective advantages are derived from the historical development of Hong Kong Port and the closer proximity of Shenzhen Port to the hinterland. Ways to enhance collaboration include, among others, information sharing to improve visibility, road network and other infrastructure investment to strengthen linkage, and joint venture to develop port-centric logistics.

INTRODUCTION

Globalization and international trade have stimulated the development of world logistics. An efficient and cost-effective supply chain has become one of the critical factors of success in global business. Increasingly, manufacturers rely on outsourcing, off-shoring, and logistics integration to gain competitive advantage on cost and service. As a result, global sea freight has increased significantly in volume in recent decades. Together with containerization technology, the role of container port in the global supply chain has become increasingly critical (Cuadrado *et al*., 2004). Ports are no longer considered as merely starting or ending points in export and import trades. They are now regarded as important links in the door-to-door transport operation as well as the major logistics platforms for value-added activities within the supply chain (van Klink, 1994).

With globalization of manufacturing and marketing, global economy has shifted towards the rapidly developing countries in Asia such as China, India, and Vietnam. Take China as an example. It experienced on average a double-digit annual growth rate in GDP in the 1990s and the 2000s and became virtually the backyard factory of the world (Knoema 2012). Areas with abundant sources of cheap labour and resources, such as the Yangtze River Delta area in the eastern provinces and the Pearl River Delta area in the southern provinces, have attracted thousands of foreign investors to set up plants there for production of consumer goods. They are subsequently exported back to developed countries for sales. The accelerated economic growth in China has also raised the average income of the nation hence the demand for imported goods from developed countries. Both these activities stimulated rapid development of container ports to meet the need for increasing export and import trades. For instance, the two leading ports in China – Shanghai Port and Shenzhen Port – have both experienced a remarkable growth in container traffic of 338% and 296% from 2002 to 2010 (Containerisation International, 2012) Their throughput volumes were 29 million and 22.5 million twenty-foot equivalent units (TEUs) respectively in 2010 placing them the top and the fourth ranking ports in the globe (World Shipping Council, 2012). Table 1 shows the top ten busiest container ports in the world in 2009 and 2010 in terms of throughput or annual TEUs processed. Six of them are located in China.

Table 1 Top ten container ports in 2010

Rank in 2010	Rank in 2009	Port	Country	Container Traffic (in thousand TEUs) 2010	2009	% Change from 2009
1	2	Shanghai	China	29,069	25,002	16.3
2	1	Singapore	Singapore	28,431	25,867	9.9
3	3	Hong Kong	China	23,699	21,040	12.6
4	4	Shenzhen	China	22,510	18,250	23.3
5	5	Busan	South Korea	14,194	11,980	18.5
6	8	Ningbo	China	13,144	10,502	25.2
7	6	Guangzhou	China	12,550	11,200	12.1
8	9	Qingdao	China	12,012	10,262	17.1
9	7	Dubai	United Arab Emirates	11,600	11,124	4.3
10	10	Rotterdam	Netherlands	11,140	9,743	14.4

Source: World Shipping Council 2012

Source: Liu, Tian & Wang 2009

Figure 1: Locations of ports in the Pearl River Delta area

Among the top ten ports as shown in Table 1, the ports in Hong Kong and Shenzhen share the same hinterland of the Pearl River Delta (PRD) area as shown in Figure 1. The PRD area is now one of the world's largest export manufacturing bases. To cope with the huge volume of export, five major ports in Shenzhen (with Shekou, Chiwan, Mawan and Da Chan in the west and Yantian in the east) were developed in the last couple of decades. The primary container ports are Yantian, Shekou and Chiwan. These ports, collectively known as Shenzhen Port, play an important role in distributing the goods manufactured in the PRD area to the world. In contrast, Hong Kong Port (which comprises a world class container terminal in Kwai Chung and Tsing Yi area and a river trade terminal at Tuen Mun) were developed in the 1970s and the 1990s to cope with the dramatic economic growth of the city when it was still a British colony. Historically, Hong Kong Port was an entrepôt and established early. It is more technically advanced and operationally efficient to meet the ever-growing needs of regional international trade. Upon the implementation of the open-door economic policy of China in 1978, Hong Kong

Port became the regional hub and gateway to Mainland China. It enjoyed a long period of prosperity until the emergency of Shenzhen Port in the 1990s. Serving the same hinterland, i.e., the PRD area, the two ports inevitably compete with each other for users, which include freight forwarders and shipping lines. This internal competition, if left unchecked, will not only affect the survivability of the two ports but also decrease their competitiveness against other major ports, such as the ports of Singapore and Busan, in the Asia Pacific region.

In comparing the two ports, Hong Kong Port is well known for its efficiency and ability to handle huge amount of containers. In 2011, 24.4 million TEUs were handled (Hong Kong Port Development Council, 2012) making Hong Kong Port the third busiest port in the world. It provides services to about 440 shipping liners per week sailing to about 500 destinations worldwide. The port is well known for its efficiency. The average turnaround time for container vessels in Hong Kong is about 10 hours. For conventional vessels working in mid-stream at buoys or anchorages, it is 42 and 52 hours respectively (Wikipedia, 2012). In comparison, Shenzhen Port now acts as a gateway to China through the PRD area which is recognised as the 'economic powerhouse' of the country. The port is rich in natural resources with excellent geographical location and coastline advantage. It serves a total population of about 500 million in the southern region of China and plays a crucial role in export and import. Shenzhen Port contributes approximately US$ 1 trillion to the GDP of the country (Pan, 2007).

Despite there are studies on the interdependent relationship of Hog Kong Port and Shenzhen Port (see for example Song, 2002; Yeh et al., 2002; Cullinane et al., 2004; McKinnon, 2011), empirical studies on competitiveness of the two ports as well as possible areas for collaboration from the users' perspective are limited. This research uses a questionnaire to survey the users – both freight forwarders and shipping lines – of the two ports. The aim is to determine quantitatively the current level of competitiveness in the eyes of the users and investigate how they can work together to turn harmful rivalry into advantageous partnership that will benefit both parties as well as the customers. Collaboration between the two ports is also facilitated by the fact that both Hong Kong Port and Shenzhen Port are partly owned by the same company - Hutchison Whampoa Ltd. (McKinnon, 2011).

This paper is structured as follows: First, a literature review is given on the common factors affecting the choice of ports by users and the significance of port collaboration. The review aims to help reader understand the rationale behind the design of the questionnaire. Then, the methodology of the study is presented in detail. After that, the findings of the survey are presented followed by a thorough discussion on the implications. Finally, conclusions and recommendations are made based on the findings. Also, limitation of the study is discussed and directions for further research are also suggested.

LITERATURE REVIEW

With globalization and growing international trade, port users such as freight forwarders and shipping lines have become key players in determining of the choice of ports in a global supply chain (Robinson, 2002; Slack, 1985; van de Voorde and Winkelmans, 2002). Many researchers agree that costs, facilities, and services, such as port charges and transport costs to and from the port, availability of equipment and facilities, quality and efficiency of handling containers, are the major factors of competition among ports (Fleming and Barid, 1999; Ha, 2003; Robinson, 1998). Table 2 summarizes the major factors of port completion and the mitigation measures as reported in the literature.

Table 2 Major factors of port competition

Factor of Competition	Mitigation Measure	Studies
Port costs ▪ port charges ▪ terminal handling charges ▪ charges for container demurrage and detention	Investment in IT to enhance efficiency	Rodrigue *et al*. (2006)
Port facilities ▪ berth length ▪ availability of container yards ▪ availability of container equipment ▪ automation of cargo handling system ▪ additional berth to meet unexpected needs	Investment in port facilities to increase throughput and to enhance efficiency	Rodrigue *et al*. (2006); van Klink & van den Berg (1998)
Port services ▪ efficiency in customs clearance procedure ▪ availability of cargo tracing system ▪ efficiency in door-to-door service ▪ prompt settlement of customer dissatisfaction and claim	Automation of processes using IT and streamlining of custom clearance procedure	Flemming (1997); Ha (2003); Haynes *et al*. (1997); Notteboom (2004)
Transport network to hinterland ▪ road network ▪ intermodal interchange ▪ feeders services	Investment in infrastructure to improve connectivity and to expand hinterland coverage	Notteboom & Winkelmans (2001); Robinson (2002); Rodrigue *et al*. (2006)
Port and logistics integration ▪ loading/unloading of cargoes ▪ warehousing ▪ crossing docking ▪ distribution ▪ other value-added services	Investment in port-centric logistics to provide integrated and value-added services for improvement in responsiveness and reduction in overall distribution cost	Notteboom (2002); Notteboom & Rodrigue (2005); van Klink (1994)

While competition between ports are getting fierce due to the increasing demand of users for lower shipping cost and better port services, Juhel (2000) contends that a co-operative relationship between ports can allow them to provide a more flexible distribution services hence benefiting all the parties involved. Avery (2000) opines that a strategic alliance between adjacent container ports enables ports to survive in a severely competitive environment. Brandenburger and Nalebuff (1996) coined the term “co-opetition” to describe the new strategic approach, which is a combination of competition and co-operation to create a win-win situation for all. Song (2002) also argues that a port may develop a stronger position in the competitive marketplace by adopting a co-operative strategy with other ports. The move will not only offer a mutual benefit to the participating ports to reform their market position to combat rivalry from regional competition but also enable them to increase their bargaining power in negotiating with customers such as freight forwarders and shipping lines.

Therefore, in a fiercely competitive market environment, adjacent ports need to jointly develop their competitive advantages based on their unique core competencies so as to create or enhance their port hub status in the region (Notteboom and Winkelmans, 2001). This is in alignment with the inevitable trend of horizontal and vertical integration in the transport industry. Continuing to rely solely on the traditional import and export or transhipment function will only weaken the competiveness of a port in the long run. This is because globalization and rapid development of new ports have provided alternative routes for cargo flows thereby reducing the domination of major ports at strategic locations. That is to say, to attract shipping lines to choose a particular route or port, more value-added services have to be provided. “Co-opetition” strategy can be a good, if not the best, approach for the long-term development of adjacent ports. Co-opetition strategy allows adjacent ports to make use of their respective core competences and complement their services to customers so as to achieve a win-win situation. This can be achieved by sharing information and leveraging existing facilities to meet different requirements of shipping lines, forwarders and shippers. Collaboration between ports can also provide a bigger scope for development of port-centric logistics for the region thereby offering more value-added logistics services to port users. This can help improve efficiency and responsiveness to customer requirements.

METHODOLOGY

This study uses a self-administered questionnaire survey to collect data for analysis. The questionnaire consists of three parts. Part A uses 19 questions to seek the view of the responding company on the major factors (as identified in the literature) affecting its choice of port in general. Part B of the questionnaire uses another 19 questions to ask the responding company to evaluate the competitiveness of the ports of Hong Kong and Shenzhen from a user's perspective. The criteria of evaluation are the same major factors as investigated in Part A. Part C uses seven close-ended and two open-ended questions to elicit the opinion of the responding company on which areas the two ports can collaborate. Again, these areas are identified in previous research as reported in the literature. A five-point Likert scale (Likert 1932) ranging from 1 (totally unimportant) to 5 (totally important) is used to gauge the significance of the individual factor as perceived by the responding company. A scale of 1 to 10 (with 1 representing totally uncompetitive and 10 representing totally competitive), is used to measure the respective competitiveness of the two ports from the perspective of the responding firm as a user. Finally, again a five-point Likert scale ranging from 1 (totally unimportant) to 5 (totally important) is used to gather the view of the responding company on the various areas where the two ports can collaborate to achieve mutual benefits.

A list of freight forwarders and shipping lines operating in the PRD area was first compiled from industrial yellow pages and company websites. These companies were selected on the belief that they would use either the port of Hong Kong or Shenzhen or both for their business. A total of 208 companies were identified comprising 152 freight forwarders and 56 shipping lines. The self-administered questionnaire was sent to each of these companies either via e-mail or post (for those companies with only postal addresses in the yellow pages). The survey was conducted in September 2011. Three follow-up e-mails or telephone calls (for those companies with only postal addresses and contact phone numbers) were used to encourage response. In the end, 78 valid responses were received representing an overall response rate of 37.5%. Among them, 59 are from freight forwarders (response rate: 38.8%) and 19 are from shipping lines (response rate: 33.9%). As the data were collected in ordinal scale, Wilcoxon signed rank test for single and paired samples with normal approximation and adjustment for tied ranks, were used for analysis (Wilcoxon, 1945).

FINDINGS AND DISCUSSION

Selection of Container Port

Table 3 shows the distribution of freight forwarders and shipping lines among the 78 responded companies which call at the ports of Hong Kong and Shenzhen. Table 4 shows the reasons of the respondents for using the selected port. It can be seen the majority of the companies (94%) have called at both ports. They use the ports mainly for import and export activities. Owing to the historical development of the port of Hong Kong as an entrepôt and its unique location in South Asia, many companies are also using it as a transhipment hub.

Table 3 Selection of container port by shipping lines and freight forwarders (N = 78)

Port Called	N	Percent
Calls at Hong Kong Port only	2	2.6%
Calls at Shenzhen Port only	3	3.8%
Calls at both Hong Kong Port and Shenzhen Port	73	93.6%

Table 4 Reasons of all responded users for calling at the selected port (N = 78)

Reason of Calling	Hong Kong Port	Shenzhen Port
Import only	3	1
Export only	8	8
Both import and export	65	66
Transhipment	35	17

Note: Multiple answers permitted.

Factors Affecting the Choice of Container Port

All survey subjects (freight forwarders and shipping lines alike) were asked to indicate the significance of various factors affecting their choice of container ports regardless of which port they had or preferred to use. Table 5 shows a summary of the findings.

Table 5 Common factors affecting the choice of port of all responded users (N = 78)

Significance of Factor	**Median**	**Mean**	**SD**
Port Facilities:			
▪ Berth length	4*	3.9	0.95
▪ Availability of container yards	4*	4.2	0.76
▪ Availability of container equipment	5*	4.5	0.62
▪ Automation of cargo handling system	4*	4.0	0.73
▪ Additional berth to meet unexpected needs	3	3.1	0.63
Port Location:			
▪ Convenience of entry/exit for vessels	4*	4.1	0.83
▪ Connection with other transport modes (rail and truck)	4*	4.4	0.74
▪ Being a transhipment centre	4*	4.2	0.60
Port Costs:			
▪ Port charges	4*	4.2	0.77
▪ Terminal handling charges	4*	4.3	0.73
▪ Charges for container demurrage and detention	4*	4.3	0.71
Port Services:			
▪ Efficiency in customs clearance procedure	5*	4.4	0.70
▪ Availability of Cargo tracing system	4*	4.1	0.81
▪ Efficiency in door-to-door service	4*	3.7	0.73
▪ Settlement of customer dissatisfaction and claim	4*	4.1	0.74
Port Management:			
▪ Vessel congestion in port	5*	4.4	0.91
▪ Efficiency and accuracy in on-deck handling of container	4*	4.2	0.61
▪ Port management information system (port MIS)	4*	4.2	0.79
▪ Port worker performance	4*	4.1	0.62

Level of significance: (1) Totally unimportant, (2) Relatively unimportant, (3) Neither important nor unimportant, (4) Relatively Important, (5) Totally Important

Test used: Wilcoxon signed rank test for single sample with normal approximation and adjustment for tied ranks

* Significant at $\alpha = .001$

As shown in Table 5, port facilities in terms of availability of container yards and equipment, port location in terms of connection with other transport modes, port services in terms of efficiency in customs clearance procedure, and port management in terms of minimizing vessel congestion in port are among the most critical factors of consideration in choosing a port from the perspective of the users.

Competitiveness between Ports

Responding companies that have called at both the ports of Hong Kong and Shenzhen – 73 out of 78 - were asked to compare the competitiveness of the two ports in various aspects. A rating scale from 1 to 10 with 1 being totally uncompetitive and 10 being totally competitive was used for the evaluation. Respondents were asked to give their views on the competitiveness in six aspects as identified in the literature. Wilcoxon signed rank test for paired samples was used to determine whether there is any significant difference between the two samples. Table 6 shows a summary of the findings.

Table 6 Comparison of competitiveness between Hong Kong Port and Shenzhen Port (N = 73)

	Hong Kong Port			**Shenzhen Port**			**Normal Approx.**	
Competitiveness of Factor	**Med.**	**Mean**	**S.D.**	**Med.**	**Mean**	**S.D.**	***Z***	***p***
Port Facilities:								
▪ Berth length	8	8.1	1.49	8	7.6	1.13	-2.301	.021*
▪ Availability of container yards	8	7.9	1.37	8	7.8	1.08	-1.024	.306
▪ Availability of container equipment	8	8.2	1.00	8	7.7	1.07	-2.908	.004*
▪ Automation of cargo handling system	9	8.1	1.28	7	7.4	1.46	-3.400	.001*
▪ Additional berth to meet unexpected needs	8	7.7	1.23	8	7.8	1.08	-0.253	.800
Port Location:								
▪ Convenience of entry/exit for vessels	9	8.6	1.42	8	7.8	1.04	-4.133	.000*
▪ Connection with other transport modes	8	7.4	1.41	9	8.5	1.18	-4.463	.000*
▪ Being a transhipment centre	9	8.6	1.46	8	7.5	1.34	-4.326	.000*
Port Costs:								

▪ Port charges	6	6.1	1.48	9	8.6	1.28	-6.260	.000*
▪ Terminal handling charges	5	6.0	1.57	9	8.8	1.15	-7.052	.000*
▪ Charges for container demurrage and detention	7	6.3	1.62	8	7.9	1.64	-5.038	.000*
Port Services:								
▪ Efficiency in customs clearance procedure	8	8.2	1.61	7	6.9	1.52	-4.930	.000*
▪ Availability of cargo tracing system	8	8.1	1.53	7	6.8	1.48	-4.408	.000*
▪ Efficiency in door-to-door service	8	7.4	1.13	8	7.5	1.01	-1.278	.201
▪ Settlement of customer dissatisfaction and claim	8	7.7	0.82	7	7.2	1.04	-3.832	.000*
Port Management:								
▪ Vessel congestion in port	8	7.2	2.44	8	6.9	2.05	-1.474	.140
▪ Efficiency and accuracy in on-deck handling of container	9	8.5	1.19	8	7.7	1.07	-4.492	.000*
▪ Port management information system (port MIS)	9	8.8	1.23	8	8.0	1.37	-5.102	.000*
▪ Port worker performance	9	8.4	1.27	8	7.8	1.33	-4.203	.000*

Level of significance: 1 – 10 with (1) being totally uncompetitive and (10) being totally competitive
Test used: Wilcoxon signed rank test for paired samples with normal approximation and adjustment for tied ranks

The findings show that in general Hong Kong Port is more competitive in port facilities, services, and management. Berth length, availability of container equipment, and automation of cargo handling system at Hong Kong Port are considered superior. Being a transhipment centre also gives Hong Kong Port a competitive edge over Shenzhen Port. Port services such as efficiency in customs clearance procedure, availability of cargo tracing system, and rapid settlement of customer dissatisfaction and claim are also the strengths of Hong Kong Port. In addition, efficiency and accuracy in on-deck handling of container, the use of advanced port management information system (port MIS), and superior port worker performance at Hong Kong Port are regarded as the results of more effective port management when compared with Shenzhen Port.

In comparison, Shenzhen Port is more competitive in port location and cost. Being closer to the hinterland and with a better connection with other transport modes, Shenzhen Port is in a more advantageous position to serve the PDR area where the factories are located. Another competitive edge of Shenzhen port is its lower port cost in terms of port charges, terminal handling charges, and charges for container demurrage and detention. According to a 2004 study on Hong Kong Port, the total through cost of using Shenzhen Port was 10% cheaper for a 20-foot container and 7% cheaper for a 40-foot container. Lower road haulage cost and terminal handling charge are the major competitive strengths of Shenzhen Port over Hong Kong Port (Economic Development and Labour Bureau, 2004).

Areas of Potential Collaboration

To find out how the ports of Hong Kong and Shenzhen can collaborate, respondents were asked to indicate from a user's perspective the significance of the areas where collaboration can be attempted. Table 7 shows a summary of the findings.

Table 7 Areas of potential collaboration between Hong Kong Port and Shenzhen Port (N = 78)

Area	Median	Mean	S.D.
Information sharing	4*	4.1	0.73
To build up connected transportation network together	4*	4.3	0.69
To develop extended hinterland together	4*	4.3	0.75
Multi-market presence (*e.g.*, to have different specializations in products)	4*	4.1	0.85
To conduct R&D together to improve efficiency and accuracy in container handling	4*	4.2	0.77
Seaport authority cooperation (*e.g.*, formation of port association)	4*	4.1	0.82
To form joint ventures to provide high quality logistics services	4*	4.1	0.77

Level of significance: (1) Totally unimportant, (2) Relatively unimportant, (3) Neither important nor unimportant, (4) Relatively Important, (5) Totally Important
Test used: Wilcoxon signed rank test for single sample with normal approximation and adjustment for tied ranks
* Significant at $\alpha = .001$

The findings show that in general users of both ports believe that Hong Kong and Shenzhen governments can work together to develop transportation network linking the two ports to jointly serve an extended hinterland. To the freight forwarders, united R & D effort to improve efficiency and accuracy in container handling is also a major area for collaboration. Although total through cost of using Shenzhen Port is lower, better port service at Hong Kong Port is still attractive to some users. However, the complex regulation control governing cross-border moves poses an obstacle which needs to be overcome to facilitate collaboration (Economic Development and Labour Bureau, 2004). To the shipping lines, specialization of the two ports in handling different products can help develop multiple market presence. Closer cooperation between the two port authorities, such as formation of a port association, is also critical to successful collaboration.

CONCLUSIONS AND FURTHER RESEARCH

Through a sampled questionnaire survey, this study has investigated the current level of competition between Hong Kong Port and the adjacent Shenzhen Port, both of which share the same common hinterland in the PRD region. The survey also explores the scope for collaboration between these two competing ports. The findings reveal that Hong Kong Port excels in facilities, services, and management while Shenzhen Port surpasses in location and costs. The respective advantages are related to the historical development of the two ports and their geographical locations with respect to the common hinterland. Ways to enhance collaboration include, among others, information sharing to improve visibility, simplification of custom clearance procedure at border, standardization of processes and operations at both ports to facilitate optimization, investment in road network and other infrastructure to strengthen linkage, and joint venture to develop port-centric logistics.

This study is a relatively simple survey using non-parametric statistical analysis to present a general picture of the current level of competition between the ports of Hong Kong and Shenzhen for comparison purpose. Although it does have contributed to knowledge by providing a snapshot of the current situation, the relatively short questionnaire has prohibited the gathering of more in-depth information to explore the myriad factors affecting the choice of port by the users. Also, the survey has focused only on the customers. The perspective of the port operators and other stakeholders have yet to be investigated particularly when port collaboration is a joint effort involving many parties including both the private and the public sectors. Future research may extend the survey to cover a larger sample and to include other parties and stakeholders. Another limitation is that differences in political governance of Hong Kong and Shenzhen have not been accounted for in this study. As governance affects policy formulation and resource allocation that may limit the scope of collaboration between the two ports, it would be desirable to take the political elements into account in future investigation.

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NOTE: A full list of the references can be obtained from the authors.

SUCCESS FACTORS OF COLLABORATIVE PRODUCT DEVELOPMENT IN PRODUCTION NETWORKS

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ABSTRACT

Collaborative product development in production networks is a method to accomplish successful business in today’s globally networked business environments. Mainly it requires commitment to co-operation, hard work at all organisational levels and flexible interfaces inside and on the peripheries in the outer limits of the production network. This research recognised nine main categories constituting critical success factors for collaborative product development in the environment of an SME manufacturing network between the main supplier as a network leader and the most significant subcontractors/partners: 1) Characteristics of organisations/partners with common interests, values and organisational cultures, 2) common global customer-driven networking strategy, 3) maintaining positive tension in network relations, 4) people as a main resource in a network, 5) common development of end-product as a target, 6) formal leadership practices, 7) speed and dynamics of knowledge-based skills, 8) transparency and quality of information, and 9) technology management.

INTRODUCTION

The globalization and integration of markets have come to play a significant role in today’s logistic business environment. Businesses operate in a global marketplace and the demand for cost efficiency and customer responsiveness has increased. Therefore, global location of production and distribution facilities and time-based competition are the major driving forces in today’s business environment. Customers also increasingly demand a wide variety of products with minimal lead-time. (Bhatnagar and Visswanathan 2000, Childerhouse et al. 2002) Unpredictability of material demand is also constantly increasing and therefore causes pressures to reduce logistics lead-times even further. Therefore supply chain management has become an essential source of competitiveness of ever increasing significance (Singh 2004). The information age and globalisation force companies to place a premium upon collaboration as a new source of competitive advantage (Simatubang and Sridharan 2005). Zhang and Huang (2012) indicated that the impacts of business environment cost parameters on supply chain configuration decisions relate mainly to both various cost elements and lead time questions. As Collin et al. (2009) noted, a supply chain should evolve with the dynamics of a business.

As Sherer (2003) has pointed out, although networking among small and medium-sized manufacturing firms (SMEs) is a growing phenomenon, there has been little empirical study of the factors that lead to the success of these networks. Selviaridis and Spring (2007) also note in their literature review that there is a clear research gap in reporting the actual empirical results of 4PL (Fourth Party Logistics) service providers managing such business networks. Sherer’s study identified eight success factors for manufacturing networks of SMEs forming a framework for assessing the significance of various factors affecting the competitiveness of manufacturing networks in the SME context. Numerous frameworks for success factors have been presented, yet frameworks for success factors in manufacturing networks are fairly uncommon. This point of view also forms the main background of this research.

The purpose of this paper is to describe opportunities to improve the competitiveness of engineering work in Europe, where cost pressures are increasing due to the global competition environment and sourcing from low cost countries. This research examines the product development process for existing products, in which cost-competitiveness was impaired and was too far away from the target deal maker zone to enter new markets. The starting point for this development process was to improve cost-competitiveness while still maintaining the high quality and technical performance of the product for which the company which is the subject of this empirical case study was so well known. Therefore this development process took an extremely market-driven approach. Collaboration between strategic partners in this supply network has been a key solution in the conduct of this development process. The purpose of this paper is therefore to describe the process to perform this technical and operational development in supply network through various collaboration practices.

LITERATURE REVIEW

Strategic partnerships are formed to achieve a set of goals, but at company level the goals inside the network may differ. Networks seeking to co-market or co-produce products and services in particular require a very high degree of interdependence as business success is largely dependent upon the network's effectiveness. Such networks involve sharing of competitive knowledge and expertise, which may lead to greater opportunism and operations risk. (Sherer 2003) Therefore the identification of critical success factors and the creation of a framework for the assessment of this point of view are essential for the management of manufacturing networks as it makes it possible to organise operation models of co-operation at the practical level. For example, to organize common design and planning systems at all levels for a very flat virtual product development organisation.

According to Sherer (2003) the most important success factor in the manufacturing networks of SMEs is the characteristics of the participants in the network. Thus in participant selection, character is more important to investigate than expertise, which can also be articulated such that there is a minimum need regarding the right expertise and cost level this new possible partner can achieve, but this is not enough if the characters are wrong. This includes shared values, personal relationships and monitoring. Sherer identified eight critical success factors as a framework for SMEs manufacturing networks. These categories are:

1) Participant character
2) CEO support
3) Confidence
4) Dedication
5) Capabilities
6) Relationships
7) Intermediary
8) Technology

In addition to Sherer's (2003) framework, several other frameworks are also represented in various contexts to describe success factors in supply chain collaboration and manufacturing co-operation. For example, Simatubang and Sridharan (2005) presented a framework for understanding the interaction phenomena between different features of supply chain collaboration from the inter-organisational perspective. The framework consists of five features of collaboration:

1) A collaborative performance system (CPS)
2) Information sharing
3) Decision synchronisation
4) Incentive alignment
5) Integrated supply chain processes

The concept of market orientation is crucial to achieving achieve the creation of customer value in today's marketplace by combining the strengths of marketing and supply chain competencies. Different operational areas sharing the same customer focus and market commitment have certain roles in adding value to the company. Demand chain management (DCM) is an approach introduced to capture synergies between supply chain management and marketing starting with the specific customer needs and designing the chain to satisfy these needs. (Jüttner et al. 2007) Gosling et al. (2009) place the focus on flexibility in response to the high levels of complexity and uncertainty, and this can be divided into two main approaches:

1) Vendor flexibility
2) Sourcing flexibility

Although this paper has a marked manufacturing network and collaborative product development approach orientation, the target-setting of product development is totally customer-driven and co-operation and collaboration of a manufacturing network are considered to be effective supply network operations. The customer-oriented demand chain management approach is described in Figure 1, which is also directly applicable to the construction of framework model for success factors of manufacturing network.

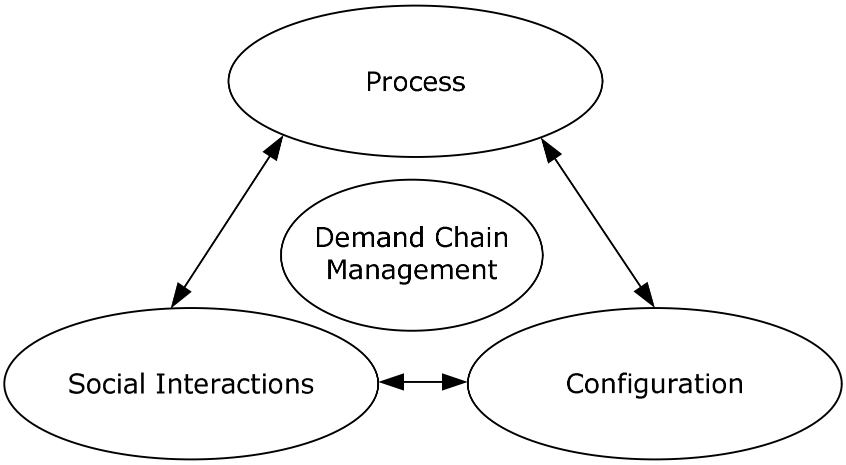

Figure 1. A conceptual framework for demand chain management. (Jüttner et al. 2007)

According to Westphal et al. (2007) collaboration is today an established option to deal with the increase in product and service complexity, the dynamics of changes, requirements for responsiveness and still ever greater demands for high quality. It helps to overcome the limitations of a single enterprise, especially of small and medium sized enterprises, regarding competencies, capacities and financial resources. Collaboration creates an environment in which enterprises and human actors can temporarily or permanently merge their processes to conduct joint business in a non-hierarchical way, in other words, they are able to work in a non-restrictive flat organisational structure. Virtual organisation is one special type of collaboration, which enjoys strong support through computer networks. (Westphal et al. 2007) Gunasekaran et al. (2008) examines the relation between supply chain management (SCM) and agile manufacturing (AM) in an idea where each partner complements the other in objectives for improving organisational competitiveness. In this approach AM relies more on strategic alliances and partnerships, when SCM focuses on the integration of suppliers and customers to achieve an integrated value chain. By combining these perspectives, a responsive supply chain (RSC) is presented as a solution to meet the demands of the modern business environment. These approaches have characteristics also identified as critical success factors in this research.

Manufacturing is increasingly changing towards service oriented business in manufacturing industries. This research was not focused on service business, but it was, however, recognised that customer-oriented service business including customer interaction and the flow of customer information is an essential part of this approach for industrial businesses. As Turunen and Toivonen (2011) noted in their research, customer response taken immediately into account in the service design is a significant success factor for manufacturing industries, now and especially in the near future, as one of the megatrends in the industry sector seems to be product personalisation. This approach is also in focus in this research on the context of collaborative product development.

DESCRIPTION OF THE PROBLEM

The research problem is constructed to combine the challenges and success factors of manufacturing networks in the SME environment, and also collaboration in order to achieve a customer-driven supply network and therefore competitive products and services. On the other hand this research is based on phenomena of globalisation, where procurement and also manufacturing are increasingly being moved to Asia, especially LCC operations. Therefore it is essential for the European manufacturing industry to recognize critical success factors which can improve the cost-efficiency and competitiveness of products and services in this business area.

The basis of this research is a case study in a situation where a specific product segment in the machinery engineering industry had lost its cost-competitiveness and the company had to make major changes in order to retain its position in the markets. The company is a market leader in its main product segments, and as such well known, but with financial constraints the well established brand is only one of the many factors affecting customers' final decision. The aim in the development process was to keep technical features and quality at the top level, but at the same time to cut production costs, e.g. by changing the underlying machine structure in ways that even affected the building process and manufacturing practices of the units. This was an extremely interesting starting-point for academic research. It necessitated a literature survey to be able to identify existing frameworks of success factors in manufacturing industries, especially in the SME context for doing such a major re-work on the end product in a tightly coupled company network and partnership environment. Analysis of existing models in literature and case study revealed the same direction and main findings although with different emphases. Therefore the aim for this research and it reporting has been both to improve practical operation and analysis models in manufacturing industries, especially in SMEs and to develop a theoretical framework thereby influencing the academic discussion in this field.

RESEARCH WORK

The article is based on a research project conducted in the period 2010-2012. The research methods were literature survey related to collaboration in supply chain management and business networks and concurrent engineering, and also theme interviews on the success factors of global production networks. The main focus was on in this practical solution aspect. This paper is mainly based on a case study in an SME manufacturing network, but the approach is extended to two other networks in the machinery industry through an in-depth analysis of the responses to two questionnaires related to success factors of manufacturing network in the same problem area. This aimed at a more generalised framework of success factors, not only based on one collaborative product development process.

The practical impact of this research is based on a case study conducted in a machine construction company manufacturing mining process equipment. The company operates globally with production in Finland and Chile segmented in such a way that there is only one production unit available for specific equipment. The company has sales branches all around the world, on all continents, and they also provide support services at all locations. The subject of this research relates to the global financial recession of 2008-2009, when the case company like all the others was suffering from drastic decrease in sales volume. As a major difference from other companies in this field, instead of personnel reductions, the company decided to concentrate on the development of products and business processes for the period of fast growth predicted in the near future. One of their subcontractors was also very active in supporting this effort and they decided to start collaborative product development of a specific product which had lost its cost-competitiveness in its market segment.

The starting-point for this development process was to increase cost-competitiveness while still retaining the high quality and technical performance of the product. Therefore this development process took an extremely market-driven approach. The target set for the development project was to achieve a very ambitious 30 percent cost decrease through new technical and production solutions and also by applying well studied specification changes greatly affecting cost structure, but only slightly the end product capabilities (e.g. reduction in driving speed of the unit from point A to B), as it was found that ultimately in this mode of working time is of so little consequence to the true working activities that most of the customers would prefer cheaper unit to the current maximum driving speed). Collaboration between strategic partners in this supply network was a key solution to conduct this development process.

The product development process was divided into three different technical areas: 1) hydraulic systems, 2) electricity and 3) power electronics. In all the technical areas the main approach was intense collaboration of planners in all the organisations involved and especially in collaboration between the same organisational levels. The top management of all the manufacturing companies (SMEs) were committed to this project, but the main work was based on collaboration on various organisational levels without the existence of top management level: As such this model of collaboration offered the designers and middle management participating in this process a chance to work in a flat organisational structure environment which left them free to indulge their passion for high quality and target orientation towards the goal. The second main approach and prerequisite for success was target setting, which was challenging, including autonomy enough to develop totally new solutions. Therefore the product development group had only the challenging target to achieve cost-savings, market-driven main features needed for the equipment and well-defined time schedule for the development project. Otherwise the development group had free hands to conduct this project.

As a result this project achieved very ambitious target-setting in cost savings in manufacturing a prototype of the equipment applying the new technical and structural solutions of the product. In addition to cost savings and improvements in production logistics, this innovative and collaborative development process also resulted in some technical improvements compared to the previous product generation, which will be delivered to other product ranges in the near future, Thereby achieving additional "project bonuses" for the companies themselves. In addition the position of the network leader as a respected partner improved.

From the research project point of view, the main focus was on the identification of success factors in manufacturing networks. This was conducted through expert interviews with the personnel involved in this development project and by analysing company documentation related to this project. This research identified a total of 16 success factors in the first stage, which extended during research process to a total of 36 success factors after more detailed analysis. Later these success factors were categorised and generalised to nine umbrella success factor categories.

RESULTS

The research identified 16 success factors in the specific collaborative product development process. These success factors are:

1) Challenging present approach
2) Well-defined target setting related to customer-driven needs
3) Commitment of partners
4) Motivation and enthusiasm
5) Segmentation of product development project into clearly defined technical areas
6) Leadership of completeness, but not too strictly
7) Experienced project leader with capability to manage total project
8) Pursue total cost-savings instead of minute details
9) Partners have both planning and manufacturing experience
10) Non-formal personnel networks
11) Transparency of costs and profitability
12) Invite tenders for products and services
13) Testing the product in real operation environment before manufacturing phase → feedback
14) Co-operation of ICT systems with planning partners

15) Publicising the results of product development inside the manufacturing network
16) Utilisation of economic recession in the markets in order to increase competitiveness

After identifying these 16 success factors, this research extended the analysis of the success factors of manufacturing networks to two other manufacturing networks, which had partly the same subcontractors. Through analysis of three totally different SME manufacturing networks in the machinery engineering industry it was possible to identify a list of 36 success factors, which in turn led to the identification of nine success factor categories. These categories are suitable for both manufacturing SME networks and collaborative product development. These nine categories are:

1) Characteristics of organisations/partners with common interests, values and organisational cultures
2) Common global customer-driven networking strategy
3) Maintaining positive tension in network relations
4) People as a main resource in a network
5) Common development of end-product as a target
6) Formal leadership practices
7) Speed and dynamics of knowledge-based skills
8) Transparency and quality of information
9) Technology management

One of the main results was the identification of the internal dynamics and motivation for common product development process, which was based on common and open communication and co-operation between planners and middle management in all the organisations involved in the development process. The top management of the companies gave their support and commitment to the development project in the form of resources, but they did not dictate the co-operation and planning processes. This clearly indicated that encouraging a working environment with clearly defined targets as an end result of the project causes positive tension in network relations and therefore creates a positive atmosphere. In this case study, the flat virtual organisation involved in a collaborative product development process with a great degree of freedom combined with open and active communication inside the network was the main reason for the success of this development and its fast and effective completion. In a way it can be said that as the characteristics of the companies involved were similar enough in development, these companies were able to utilise the common goal and flat organisational formal leadership structure based on expertise leadership and not on organisational level leadership models. This open fast basic teamlike development in the expertise driven environment gave the project the much needed transparency in development steps and maintained the positive tension throughout the process. For future processes the companies did find that in the future they need to work even more with their customers when they do exercises like these, as in this case the market demand for new specifications and end product options was the main basis for the development cycle, but the customers were not heavily involved in the development process inside the cycle. The result of this was an end product which needed one additional cycle of development to fulfill all the needs of the first customers of the new product. If the few lead user customers had been involved in the decision-making processes inside the cycle, this might have been avoided.

DISCUSSION AND CONCLUSIONS

The main finding is that it is possible to lower production costs e.g. by 30 percent in a prototype phase through innovative, increasing and intense collaboration with partners and also the expected additional costs in the near future when the findings of the development cycle are extended to other product ranges. Although all the cost savings were not necessarily reduced in the end-product in mass production, the results are still noteworthy. This was proved through a case study in a company located in Finland which is a global market leader in its own business segment. This research found 36 key success factors in nine categories including recognition of critical points to describe the process to achieve the very ambitious targets set in this case. In addition to cost savings and improvements in production logistics, this innovative and collaborative development process also resulted in technical improvements compared to the previous product generation. An essential basis for this development project was the recognition of customer needs set for this product segment. Analysis of competitive factors in markets supported focusing on the critical technical features of the product and also the recognition of the minimum requirements set by customers. Therefore this kind of approach has significant effects in the machinery industry.

The framework of the research relied on existing framework models presented in the literature. By combining a case study with the existing frameworks, the study provides a new approach to collaborative product development in the machinery industry to increase cost-competitiveness in the global business environment with its ever greater needs for cost savings or alternatively for entering the potential new markets. This research proves that it is possible to produce high-quality products in a European high-cost country at globally competitive cost level through increasing and real partnership in supply networks. In addition, this development process led to technical improvements and therefore even better customer satisfaction.

The research recognised the significance of service business in machinery industries, although this was not a focal area. The same approach could be applied in the development process of service supply and this would likely produce new business solutions and models in order to increase competitiveness in today's markets.

This research indicated that large degree of freedom to work as a distinguished professional in a very flat and virtual product development organisation composed of several SME companies is very motivating way to work and leads to very good results. As a theme for further research this would need more in-depth research on the organisational operation models and leadership.

The collaborative product development project was based on targets for end-product set according to customer needs as determined by sales functions. A vertical research of sales process formation and development combined with field research related to customer experiences and satisfaction of the new product developed would be worth further scholarly attention. This paper presents the results at prototype level, but there is a need for information about real customer experiences after 2-3 years of using the equipment. After the vertical research it would be possible to assess the benefits of this collaborative product development process and, for example, effects on real production costs and technical quality.

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CRITICAL POINTS IN SUPPLY CHAINS AND PREPAREDNESS FOR CHANGES IN SUPPLY CHAIN NETWORKS

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ABSTRACT

Current trends, for example increased complexity, global procurement and market areas and increasing dynamics in the form of a need for agile and fast responsive supply chains, are increasing the risks in global supply chains. This also implies a more intense focus on the assessment of vulnerability and risk management approaches in supply chain management. This paper presents a framework for identifying critical points in supply chains and for preparing for rapid and often continuous changes in supply chain networks. The framework presented is based on supply chain risk classification and decision-making models in supply chain management.

1. INTRODUCTION

The continuously changing business environment is characterized not only by complexity, but also by uncertainty, which brings challenges for supply chain management. Especially in recent years, various disruptions have become more common in supply chains due to increasing supply chain complexity. Demands for more agile supply chains have also increased supply chain risks (Giannakis & Louis 2011). Many factors such as political issues, fluctuations in demand, changes in technology, financial instabilities and natural disasters have led and continue to lead to uncertainty and the emergency of risk in supply chains. In order to reduce supply chain vulnerability, managing such risks is essential. Supply chain risk management has become one of the main interests in managing supply chain.

Supply chains are susceptible to disruptions with unanticipated consequences. Sodhi & Tang (2012) mention three underlying reasons: there are more points of possible disruption in supply chains than in the past; supply chains are longer with less visibility, which causes slow decision-making and response in case of a disruption; and local "fixes" create problems in other parts of the supply chain. Due to this increase of uncertainty in supply chains, enterprises have to allocate more resources to predict the demand, supply and internal uncertainties in order to decrease the vulnerability and increase the tolerance of their supply chains (Vanany et al. 2009).

A disruption in a supply chain may have a significant impact on the short-term performance and long-term financial situation of the company, making risk management even more vital to reduce the supply chain disruptions Supply chain risk management is about the synchronization of the supply chain's components to face the possible risks and uncertainties caused by logistics or supplier's activities. Moreover, supply chain risk management is concerned with managing current risks by cooperation between different phases of supply chain in a way to guaranty profitability and cohesion in chain. (Tang 2006) Understanding and identifying various risks in the supply chain help managers to make effective strategic decisions in order to reduce the impact of these risks. Before applying methods to reduce the risks in the supply chain, managers need to classify these risks and identify the conditions that cause them.

The purpose of this paper is to describe the status quo of supply chain risk management by analysing the main supply chain risks, focusing especially on strategic decision-making processes. The main objective is to define the most critical points in supply chains and to ascertain what different trends and elements affect supply chain structures. The aim is to explore how changes in these elements affect supply chains.

2. METHODOLOGY

The paper is based on a literature review, case studies and futures research methods, especially scenarios built with a futures table. In the literature review we examined various risks occurring in supply chains, supply chain risk management methods and trends and also the changes affecting supply chain networks. We also interviewed the managers of some global process industry companies. The interviews were conducted as theme interviews, when interviewer is not tied to a structured questionnaire. The scenario method has been used as a part of the framework created during the research process.

With the futures table and scenario methods variables can be structured and possible variations of the future can be described simultaneously in a logical way. Generally futures research aims to strengthen the awareness of the future and support decision-making and futures management. Futures research consists of collecting the intuitive knowledge related to the future, critical analysis, creative synthesis and systematic presentation.

The following three questions are answered: (1) What are the most relevant trends affecting supply chains? (2) What are the most critical points in supply chains and how can these be recognised? and (3) How can companies be prepared to cope with changing situations? In order to answer these questions the paper introduces the framework to identify and manage critical points in supply chains. The framework consists of determining trends, creating future scenarios and identifying critical points. The framework was modified during the research process.

3. TRENDS AND CHANGING ENVIRONMENT

Recent trends in global production have both increased supply chain complexity and strengthened the comprehension that logistics strategies and practices are essential elements of business strategy. Logistical complexity increased when companies changed from centralized, vertically integrated, single-site manufacturing facilities to geographically dispersed networks of resources that collectively create value for the customer. In addition to increased complexity, the supply chains have changed the dynamics in a continuously changing business environment. This development seems to be likely to continue in the future. Therefore supply chain management is an essential source of competitiveness in enterprises and its significance has continuously increased. The competition will be increasingly between sets of networks rather than individual firms. (Gadde & Snehota 2000, Stock et al. 2000, Kinder 2003)

Christopher (2000, 2004) introduced the concept of agile supply chain, which is a suitable approach, especially for seasonal business areas, where real customer demand is difficult to forecast. The agile supply chain is market sensitive and needs advanced use of information technology in order to improve the visibility of demand throughout the whole supply chain. The increasing complexity of supply chains mentioned above is one of the biggest barriers to agility. (Christopher 2000, Christopher et al. 2004) In any case the agile supply chain entails some risks by its own. Agility emphasizes customer service, but increases the risks of reduced financial and operational performance. In other words, flexible operations generally need spare capacity, which reduces productivity and therefore increases costs. With an agile supply chain there is also more risk that customers mainly interested in low prices will move to other suppliers. There is also more risk of underused resources and higher overheads. (Waters 2011)

There is no doubt that current trends in logistics increase the risks to supply chains. Intense competition between companies, the emergence of new products with short life cycle and increasing customer expectations have caused companies to manage and invest in effective supply chains. Some of the most important drivers causing the changes in supply chains according to Waters (2011) are:

- recognition that decisions about the supply chain have a strategic impact on the organization
- realization that logistics gives opportunities for substantial savings
- emphasis on customer satisfaction and its dependence on logistics

- new operations, such as virtual organizations, just-in-time, agility, mass customization, lean operations and time compression
- globalization and growing international trade
- improved communications, particularly through e-business
- other technology, including for example vehicle telematics, intermodal systems, tracking systems, automated handling
- increasing competition, with distant suppliers competing directly with local ones
- integration of supply chains, strategic alliances and partnerships
- organizations focusing on core competencies and outsourcing logistics
- green logistics issues and growing concern about environmental impacts
- changing government policies on the ownership, regulation, use, responsibilities and cost of transport.

Normman and Jansson (2004) mention that some trends clearly affecting the vulnerability and increase in risks of supply chains, are growth in production and research and development outsourcing, companies' tendency to reduce the number of suppliers, global supply chains, reduction of intermediate storage, inventory and lead time, integration of processes among companies, growth of demand for just-in-time supply at shorter intervals, as well as shortening of product life cycles.

Sheffi (2005) examined enterprise vulnerability using numerous examples which may through global supply networks concern each globally operating enterprise regardless of location. Earthquakes, terrorism, fires etc. may cause disruptions, especially if a company applies lean operation models in its business operations. Sheffi determines a firm's susceptibility to a disruptive event as a combination of the likelihood of a disruption and its potential severity. Sheffi also recognised the difficulty of measuring vulnerability by single metrics, because of the wide variety of disruptions and their consequences.

Many trends bring benefits, but at the same time they also increase some risks. For instance, integration of supply chains in addition to benefits also entails some risks through greater reliance on fewer trading partners and single sourcing. In the same way, an emphasis on cost reduction can remove all slack from the supply chain and so increase its susceptibility to unexpected events. Improved communications make the supply chain vulnerable to any problem in the network of systems and globalization increases risks from operating at distant and unfamiliar locations. Outsourcing increases the risks from lost control and reliance on external partners. In addition, one surprising risk related to outsourcing is that it does not always work as well as expected, yielding neither the service level needed nor the expected reductions in cost. (Waters 2011)

4. RISK CLASSIFICATION IN SUPPLY CHAINS

Supply chain risks may be caused by various factors such as political situations, product accessibility features, distance from the source, demand fluctuation, technology change, change in the labour market, financial instability or management replacement (Olson & Dash Wu, 2010). According to Chopra and Sodhi (2004) the most important sources of risk in supply chains are delays in the supply of materials by suppliers, forecast errors, system downtime, capacity issues, inventory issues and disruptions. They classified the risks into nine categories: disruptions, delays, systems, forecast, mental properties, procurement, receivables, inventory and capacity.

Generally risks can be classified into two types: operational risks and disruption risks. Operational risks arise from within the supply chain network, disruption risks are external risks to the network. (Tang 2006) The attributes of operational risks are due to the interactions between firms across the supply chain network, such as supply risk, demand risk and trade credit. Operational risks consist of inherent uncertainty regarding customers' uncertain demands, unreliable supply and uncertain costs. (Tang 2006) Examples of operational risks are forecast errors, material shortage, quality problem, machine failure, transportation risks, storage risks and information technology disruptions. (Deleris & Erhun 2007) Disruption risks arise from interactions between the supply chain network and its environment, such as terrorism, natural disasters, economic recessions and industrial action. (Tang 2006) The notable issue is that usually the disruption risks have more negative impacts than do operational risks (Norrman & Jansson 2004).

Christopher et al. (2011) classifies the supply chain risk into five categories:

1. process risk
2. control risk
3. demand risk
4. supply risk
5. environmental risk

The first two risk categories relate to factors internal to an organisation, the third and fourth relate to factors internal to the supply chain, but external to the organisation and the fifth category relates to factors external to the supply chain. (Christopher et al. 2011)

According to the interviews with management, the most significant and serious risks are those causing direct or indirect losses in sales or interruptions in production. Undisturbed production and sales are therefore considered the main targets in supply chain risk management, where the costs only play a secondary role. The reasons for losses in sales may include delivery delays to retailers or surprisingly strong demand peaks causing shortages of products to sell. These are clear risks and can harm customer relationships and even result in loss of customer. Interruptions in production, in the logistics centre or in inventory can all lead to product shortage at the customer service level. Interruptions in production are therefore a significant risk. Long-term interruptions in production are rare, but can have significant cost impacts. Interruptions in water or electricity supply, fire or other accidents are examples which can cause serious interruptions in production. Dependence on subcontractors is a risk if subcontractors cannot deliver the agreed amount of raw materials when needed or if they have some other problems. Political unrest also causes risks.

In order to manage the supply chain risks a specific method is needed. Giannakis and Louis (2011) proposed a framework for designing of a multi-agent decision support system to manage the risks of a production unit’s supply chain. Wagner and Neshat (2010) introduced a method using Graphs Theory to assess and reduce the vulnerability of the supply chain. They used Failure Mode, Effects and Critically Analysis (FMECA) to identify and assess risks. They also studied the impact of different risks on the system as well as impact of risk reduction activities on system performance.

According to Thun and Hoenig (2011) two different methods to deal with supply chain risks can be found: reactive and preventive supply chain risk management. Their study showed that companies with higher levels of supply chain risk management had better overall performance. Moreover, those enterprises which used reactive SCRM were more successful in reducing the bullwhip effect, while those who used preventive SCRM showed better performance in flexibility and safety stock inventory.

Oke and Gopalakrishnan (2009) studied the risks of retailers’ supply chains. They categorized the risks in two different areas: high volume inherent risks and low volume disruption risks. Matook et al. (2009) proposed a framework for suppliers’ risk management with five levels: identification, assessment, report and decision making, managing risks and studying the performance of risk management.

Source	Supply Chain Risk Classification
Christopher et al. (2011); Christopher & Peck (2004)	Internal risks for the company (process and control), external risks for the company, but internal for the supply chain (supply and demand), external risks for the supply chain (environment)
Waters (2011)	Internal (in operations) and external (come from outside the supply chain) risks
Matook et al. (2009)	Risks of price, quantity, quality, technology, economy, environment, process, management, chaos and inventory
Oke & Gopalakrishnan (2009)	Supply, demand, other risks which cause costs
Manuj & Mentzer (2008)	Supply, demand, operation, safety
Tang (2006)	Operation and disruption risks
Wagner & Bode (2006)	Supply, demand, catastrophic risks
Kleindorfer & Saad (2005)	Supply, demand, disruption, natural disasters
Jüttner (2005)	Supply, demand, process, control, environment
Gaonkar & Viswanadham (2004)	Deviations, disruptions and incidents
Chopra & Sodhi (2004)	Disruptions, delays, systems, forecast, mental properties, procurement, receivables, inventory and capacity
Norrman & Jansson (2004)	Supply and demand

Table 1. Different methods to classify supply chain risks

4. SCENARIOS AS A PART OF SUPPLY CHAIN STRATEGIC DECISION MAKING

Uncertainty means that several possible events are possible after a decision, but only one of them will actually occur. Enterprises seek to find strategies and concepts to fight against potential disruptive events. They need to identify, analyse and mitigate risks to stay competitive in the actual economic context. Supply chain risk management contributes to the decision-making processes in most functional areas within business, for instance marketing decisions concerning product delivery lead times.

Supply chain risk management is a challenging task and still in its infancy. When managers try to improve operational efficiency they rarely consider all the risks. Typically they focus on some of the more obvious risks, but they do not take a balanced view of them all. This may inadvertently raise overall levels of risk and supply chain vulnerability. The remarkable point is that this increase in risk is not a deliberate decision, but an unplanned side effect of related decisions. (Waters 2011)

According to Fahey and Randall (1998) scenarios can help managers discover and understand a variety of possible contexts for decisions about the future. Moreover, integrating strategic analysis and scenario development can strongly influence the destiny of an organization. Scenarios can play an important role in identifying strategic alternatives at both the corporate and business unit levels. One of the questions that needs to be considered concern what risks and vulnerabilities are associated with each alternative and how they can be managed. That way the process also helps managers to manage the possible risks in the supply chain.

Scenarios can be used when facing uncertainty. Scenarios focus attention on unknowns that are important and about which there is great uncertainty. Using scenarios makes it less likely that managers will attempt to defend the indefensible and more likely that they will react quickly and with confidence to unexpected challenges. Scenarios allow managers to continually test their perceptions of an uncertain future. (Fahey & Randall 1998) Scenario building is an instrument that aids decision-makers by providing a context for planning, lowering the level of uncertainty and raising the level of knowledge in relation to the consequences of actions which have been taken, or are going to be taken, in the present. The future will always be unpredictable, but by adopting the right approach and by using appropriate techniques, it can be imagined, planned for and managed. Scenario building has proved to be a powerful and effective component in the strategic planner's toolkit. Scenarios generate a distinctive kind of knowledge and promote organizational learning. They provide a process for enhancing decision makers' understanding of how to prepare for and manage change, they increase the comprehension and acceptance of uncertainty by engaging all concerned in creative thinking, and they demonstrate to stakeholders in an organization how they and it could thrive in future environments that may be strikingly different from the present. (Ratcliffe 2000)

5. FRAMEWORK

This paper presents a framework for the recognition of critical points in supply chains and to prepare for continuous changes in supply chain networks. The framework is based on supply chain risk classification and decision-making models in supply chain management. The framework consists of following steps and elements:

1. Recognizing trends
2. Creating variables of futures table
3. Creating alternative scenarios
4. Identifying critical points in supply chain
5. Preparing to changes
6. Describing impacts on supply chains

First the trends affecting the surrounding business environment need to be recognized. Trends affect supply chain operations, which is why companies need to be aware of them. The most important ones to be recognized are the megatrends, such as globalization and environmental awareness. Based on the recognized trends, business environment variables of the futures table will be formed by evaluating which issues trends affect. In the following step the alternative business environment scenarios are formed. The scenarios are formed with different combinations of values of variables.

Once the possible scenarios are known, we can describe the supply chains in each scenario and find critical points in these. In order to find the most critical points in supply chains, the supply chains need to be described in detail from raw material acquisition to the deliveries to the end customer. Each phase in a supply chain contains risks which need to be recognized and managed. With the help of supply chain risk classification and system boundaries, each phase of the supply chain can be examined. Depending on the approach, the inbound logistics, the outbound logistics or the whole supply chain can be examined. With the help of scenarios we can describe the impacts on supply chains, prepare for possible changes and make strategic decisions based on these. Moreover, if we use some simulation models to simulate the various scenarios in supply chains, for example, the cost and energy efficiency impacts on supply chains can be examined.

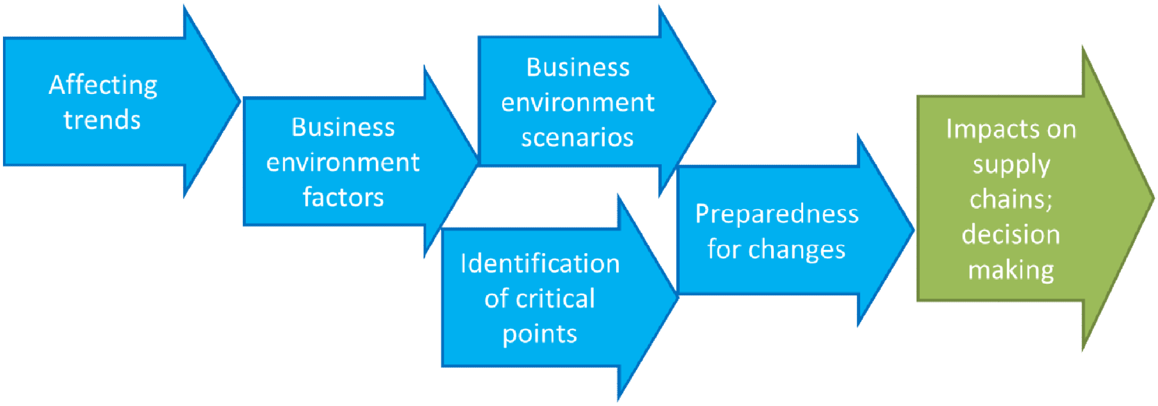

Figure 1. Framework of managing supply chain risks and preparing to changes.

6. CONCLUSIONS

The importance of supply chain risk management as a research area is increasing. Managers are forced to make decisions under uncertain circumstances and industrial companies need to manage their supply chains effectively in order to increase reactivity and efficiency. Everyday problems like supplier losses or quality problems make supply chain risk management important.

Supply chain risk management is challenging, and covers different problems and methods in various industries. Factors such as natural disasters, terrorist attacks, rapid changes in customer demands, products’ short life cycle, machinery failure, operational problems and problems related to supply are the main factors constituting risks in supply chains. Both internal and external factors play a significant role in causing risks for the supply chain and its various phases.

Risk management and the assessment of the vulnerability of supply chains are in an essential role in today’s business environment. The existence of risks means direct effects on profitability of the business due to the possible loss of production and sales, and through probably very costly corrective measures. Therefore the recognition and evaluation of critical points and preparedness for possible failures in business process are highly significant in today’s global business environment.

The main finding is that in order to help strategic decision processes and to prepare for unexpected situations, the risks, trends and future challenges in supply chains need to be identified. Logistics optimization systems can also offer supportive tool to plan supply chain networks and to simulate different scenarios. Recognition of critical points in global supply networks from the perspective of a single company needs a systematic approach. The need for a comprehensive model which can cover different supply chain risks and considers all of the components of supply chain is obvious. This research recognized an ICT based tool with continuous analysis of possible risks and uncertainties in global businesses as an essential approach to this theme. This also forms very interesting and significant topic for further research.

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THE ACCEPTABILITY OF ROAD PRICING: COMPARISON OF VIENNA TO FOUR OTHER EUROPEAN CITIES

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INTRODUCTION

The literature on the acceptability of road pricing has grown tremendously in the last decade (see, for instance, Schade and Schlag (2004), Jaensirisak et al. (2005); Ubbels and Jong (2009); Ubbels and Verhoef (2006); Fujii et al. (2004); and Verhoef et al. (2008)). There are two major reasons as to why this topic continues to attract attention: (1) road pricing is an efficient way of alleviating traffic congestion, reducing environmental impact and generating revenue; and (2) while the efficiency argument in (1) is generally appreciated, researchers have realised that the low acceptability of road pricing is the main obstacle to its implementation – see for instance Frey (2003); Sikow-Magny (2003); and MC-ICAM (2003). Cases that support the first points are the congestion charges in London (UK), Stockholm (Sweden) and Singapore where road pricing has been used successfully to reduce traffic and improve the local environment. For the second, a case in point is Edinburgh (Scotland), where the proposed road pricing was put to a public referendum. The majority were against it, i.e. the scheme was unacceptable to them, and it was therefore abandoned (see, for instance, Hensher and Pucket (2005)).

The aim of this paper is to compare both studies to provide an insight as to whether Vienna is ready for road pricing and to infer whether road users in Vienna have different preferences from those in the previous studies conducted in other cities.

To be able to do this, we have used a replication study. Thus, this paper's contribution to the literature of transport economics and planning is threefold: firstly, it explores factors that determine road users' preferences for road pricing in Vienna, which has not previously been studied; secondly, it applies a previous approach to a new situation to infer to what extent that approach is appropriate for this situation; And thirdly, it gathers information on the relevant criteria needed for a higher general acceptance for creating and implementing road pricing models, and is thus of high relevance to the whole transport and logistics industry.

The rest of this paper is organised as follows. Section 2 is a research background and theoretical framework. Section 3 presents the methodological approach used while Section 4 presents the results. Finally, Section 5 gives some concluding remarks.

RESEARCH BACKGROUND AND THEORETICAL FRAMEWORK

The literature on the acceptability of road pricing includes a substantial number of studies which examine attitudes towards road user charges, even if these are presented under a variety of guises such as "support", "acceptance", "in favour of" and "public opinion" – see, for instance, Jones (1991, 1995, 1998). The literature review offered by Jaensirisak et al. (2005) is arguably the most thorough – and up-to-date – summary of these, as it not only considers the literature on acceptability in general but also divides this into three categories, namely studies from the UK, work drawing on predictive studies, and other studies from the rest of the world. Their conclusions were that it is possible to achieve a high level of acceptance if the scheme is designed appropriately; that it is essential to analyse the impact of the level of toll rates on the level of acceptability, and, last but by no means least, that the distinction between users and non-users has so far been neglected. However, there are, of course, further studies looking at attitudes to road user charges which have been conducted since 2005 and are therefore not included in Jaensirisak et al.'s review. Dill and Wienstein (2007) ran a project which included two telephone surveys exploring the (hypothetical) support of Californian residents for both tax and fee options to fund transportation. Another study, conducted in the Netherlands by Schuitema and Steg (2008), analysed how the acceptability of transport pricing policies was affected by revenue use. Kottenhoff and Freij (2009) used primary and secondary data made up of passenger counts, evaluations of customer satisfaction, travel surveys and interviews to evaluate the role of public transport in the acceptability and feasibility of this congestion charge.

As well as reviewing the literature about road user charges, it is also important to consider the acceptability model used for both studies. As several acceptability models exist, the heuristic model designed by Schlag (Schlag and Teubel 1997; Schlag 1998; Schlag and Schade 2000) and developed further by Schade (Schade 1999; Schade and Schlag 2000, 2003a, 2003b, 2004; Schade 2005) was chosen as the most suitable for the projects.

Both papers (Schade and Schlag 2003b; Fürst and Dieplinger 2012) investigated the implementation of road pricing in the European traffic system, especially in urban areas. The main objective was to assess the public acceptability of different pricing strategies in the European cities of Athens, Como, Dresden, Oslo (Schade and Schlag 2000) and Vienna (Fürst and Dieplinger 2012). A further goal was the identification of public, institutional and political barriers to acceptability, both descriptive and prescriptive. The investigation is based on the acceptability model designed by Schlag which in turn draws on the theory of planned behaviour (Fishbein and Ajzen 1975; Ajzen 1991).

The chosen acceptability model consists of several variables which help to explain the acceptability of road pricing:

Problem perception: If problems are regarded as sufficiently important, even costly measures will be accepted by the general public.

Important aims to reach: To analyse these aims a distinction based on Dawes social-ecological dilemma between social and individual aims seems to be appropriate. The pursuit of social aims (e.g. more space for pedestrians or more bicycle paths) correlates positively with the acceptability of road pricing while pursuing individual aims (e.g. I would like to use my car whenever I like) is negatively correlated.

Attribution of responsibility: distinction between internal and external responsibility; a higher attribution of internal responsibility is positively related to the acceptability of measures

Subjective knowledge**:** Unawareness concerning road pricing leads to a reduced acceptability. Objective knowledge is less important than the subjective one. Thus, it is more important what a person believes to know than what a person really knows.

Perceived effectiveness: a positive correlation between perceived effectiveness of a measure and its acceptability exist

Perceived equity: the perceived equity in the form of expected personal advantages of road pricing can be considered as an important reason for its acceptability

Social norm**:** People, who are closely associated, like family members or friends, expect a certain attitude or behaviour imposing significant pressure on this person. Therefore a measure is more likely to be accepted if this is accepted by the social environment

Socio economic factors*:* road pricing is subject to socio-economic impacts, e.g. example income. The ratio of rejection is higher in low income groups than in groups with higher income

METHODOLOGICAL APPROACH

Research design and method

For the first study initiated by Schade and Schlag 2000 the survey was conducted in Athens, Como, Dresden and Oslo (ACDO). In order to test the acceptability of road pricing among the Viennese car driving population a replication study was conducted based on Schade's and Schlag's (2000) questionnaire used for the EU-founded research project AFFORD

("Acceptability of Fiscal and Financial Measures and Organisational Requirements for Demand Management"). The questionnaire in Vienna was adapted to local conditions.

For the purpose of evaluating the above described problem a structured questionnaire was used comprising 26 only closed questions including both questions of fact and questions of opinion. The full questionnaire can roughly be divided into three parts. First, we asked about the traffic problems in the city where the survey was conducted in general. In order to analyse the behavioural response to road pricing two separate pricing strategies were developed, representing the second part of the survey. Moreover behavioural patterns and preferred solutions have been investigated in this section. In the last part some socio-economic characteristics of the respondent were queried. For instance, the education, the income and the sum of driven kilometres were subject to the questions of the final part.

Sample

The sample was taken from an existing panel of persons willing to participate in market research studies. All participants had to be residents of the city where the survey was conducted hold a valid driving licence for private vehicles and own a car or at least have one available on a regular basis. The sample consisted only of car drivers because they are most directly affected by the implementation of road pricing. Thus it can be assumed that they take a more conservative position than the total population (Schade and Schlag 2001: 73). The survey in Athen/Como/Dresden/Oslo was carried out from December 1998 to January 1999. In Vienna the interviews were conducted in December 2009 and January 2010. All samples reflects particularly well the gender distribution within the car driving population and hence the over-representation of male car drivers.

The road pricing strategies

The pricing strategies used in the AFFORD-Study in ACDO have been developed by Milne, Niskanen and Verhoef (2000, pp. 71-79) who deal with cost based policy packaging. The road pricing strategies used in the questionnaire in Vienna are based on those of the AFFORD-study and were adapted according to Steininger/Gobiet (2005) and Frey/Rauh (2006). For both pricing strategies charges based on driven kilometres have been used. Parking charges, fuel and other taxes remained unchanged.

Strategy "A" (Figure 1) represents the so called "strong" pricing strategy, as a higher charge has to be paid per kilometre driven and the entire urban/city area is covered. Moreover, an additional charge of 100% during peak times is used in order to enhance the steering effect during these times in Vienna. In ACDO an increase in parking charges and fuel taxes are used. In the scenario of Vienna, 80% of the revenues generated are to be invested into public transport while in ACDO the revenues are invested in capacity expansion of known road traffic bottlenecks and lower labour taxes.

Strategy A	
VIENNA	**ACDO***
The car drivers must pay: • 0.25 EUR per driven kilometre • within the complete city area • Mon - Fri 5 am to 8 pm; from 7:00 am to 10:00 am and 4:00 pm to 7:00 pm an additional charge of 100% applies **The revenues are going to be used as follows:** • 20% road infrastructure • 80% public transport	**The car drivers must pay:** • toll cordon with charges of 2 EUR during the morning peak (7.00-9:00 a.m.) and 0.5 EUR thereafter • parking charges increased by 0.5€/h • fuel taxes increased by 0.5 EUR/litre **The revenues are going to be used as follows:** • 2/3 to lower labour taxes • 1/3 to invest in capacity expansion of known road traffic bottlenecks

Figure 1: "Strong" pricing strategy "A"

* Athen/Como/Dresden/Oslo

The second strategy "B" (Figure 2) reflects the so called "acceptable" pricing model. For this measure, a lower charge is used. There is no additional charge during peak times, though the charge has to be paid nonstop from Monday to Friday in Vienna and in ACDO also during the weekends. The revenues in Vienna are invested equally into road infrastructure and public transport. In ACDO the revenues are used equally to offer lower fixed vehicle taxes, to invest in capacity expansion of known traffic bottlenecks and different to strategy A to improve the quality of public transport.

Strategy B	
VIENNA	**ACDO**
The car drivers must pay: • 0.10 EUR per driven kilometre • within the inner districts (1.-9., and 20.)* • Mon - Fri 12:00 am to 12:00 pm	**The car drivers must pay:** • toll cordon with charges of 1 EUR at all times (including nights and weekends) • parking charges increased by 0.25 EUR/h • fuel taxes increased by 0.125 EUR/litre
The revenues are going to be used as follows: • 50% road infrastructure • 50% public transport	**The revenues are going to be used as follows:** • 1/3 to lower fixed vehicle taxes • 1/3 to invest in capacity expansion of known road traffic bottlenecks • 1/3 to improve the quality of public transport
* spatially confined by the "Gürtel", a main urban road, in the West and all Viennese Danube bridges in the East leading to the inner districs (1-9, 20)	

Figure 2: "Acceptable" pricing strategy "B"

Due to the current toll ring in Oslo slightly adapted strategies where used there. Clearly all these pricing strategies represent only two approaches among a virtually infinite set of alternatives. The particular purpose of this approach and the pricing strategies chosen was to offer realistic pricing packages as well as the use of the revenues but not the mere evaluation of single criteria (Schade 2005: 128).

RESULTS

Table 1 lists the results for pricing strategies "A" and "B" of all 5 European Cities. The 'subjective knowledge' of such strategies is quite low, which is not surprising due to the fact that they do not exist in practice yet. Though, there are differences between the cities. The knowledge about the measures is quite low in Oslo and Dresden. In Athens and Como the subjective knowledge is slightly higher. Compared to other European cities, Vienna is in the mid-range. In all cities the 'perceived effectiveness' is considerably higher than the level of 'subjective knowledge'. Therefore, it can be argued that the respondents evaluate the strategies as effective to a certain degree with regard to the reduction of urban traffic and, as a consequence, have confidence in these strategies despite their low subjective knowledge (Schlag and Teubel 1997: 136). One interesting finding is that in Vienna and Oslo the perceived effectiveness for the "stronger" strategy is higher. A reason for this phenomenon could be the fact that Oslo has an existing pricing system and so the respondents already have experience with such a system. Additionally, respondents in Vienna are aware of pricing strategies similar to this in the transport sector - many different pricing strategies exist for trucks. The 'expectation of personal benefits' reveals that the majority of the respondents associate both pricing strategies more with disadvantages, although in all cities – except Oslo - the positive response to the "acceptable" strategy "B" is significantly higher. One reason for this phenomenon may be the higher price for a single crossing of the cordon. In all sites the 'social norm' or pressure is low for both strategies.

All in all, neither pricing package is accepted though there is a significant increase in acceptability of strategy "B" compared to strategy "A". There are noticeable differences between the five cities. Very strong refusal is seen for Dresden and Como, while in Vienna and Athens acceptance for both strategies is less negative. In Oslo, rejection for strategy A is very strong, but acceptance for strategy B is much higher.

City	Strategy	Subjective knowledge	Perceived effectiveness	Personal benefit expectation	Social norm	Acceptability
Vienna	A	1.48	2.55	-.42	1.85	1.92
	B	1.45	2.54	-.23	1.93	2.22
Athens	A	1.70	2.51	.07	2.25	1.96
	B	1.69	2.56	.30	2.41	2.29
Como	A	1.92	2.23	-.39	2.08	1.80
	B	1.72	2.38	-.28	2.21	2.17
Dresden	A	1.32	2.37	-.60	1.70	1.65
	B	1.39	2.37	-.37	1.98	2.07
Oslo	A	1.23	2.50	.16	1.85	1.85
	B	1.27	2.15	-.11	2.37	2.38

All means can vary from 1 (e.g. know nothing at all, absolutely unacceptable) to 4 (know a lot, totally acceptable) with one exception – personal benefit expectation – where means can vary from -1 (expected disadvantages) to +1 (expected advantages).

Table 1: Evaluations of strategy "A" and "B" (means)

A detailed analysis of the acceptability of strategies A and B is shown in Table 2.

Strategy	Total	Athens	Oslo	Dresden	Como	Vienna
A	22	25	24	17	15	29
B	40	43	48	31	34	45

Table 2: Acceptability of strategies "A" and "B" (% who rated the strategy as rather or totally acceptable)

Compared to the other 4 European cities the acceptability in Vienna is very high. Merely strategy B in Oslo is slightly higher.

Multivariate Results

Multivariate analyses, i.e. factor analyses and multiple regression analyses were applied in order to respond to the following questions: (1) Why is the acceptability of certain pricing strategies within car drivers so low? (2) Which factors have an impact on the level of acceptability?

A two-step procedure was carried out in both studies. Factor analyses were used for data reduction of variables with multilevel items, which was necessary for the second step which defined the factors contributing to explanations for acceptability by means of regression analyses (Schade and Schlag 2000: 80).

The factor analysis is used for two main reasons (Schade and Schlag 2000: 80-81): (1) to test differentiation in the theoretical basis of certain variables (e.g. 'traffic-related' vs. 'environment-related problem perception', 'social' vs. 'individual aims'); (2) to reduce the data needed for the following regression analyses

Table 3 summarises the analyses of the 'problem perception', 'objectives', 'expectations' and 'attribution of responsibility' factors. The theoretical differences can be corroborated, e.g. with regard to the 'attribution of responsibility' a distinction between 'internal' and 'external responsibility' can be identified. The results of Vienna are very similar to these of the other 4 cities.

Factor	**Number of items**		**Alpha Cronbach**		**Mean**		**Total variance explained**	
	Vienna	ACDO	Vienna	ACDO	Vienna	ACDO	Vienna	ACDO
Problem perception (traffic)	3	2	.512	.58	2.86	3.18	58.96%	60.83%
Problem perception (environ.)	3	4	.722	.72	2.73	3.01		
Social aims	5	5	.642	.60	2.96	3.30	45.39%	44.9%
Individual aims	5	4	.670	.58	3.21	2.84		
Pos. outcome expectation	3	3	.683	.71	2.42	7.70	59.29%	57.42%
Neg. outcome expectation	4	4	.695	.64	2.88	2.67		
Internal attribution of responsibility	2	2	.588	.74	2.83	2.48	54.91%	56.37%
External attribution of responsibility	6	4	.653	.53	2.88	3.21		

Table 3: Selection of factors created by factor analysis and their descriptive values (means)

The regression analysis was used to answer the following questions related to acceptability (Schade and Schlag 2000: 85): (1) Which factors contribute to explanations for acceptability? (2) Can strategic responses be detected? (3) In what ways do socio-economic factors play a role?

In the following, multiple linear stepwise regression analyses were conducted in order to assess the value of explanations for the variables regarding the dependent variable acceptability of both pricing strategies (Schade and Schlag 2000: 85-86). The independent variables were 'subjective knowledge', 'perceived effectiveness', 'personal benefit expectation' and 'social norm' (Schade and Schlag 2000: 85-86).

In table 4 the regression analysis of strategy "A" in Vienna and ACDO can be seen. The regression analyses in Vienna shows that 'personal benefit expectation' accounts for 44.3% of the criterion variance. Hence, a higher acceptability of strategy "A" is to be expected if personal advantages are expected, if the social pressure is high, and if the strategy is regarded as effective. These three significant variables in total account for 55.8% of the criterion variance. The variable 'subjective knowledge' is not significant and therefore not listed.
The regression analyses of strategy "A" in ACDO shows that three significant variables in total account for nearly 30% of the criterion variance. The surprising result is that social norm has in ACDO the most predictive value of all factors and accounts for 21.5% of the criterion variance. In contrast to Vienna is the variable `subjective knowledge´ significant but does not improve the equation.

VIENNA			
Predictor variables	R^2	B	β
Personal benefit expectation	.443	.619**	.470
Social norm	.531	.414**	.310
Perceived effectiveness	.558	.196**	.172
Constant		.918**	
F total = 103.631 ; df = 3/249			
ACDO			
Predictor variables	R^2	B	β
Social norm	.215	.355**	.354
Perceived effectiveness	.262	.189**	.207
Personal benefit expectations	.299	.227**	.203
Knowledge	.303	.074*	.066
Constant		.152	
F total = 100.829** ; df = 4/926			

*.01 < p < .05; ** significant at p < .01; R^2 = coefficient of determination; B = regression coefficient; β = standardised regression coefficient

Table 4: Stepwise multiple regression analysis of the acceptability of strategy "A" in Vienna and ACDO

As displayed by Table 5 the regression analysis for strategy "B" in Vienna and ACDA corroborates the findings of strategy "A". In the case of Vienna the 'personal benefit expectation' is slightly lower compared to strategy "A" but accounts for 36.2% of the criterion variance and therefore still represents the highest value by far. Together with the 'perceived effectiveness' and the 'social norm' all three variables account for 53.9% of the criterion variance. The variable 'subjective knowledge' is again not significant. In the case of ACDO the three variables (social norm, perceived effectiveness and personal benefit expectations) account for 38% of the criterion variance.

VIENNA			
Predictor variables	R²	B	β
Personal benefit expectation Perceived effectiveness Social norm Constant	.362 .493 .539	.528** .371** .306** .806**	.396 .313 .242
F total = 95.932 ; df = 3/249			
ACDO			
Predictor variables	R²	B	β
Social norm Perceived effectiveness Personal benefit expectations Constant	.301 .347 .381	.364** .206** .224** .522	.378 .207 .214
F total = 189.816** ; df = 3/924			

*.01 < p < .05; ** significant at p < .01

Table 5: Stepwise multiple regression analysis of the acceptability of strategy "B" in Vienna and ACDO

In a further step, the background variables ('traffic related' vs. 'environment related problem perception', 'social' vs. 'individual aims' and 'internal' vs. 'external attribution of responsibility') were integrated into one model with the variables already analysed ('subjective knowledge', 'perceived effectiveness', 'personal benefit expectation', 'social norm' and 'acceptability'). Arithmetic means were generated for all variables by combining strategies A and B (Schade and Schlag 2003b: 56). All analyses were carried out for the total sample. As shown in Table 6, in Vienna the "personal benefit expectation" has the highest predictive power again and accounts for 43.8% of the criterion variance. Furthermore, the predictive power of acceptability is significantly influenced by the criteria "social norm" and "perceived effectiveness", which amount to 54.7% and 58.3% respectively. Within the background variables, the "social" as well as the "individual aims" proved to be useful predictor variables. As expected, a high rating of social aims - like more space for pedestrians or more bicycle paths - indicates a positive effect on acceptability, whereas a high rating of individual aims was proved to affect acceptability negatively. The other, non-significant variables do not show up in Table 8. The results for ACDA are also shown in Table 8. The variables examined in direct relation to the pricing strategies (social norms, perceived effectiveness, personal outcome expectation, etc.) reveal again the highest predictive power. Social norm accounts for 23.6% of the criterion variance and thus show the highest influence, followed by personal outcome expectations.

VIENNA			
Predictor variables	R²	B	β
Personal benefit expectation	.438	.522**	.386
Social norm	.547	.329**	.251
Perceived effectiveness	.583	.220**	.188
Social aims	.609	.251**	.160
Individual aims	.629	-.254**	-.150
Constant		1.130**	
F total = 82.733 ; df = 5/249			

ACDO			
Predictor variables	R²	B	β
Social norm	.236	.269**	.274
Personal outcome expectations	.317	.296**	.270
Perceived effectiveness	.347	.164**	.170
Traffic-related problem perception	.359	-.179**	-.123
General (societal) important aims to reach	.369	.113**	.083
Internal attribution of responsibility	.376	.078**	.088
Knowledge	.380	.068**	.065
Constant		.320	
F total = 80.34 ; df = 7/918			

*.01 < p < .05; ** significant at p < .01

Table 6: Stepwise multiple regression analysis of the acceptability of strategies A and B in Vienna and ACDO

DISCUSSION AND CONCLUSION

The paper reveals that both pricing strategies in all cities are not accepted, however, acceptability regarding the "acceptable" pricing strategy is higher than that for the "strong" one.

The comparison of the multivariate results of ACDO and Vienna shows that the acceptability in Vienna is significantly higher than in all other cities. This is probably due to the following reasons:

1. The replication study was performed about a decade after the original survey. In this period of time, awareness of social effects of transport and the related costs rose significantly in the population as awareness of topics such as global warming due to greenhouse gases and other social costs of traffic have increased.
2. A fundamental difference between the two studies lies in the use of the generated budgets. Whereas in ACDO the use of money primarily for rather broadly defined purposes was recommended, in Vienna a direct investment in public transport and public infrastructure was predicted. Thus, the personal benefit can be perceived much more easily - direct effects can be expected.
3. Taking in to account that close to a majority of the car-driving population could be convinced by a reasonable road pricing system, it can be assumed that the entire population would have a clear preference for such a system. The results clearly indicate that for the successful introduction of a road pricing scheme in a city both awareness of necessity and usefulness needs to be insured and resulting personal benefits for the road users (including private and freight transport) need to be provided.

Our data show that traffic problems are perceived in Vienna, though the present situation is still far from the situation in London before the introduction of road pricing, when traffic speed in the city centre fell to that of a stagecoach (Steierwald, Künne and Vogt 2005: 791-792).

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AN EVALUATION OF CONTRACTOR SELECTION MODELS FOR MAJOR ENGINEERING PROJECTS : EXPERIMENTAL STUDY

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ABSTRACT

Tender evaluation and contractor selection for the delivery of major projects and services is acknowledged as a complex undertaking that embodies many uncertainties. The criteria used for making judgments about potential suppliers and their ability to deliver are varied and many, and often traded-off on the basis of multiple conflicting objectives and stakeholder values. For major projects, this is particularly important. Consequently, decisions must be premised on a contractor's capability as measured in terms of total "value" across all project or system life cycle stages, and not just in its delivery.Other equally important issues emerge as a consequence of the environment in which decisions are made in the presence of uncertainty and risk due to complicated relationships as a result of multiple conflicting objectives. Accordingly, this paper will present the literature on the contractor selection process to identify and establish the relative importance of common criteria used in an actual choice of contractor for major projects as well as the results of an multi-criteria modelling aiming to advance the knowledge and understanding of Contractor Selection, with particular emphasis towards determining which factors (criteria) influence the choice of a contractor.

INTRODUCTION

Tender evaluation and contractor selection continues to be an area of significant importance and interest to organisations responsible for delivering project outcomes. Occurring early in the project lifecycle, it is perhaps one of the most critical undertakings performed by clients, the effectiveness of which is directly related to project success and the achievement of specified objectives (Holt, Olomolaiye et al. 1994a; Lopes 1994; Alsugair 1999). For major projects, this is particularly important. Development time and operational life cover many years, perhaps decades, and often include unprecedented (Non-existent) technologies (Miller and Lessard 2000; Williams 2002; Flyvbjerg, Bruzelius et al. 2003; Watt and Willey 2003). Consequently, decisions must be premised on a contractor's capability as measured in terms of total "value" across all project or system life cycle stages, and not just in its delivery.

Other, equally important issues emerge as a consequence of the environment in which decisions are made in the presence of uncertainty and risk. The environment for making judgments about suppliers and their ability to deliver is complex, comprising high levels of ambiguity and uncertainty, competing stakeholder values and complicated relationships as a result of multiple conflicting objectives (Keeney and Raiffa 1976; Weber 1991; Hatush and Skitmore 1997; Ng and Skitmore 2001; Watt and Willey 2006). The attendant uncertainty and complications give rise to what is referred to as a "messy" scenario in which the likelihood of making a decision along objective lines diminishes, significantly. Given the nature of Contractor evaluations within the context of major projects, the final selection is ultimately premised on an outcome referred to as "satisfycing". This is particularly the case for major projects where selection is often subject to a multitude of constraints or restrictions.

Further complications arise as a result of inconsistencies in identifying suitable and relevant criteria and assigning appropriate weights, all of which vary as a function of many factors, least of which are the organisational objectives and experience of the evaluator. The approach to selecting contractors has been largely constrained to criteria related to either cost and/or technical aspects of the project (Holt, Olomolaiye et al. 1994a; Degraeve 1999; Narasimhan, Talluri et al. 2001; Mahdi, Riley et al. 2002). Whilst these are important factors, they only deal with part of the problem, and do not provide a basis for determining a coherent or reliable measure of total value (Lopes and Flavell 1998; Watt 2006). For instance, a contractor may have an effective technical solution and low price, and appear to achieve high levels of performance, but only at the expense of additional resources. Consequently, such practices have resulted in the need to broaden evaluations with more criteria that reflect an assessment of contractors and their ability to perform across all project dimensions; experience, reputation, past performance, managerial experience and competence, and engineering capability. These do reflect additional risks and are value drivers that, when ignored, have led to in-effective governance of programs and subsequent failures despite being successful when measured in economic and technical terms (Morris 1989; Watt and Willey 2006).

Given the complexities and underlying issues surrounding contractor selection, and the variety of criteria available, how then do clients choose suppliers and what is the relationship between the criteria used in an evaluation? Which criteria influence choice? Is price a more important criterion than experience, capability, expertise, or performance? Does the relative importance vary as a function of industry, position, experience or project complexity? These questions form the basis of continuing research to investigate which factors influence the actual choice of a contractor for major projects and the relative importance of the criteria used. That is, how do clients actually choose a contractor or vendor for the delivery of large scale projects? Despite its importance, this aspect of contractor selection remains largely unexplored, as evidenced by the very few studies reported.

The type and importance of criteria used to evaluate and select contractors or suppliers has been examined under various industrial purchasing situations. These include the supply of professional services and procurement of capital equipment and systems, through to the delivery of large scale projects (Hatush and Skitmore 1997; Alsugair 1999; Hensher, Louviere et al. 2000; Singh and Tiong 2006). Despite significant interest in the topic, research has tended to only focus on issues relevant to either the identification of criteria, or the development of multi-attribute Decision Support Systems. The studies by Holt, Olomolaiye et al. (1994b), Proverbs, Holt et al. (1997), and Hatush and Skitmore (1997), identified a multitude of factors and criteria considered to influence the choice of contractor. Results from these studies indicate frequent use of both general and project specific criteria. General criteria included management experience, qualifications, and capability, project management structure, past performance, workload and capacity, and reputation. Specific criteria included, financial status, experience with similar sized (contract budget value) projects, and years of experience with similar types of projects. Wong, Holt et al. (2000) and Waara and Brochner (2006) investigated the common, perhaps anecdotal, view that choice of contractor is governed by price.

Previous research has identified many attributes or factors that are considered to contribute to the success or failure of major projects and programs as summarised briefly above. However, very little is known about how these factors are determined and the relative significance of each with respect to the selection of contractors.

Accordingly, this research paper summarizes the contractor selection process to identify and establish the relative importance of common criteria used in an actual choice of contractor for major projects. The primary objective of the research is to advance the knowledge and understanding of Contractor Selection, with particular emphasis toward determining which factors (criteria) influence the choice of contractors. All identified and reported criteria were reviewed and sorted into defined categories followed by 8 principal criteria identified. The relative importance of these eight (8) criteria was identified from the previous study, plus the criterion of cost or price using a Discrete Choice Experiment and results were modelled using Multinomial Logit Models.

BACKGROUND

The identification of relevant supplier selection criteria has been the subject of much research across a variety of settings that include the purchase of industrial equipment and delivery of major projects (Dickson 1966; Dempsey 1978; Holt, Olomolaiye et al. 1994b; Hatush and Skitmore 1997; Verma and Pullman 1998; Waara and Brochner 2006). These and many other studies investigated various aspects of the supplier evaluation and selection process within the context of different purchasing and/or contractor selection situations. Aspects included the identification of selection criteria, determining their relative importance, and establishing an empirical basis with which to identify how criteria are traded-off. Other aspects included the use of analytical and multi-criteria approaches upon which to structure evaluations to establish objective measures that included both qualitative and quantitative criteria (Narasimhan 1983; Nydick and Hill 1992; Hatush and Skitmore 1998).

Investigating the supplier selection process from the perspective of the cost associated with doing business, Degraeve (2000) developed a Total Cost of Ownership (TCO) framework. Bharadwaj (2004) investigated the sourcing and supply of electronic components to determine whether the importance of selection criteria varied across different product types or categories. Weber, Current et al. (1991) provided a comprehensive overview of research directed at Supplier and Vendor selection within industrial settings. In examining these, in particular the pre-qualification process, Russell and Skibniewski (1988) outlined a number of recommendations and strategies to improve the effectiveness of decision making. Holt, Olomolaiye, et al. (1994a), in one of the most cited articles on contractor selection, investigated the perceived importance of criteria that influenced a client's choice of supplier. The conclusion drawn from that specific study found that criteria, such as, experience in projects of similar size and type, current workload, management qualifications, and time of year were considered in evaluating contractors. Other studies by Holt, Olomolaiye, et al. (1994b), Hatush and Skitmore (1997) and Proverbs, Holt et al. (1997) suggested selection criteria that provide a measure of a supplier's capability in terms of their organizational structure, management skills, banking arrangements, cash flow, management qualifications and experience, and past performance. To these, Jennings and Holt (1998) later included company reputation, financial standing, workload and capacity, and prior business relationships.

Hatush and Skitmore (1997) in a quest to identify a universal set of criteria suggested a suite of criteria to support contractor selection. Ng and Skitmore (1999) extended the analysis to include an additional group, project management, and identify the top 10 pre-qualification criteria. Fong and Choi (2000), implemented a study that investigated the various Contractor selection practices, techniques and criteria. Further studies by Alarcon and Morgues (2002), Waara and Brochner (2006), Mahdi, Riley et al. (2002), Waara and Brochner (2006) used a suite of common criteria plus author specific ones. Common criteria included company, past performance, financial and contract management, and price. Alarcon and Morgues (2002) included planning and programming, field management, and bid quality, whereas Waara and Brochner (2006) included functional characteristics, technical merit, post delivery service and operational cost. Mahdi, Riley et al. (2002) developed a formal method to evaluate contractors on the basis of past performance and current capability. Specific criteria used included experience, past performance, financial stability, current capability and work strategy.

Mangitung and Emsley (2002) examine the effectivity of the pre-qualification process, its purpose and relationship within the project life-cycle. Cheng and Li (2004) supplement previous research by Fong and Choi (2000) and extend the Analytical Hierarchical Process (AHP) to include the additional influences of all criteria acting on one another. The study by Waara and Brochner (2006), investigated the use of multiple criteria in the award of construction contracts. The particular focus of the study was an examination of evaluations in terms of price versus non-price criteria from both a client and supplier perspective. Gransberg and Barton (2007) conducted an analysis of evaluation plans and criteria specified in the Requests for Proposal of government projects valued in excess of $1.5 Billion.

METHODOLOGY

This research uses an experimental design approach to quantify the importance of common criteria used in an actual evaluation and selection of a contractor/supplier. Unique choice sets were constructed to determine the influence each criterion has on the actual choice of Contractor. Each set is comprised of three (3) tender evaluation outcomes (alternatives) described in terms of all nine criteria, but with varying levels. Respondents simultaneously evaluated all three alternatives within each choice set and selected the most preferred. Utility estimates for each criterion level were determined as was the overall contribution made by the individual criterion. Results indicate past project performance, technical expertise and cost are the most important criteria in an actual choice of contractor with organisational experience, workload, and reputation being the least important.

The relevant criteria were identified from a comprehensive literature review combined with an industry survey which identified eight (8) principal criteria. Although cost (tendered price) was not identified as a principal criterion, it was included in this Preference Study.

The preference study

The Discrete Choice Experiment (DCE) contained information on the factors which were considered to influence the choices clients make when selecting contractors for the delivery of major projects. Several criteria relevant to contractor selection were identified and assessed for incorporating into the Preference Study. Eight (8) categories of criteria were deemed to be principal influences applicable to contractor selection. Interestingly, tendered price appeared to be of little importance, in that the number of occurrences reported across the study was the third lowest of the sixteen categories defined for that study. However, despite this outcome, the criterion of tendered price was included, giving a total of nine criteria to be implemented in the Preference Study (Table 1).

Having identified the nine criteria, suitable numbers of levels and descriptions of each were determined. Several constructs were considered which included all numerical values (weights), all qualitative descriptors, or combinations of both. Numerical values (weights) were preferred, but not possible due to difficulties in constructing a suitable randomised design that ensured the sum of the normalised weights across all criteria within a given choice set would always equate to unity. Whilst the preference was for specific descriptions that provided a measure of objectivity, several criteria could only be defined in subjective terms. After several iterations, and reviews of interim designs, a decision was made to implement a $4^5 \text{ x } 3^4$ design, in which five (5) criterion were assigned four (4) discrete levels, the remaining five (5) three (3).

Experimental Design

A fractional factorial design with three interactions was developed and the following three interactions were included in the final design.

1. Project management expertise (x2) x tendered price (x3);
2. Project management expertise (x2) x past project performance (x5); and
3. Past project performance (x5) x method/Solution (x7).

Questionnaire Development and Choice Set Structure

Having developed the Discrete Choice Experiment, the next step is to format each of the choice sets and incorporate into a questionnaire. The purpose of the instrument is to establish a context, determine the influences acting on contractor selection.The final component of the pilot study investigated the approach to analysing response data and its suitability to determine the importance of the criteria used in contractor selection. Essentially this validated the approach for processing data, establishing the Multinomial Logit Model (MNL) parameter estimates and determining the extent to which each criterion influences selection. Both general and Discrete Choice data were collected from the Pilot Study.

For the Discrete Choice component seven hundred twenty (720) observations were obtained. Each of the fifteen respondents was presented with sixteen choice sets comprising three alternatives. Processing and modelling of discrete choice data was conducted on the complete data set obtained from the pilot study.

Table 1– Design Matrix - Criteria (Attributes) and Defined Levels

Criteria/Attribute	Level 1	Level 2	Level 3	Level 4
organisational experience	< 2 years	2 to < 5 years	5 to < 10 years	> 10 years
project management expertise	Low	Satisfactory	Very Good	Excellent
tendered price	10% Below Tender Average	5% Below Tender Average	5% Above Tender Average	10% Above Tender Average
technical expertise	Poor	Marginal	Above Average	High
past project performance	Unsatisfactory	Average	Good	Very Good
company standing (reputation)	Not Known	Neutral	Reputable	N/A – Not Used
method/solution	Mostly Feasible	Established not Proven	Established and Proven	N/A – Not Used
client-supplier relations	Average	Good	Excellent	N/A – Not Used
workload/capacity	Few Projects, Excess Capacity	Several Projects, Adequate Capacity	Many Projects, Limited Capacity	N/A – Not Used

RESULTS

Results indicated that the survey instrument was effective in collecting the necessary information. Estimated coefficients are significant at the 10% level for many of the variables and above what would be reasonably expected with such a small sample. Estimates increased in terms of absolute value as the level of each criterion became more desirable. Results and feedback indicate the pilot questionnaire could be completed with little difficulty, and that the structure and content was sufficient for meeting the study objectives. After completing the pilot study and making minor adjustments to the questionnaire, the Preference Study was implemented. Respondents were identified through industry and professional associations. No formal screening process was considered, as only project based organisations and associations were contacted. Two hundred and twenty two (222) valid surveys returned.

Discrete Choice Analysis

Discrete Choice Experiment (DCE) is used to determine the drivers or influences acting on the choice of contractor. For this study, a Multinomial Logit Model (MNL) was specified to estimate co-efficients for levels of the nine attributes (criteria) considered. Each of the 222 respondents evaluated 16 individual Choice Sets comprising 3 alternatives (tenderers), for a total of 10,656 observations. A Multinomial Logit model (MNL) was specified and Maximum Likelihood Estimation (MLE) used to determine the utility estimates for all levels of criteria (attributes) under consideration. The results show greater importance is placed on past project performance, or track record, technical expertise, cost and management, indicating that respondents are likely to assign more weight to these during an actual evaluation. Specifically, past project performance and technical expertise are the two most important criteria followed by tendered price and project management expertise. In addition, past project performance and technical expertise are almost of equal importance, but twice that of tendered price and three times more important than project management expertise. The collective importance of these four criteria exceeds 85%, whilst the remaining five (organisational) contribute less than 15%. This latter result is surprising and clearly runs counter to the findings from other studies in which organisational criteria were identified as amongst the most important (Holt et al. 1994; Singh and Tiong, 2006).

A number of significant findings can be drawn from the results. The high levels of importance placed on performance and expertise are clearly key considerations when evaluating contractors. As such, they reflect the greatest areas of concern and risk in achieving project objectives and stated outcomes, particularly when a significant engineering component is included. For large projects, clients expect a technically compliant solution that is capable of immediately generating or improving revenue, or operating and performing as expected. Therefore, contracting organisations with a proven track record of delivery or performance coupled with requisite technical expertise will, in all likelihood, reduce the risk associated with not meeting client expectations.

Other notable findings are summarised as follows. Organisational factors, such as, reputation, experience and client-supplier relations, are often reported as being amongst the key considerations in selecting contractors, along with cost (Holt et al. 1994; Jennings and Holt, 1998; Lopes and Flavell, 1998). However, whilst this research corroborates reasonable importance on cost, organisational criteria were identified as having relatively low importance. Of particular interest, is that organisational experience rated as the least important of all criteria implemented for the study and was expected to rate much higher. This, along with other organisational criteria, provides a measure of confidence to clients in that potential contractors have the requisite experience within a given operational environment. Accordingly, this aspect needs to be further investigated.

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CONCEPTION OF EMPLOYEE TRAINING MEASURES IN THE CONTEXT OF LONG-TERM LOGISTICS PROJECTS IN THE AUTOMOTIVE INDUSTRY

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ABSTRACT

Many automotive manufacturers are facing the core challenge of successively implementing the methods and concepts of lean production in their long-term reorganisation projects. These projects are aiming to create synchronous and value-adding processes of production and logistics. Personnel competencies are of the greatest significance with regard to successfully turning projects into practice. This publication explores the essential design of a training concept which takes the phased and sequential achievements of the Volkswagen Group's concept of logistics and successively integrates and communicates them. It focusses on the planning procedures and the underlying composition of the training concept.

INTRODUCTION

A growing demand for vehicles configurable to customer needs and a generally increasing diversity of equipment options are key complexity drivers in clocked automotive production. The automotive manufacturers' assembly lines need to integrate or keep an upstream stock of more and more components or component variants. Storage thus leaves a spreading footprint on-site the plants. However, since there is limited floor space available for production and storage, there is an increasing need for adapting existing concepts of production and logistics to changing requirements (Klug 2010).

These adaptations are based on lean production whose philosophy and methodology have met with widening acceptance by automotive production. They are focussed on giving in-plant production a synchronous, value-adding and stable shape. With regard to facing the above challenges effectively, previous in-plant approaches to optimising lean production are not enough, though. Instead, the principles of lean production need to be applied to the entire value chain (Holweg et al. 2005). This paradigm shift specifically affects the process architectures and workflows of inbound and in-house logistics which will lead to comprehensively reorganising these fields in a successive manner, taking the shape of long-term projects. Where logistics is concerned, these projects are mainly focussed on organising the flow of materials and information, integrating new IT systems, defining tasks and workflows, and enhancing the personnel's competencies at large.

The latter requires a training concept that systematically integrates and communicates the project achievements as they become available. Competency in this context signifies both process architectures and workflows to be mastered in the future and finding their place within the overall concept.

THE NEW LOGISTICS CONCEPT OF THE VOLKSWAGEN GROUP

The new logistics concept (NLK) of the Volkswagen Group is based on the Group's system of production and is thus a component part of a global strategy of production (Heizmann 2010). It aims to reduce the throughput time along the entire value chain, that is to say, from the place of in-plant installation back to the component factories and every single supplier (as shown in Figure 1). As opposed to past practice, the security of production supplies will no longer be ensured by materials on buffer stock but by very frequent deliveries of material. To accomplish this mission, the processes of production and logistics need to be synchronised (Zernechel et al. 2011). Further objectives of the concept are to improve schedule adherence, productivity, quality, and ergonomics and to reduce costs. It will take several stages to implement the NLK in all plants (Heizmann 2010). All optimisation efforts start at the in-plant place of installation and assembly. Effectively and efficiently provisioning material at the workplace reduces distances to be walked and improves the value-adding times persons spend at their place of work. Clocked routed traffic delivers the required materials directly to the place of work.

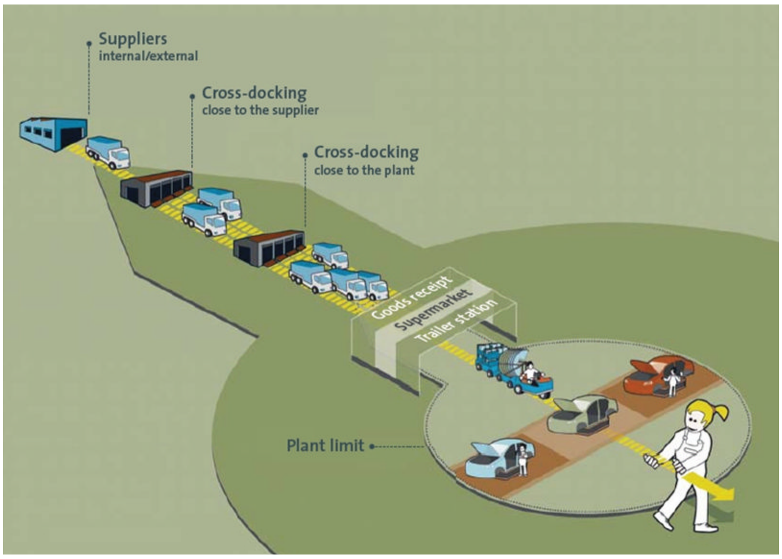

Figure 1: NLK sphere (Volkswagen AG 2010)

This is significantly reducing the number of supply deliveries as previously demanded by the use of stackers. Route traffic carriers are loaded in the Supermarket made up of a buffer area and a trailer loading station (as shown in Figure 2). The latter will mainly be required for the first NLK stages when not all suppliers will be able to sort or sequence all of their materials in the container (Zernechel et al. 2011; Heizmann 2010). This, in turn, is caused by early order scheduling "just in sequence" not being fully available due to a lack of production programme stability.

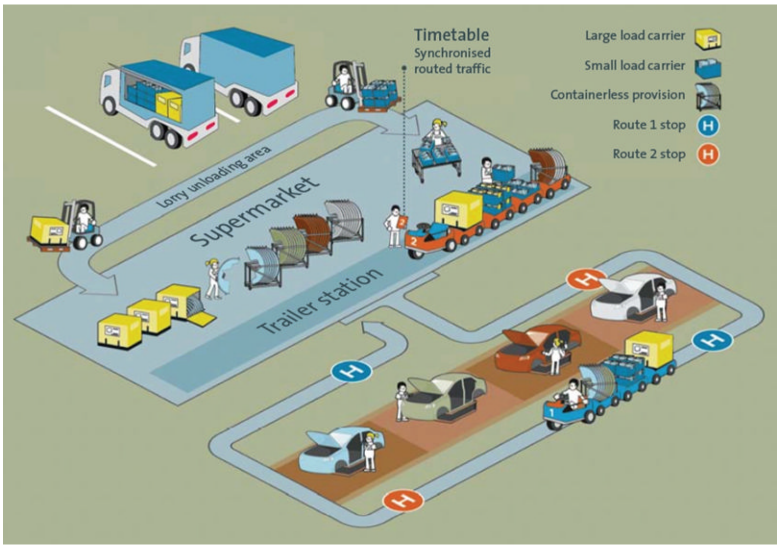

Figure 2: NLK in-house area (Volkswagen AG 2010)

In order to reduce the stock on hand, inbound logistics is planning to introduce Milk Runs and Cross Docks which will be progressively integrated into the value chain, aiming to collect small amounts of material and deliver them by highly frequent and clocked traffic (Heizmann 2010). Clocking is aligned with production cycles (Zernechel et al. 2011). In order to actually build the process architectures described, the NLK inbound area will add a new system of requesting and timetabling (Heizmann 2010).

BASICS AND AIMS OF PERSONNEL COMPETENCY

The objectives of occupational and operational further training have changed with the organisation of work. Whereas its previous focus was on the qualification required to perform certain tasks, it is more concerned with the individual and its progress in competency today (Schröder 2009). In this context, competency shall be construed as the inner disposition to act in a self-organised manner under unknown constraints (Erpenbeck et al. 2003). Competency is made up of the mental abilities (knowledge), the motivation to act successfully (commitment), and task-related prerequisites (skill) (Witzgall 2008).

Successful action is achieved by combining knowledge, skill and commitment in a characteristic manner. A distinction can be made between various aspects of competency, or, to be more precise, between professional, methodological, social and personal competency (Witzgall 2008). Subsuming these aspects under one competency results in a person's occupational competency of active decision-making and responsibility. This is comprised of a person's abilities, skills, knowledge and methods of thinking which enable that person to complete both familiar and unfamiliar tasks in a self-organised, task and mission-orientated, and responsible manner that takes account of the actual situation (Kauffeld 2006). In theory and practice, developing the competency of decision-making and responsibility has become the general and superior objective of occupational and operational training. Developing one's competency may follow both formal and informal educative and learning curves (Dehnbostel 01). Formal learning processes such as scheduled training measures are increasingly based on the concept of active learning. Active learning takes a holistic approach to the learners' activity such that the outcome of actions guide the organisation of the teaching/learning process as agreed by instructors and learners, leading to a balance of mental and physical work (Jank et al. 2011). The level of active competency someone has achieved shows in the way they are able to accomplish a set task (Frieling 2000; Kauffeld 2006).

TRAINING CONCEPT REQUIREMENTS

Successive implementation of the NLK in a project spanning a period of several years requires a training concept that allows current and future project implementation stages to be integrated and communicated in an active manner. Active communication does not refer to performing certain tasks in a training sense but primarily to obtaining the professional and methodological competency required to organise and shape a synchronous value-added chain. The scope of a person's ability depends on the function and area (inbound or in-house) that this person works for. In other words, a shop floor person needs less professional and methodological competency of organising and shaping a synchronous value-added chain than a person doing logistics planning or supply chain management work. However, since the actions of both persons will affect the successful implementation of a synchronous value-added chain, they both need to be appropriately qualified for their purposes. In this context, appropriate means that the NLK generates the professional and methodological competency of organising and shaping a synchronous value-added chain as required for accomplishing their personal tasks.

To this end, the training concept should be unitised, unitised meaning that all training measures or units can be linked up in a plug & play fashion. Thus, in-house and inbound issues should be addressed in both ways, i.e. in both separate and shared training units. The latter are of utmost significance to persons whose work requires them to have an integrated perception of the entire value-added chain.

Apart from this horizontal "unitisation", the development of a person's abilities with regard to their operational function also demands a vertical unitisation of every training course. This is saying that the level of professional and methodological competency achieved or taught may vary within a single unit of training, thereby ensuring that different competency needs can be satisfied.

EDUCATIONAL OBJECTIVES OF THE TRAINING CONCEPT

Educational objectives are the foundation upon which the training concept is erected. They determine both, the choice of didactic methods and real-life pedagogic actions and were identified by means of a questionnaire filled in by NLK experts. A benefit analysis was afterwards applied to the questionnaires. It resulted in a ranking of educational objectives the following of which were chosen in the end:

Objective "background, chances and risks": This objective focusses the background, chances and risks emanating from the NLK for the Volkswagen Group. It intends to put the NLK into the perspective of the Group's system of production, explain the interconnectedness of the Group's system of production and NLK, and illustrate the resulting chances and risks.

Objective "process modules": A process module comprises elements of the NLK's value-added chain which are either put into practice or removed with reference to the progress of the project. Supermarket and Cross Deck are examples of process modules. A process module is characterised by containing material quantities which are either placed into stock, reallocated, moved to another place or deployed for assembly or installation. The aim behind this objective is to communicate the classification, function and properties of existing and future process modules of the in-house and inbound areas.

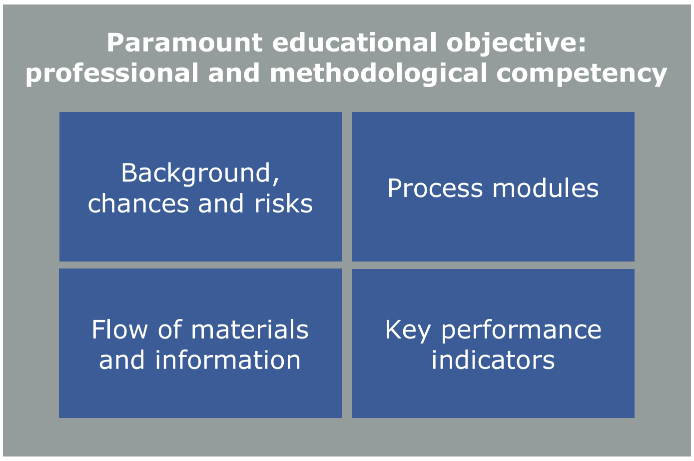

Figure 3: Educational objectives of the training concept

Objective "flow of materials and information": Reorganising the exchange of materials and information between the value chain's elements or process modules is one of the NLK's key challenges. It is therefore aimed at how the NLK communicates the flow of materials and information. Introducing a Milk Run is an example of a relevant flow of materials. Sending a supplier a request for material is an example of how to design the flow of information.

Objective "key performance indicators": Within the scope of the NLK, a set of key performance indicators known to everyone involved is used to assess the measures taken to optimise the value-added chain. This is ensured by presenting each key performance indicator, illustrating its influential factors, and showing how the key performance indicators in the set interact.

Combining the above educational objectives leads to the following paramount objective: Communication of professional and methodological competency of generating a synchronous value-added chain with reference to its logistic interdependencies (as shown in Figure 3).

CHOOSING A DIDACTIC MASTER METHOD

Choosing a didactic master method of the training concept is based on the Instructional Design procedures. Instructional design aims to develop, implement and evaluate efficient systems of instruction and learning (Dick et al. 1989); (Dijkstra et al. 1997); (Seel et al. 2004).

The final choice is thus based on three key characteristic findings: educational objectives, target group and constraints or restrictions (as shown in Figure 4). Since the training concept objectives have been discussed in detail in the preceding chapter, the text below will explain how a target group is characterised.

The details required to characterise a target group are who belongs to it, how many persons are in it, and what they know already. In this case, the target group iNLKudes everybody from a shop floor worker to the head of an organisational unit. Taking a horizontal view of the value chain, the target group comprises persons working for the supplier, carrier, logistics service provider, production, production control, procurement, and logistics. In a word, the target group is made up of persons whose relation to the value chain and, thus, to the NLK is widely varied. The didactic master method must take account of this fact. The final choice is also subject to existing constraints, iNLKuding the budget available for development, instructor / learner systems or types of learning potentially to be excluded as well as the available floor space.

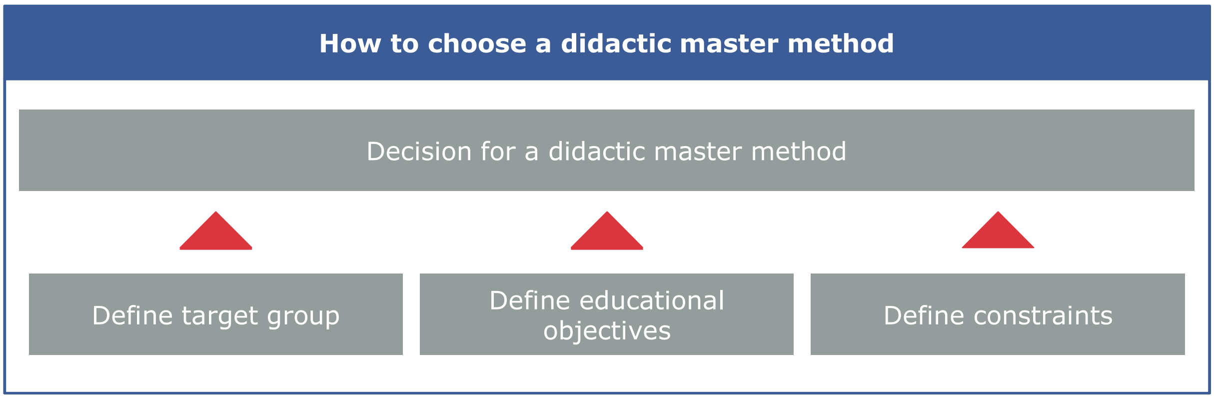

Figure 4: How to choose a didactic master method

After reviewing all information at hand, a choice was made for the active learning method of the business game. This method is particularly suited to communicating the paramount educational objective with regard to the target group to be taught. Taking account of the latter and the constraints identified led to opting for a haptic type of business game. Participants thus play an active role in the business game.

BUSINESS GAME METHODOLOGY

Business games simulate situations which are not easily understood, experienced or assessed because they are too complex, intransparent and currently not occurring and which are therefore difficult to illustrate with reference to everyday practice. Their focus on "hands-on planning" marks the difference between business games and simulations. Business games as used in occupational or operational education have no playful intentions but are dedicated to work and learning processes and, as such, distinguished from simple playful enjoyment (Blötz 2005). BLÖTZ identified the following characteristics which mark the difference between business games and other methods:

- An environment for experimental action or action testing is provided or created during the game.
- Players become part of this environment as they experiment with the overall process simulated. Unless there are rules of the game, players will develop their own set.
- The effects of the actions taken are simulated and the success of the action is fed back. This is based on various models designed to verify the suggested actions. Feedback generates more planning work which takes the simulation further.
- Simulation loops are created to keep track of the behaviour of the system.
- Business games are centred around acting and its consequences.

Targets and contents of acting emerge as players are engaged in the set environment, i.e. the game. Thus, educational objectives are indirectly communicated by the game objectives (Blötz 2005). When developing business games, the first step is to design a model of the simulated system with reference to prioritised objectives. This process is greatly influenced by the chosen level of abstraction. The next step is to decide on the type of game (computer simulation, haptic simulation, etc.), the level of control exerted by variables, and the interaction of these variables. Once all documents of the playing and reflexion stages are available, a prototype is set up and tested several times for evaluation (Kriz 2000).

DEVELOPING A BUSINESS GAME TO SERVE AS A BASIS OF TRAINING

The training concept discussed in this paper employs a business game as the paramount didactic method to communicate the educational objectives described. As mentioned before, business games simulate situations or systems which are not easily understood, experienced or assessed because they are too complex, intransparent and currently not occurring (Blötz 2005). If the NLK is construed as a system made up of several sub-systems (in-house and inbound) and elements (process modules), the first step of developing a suitable business game is to define the limits of the system. Considering that issues of different sub-systems are to be addressed by both separate and shared training units leads to a need for also delimiting the sub-systems. The system of the present business game is limited by the scope of NLK application. It must therefore cover the entire value chain from materials provisioning at the place of installation to loading the lorries on-site the supplier's. Sub-systems are separated by a process module called "plant warehouse".

Defining the limits of the system is followed by establishing what exactly the business game is to simulate. This decision is based on the educational and project targets discussed. The latter aim is to reduce the throughput time along the entire value chain, that is to say, from the place of in-plant installation back to the component factories and every single supplier. The business game must therefore mainly simulate how the entire value chain is affected by efficient materials provisioning at the place of installation and by reducing the amount of stock at hand. A consequential requirement of the business game is that it must be able to integrate all flows of materials and information iNLKuded in the simulation as well as the NLK's relevant process modules.

Next, a suitable simulation object is required in order to make the business game simulate the above effects. A choice was made with reference to the types of materials provisioning at the place of installation to be represented and the logistic interdependencies within the overall system to be simulated. Against this background, a small toy car was chosen whose components can be turned into variable sub-assemblies. Since the object of simulation allows the variant diversity of every component to be increased infinitely, the game is able to simulate variant-specific types of materials provisioning such as just-in-sequence provisioning.
Another task of the game is to successively integrate future project implementation stages. Thus, the business game must start out from a situation which supports a gradual optimisation of the system. The project targets were taken to design this initial situation. In the context discussed, the initial situation was set to assume high volumes of stock at hand and little diversity in component variants. High initial stock levels leave enough scope for optimisation measures potentially able to reduce stock accumulations along the value chain. The small initial number of component variants provides much potential of increasing the system's complexity. Dedicated training units are then applied to continuously adapting the initial situation to actual project achievements. The outlined training concept is thus able to keep pace with the evolving progress of the project.

DESIGN AND COURSE OF DEDICATED TRAINING UNITS

Under the training concept of this paper, a training unit applies to either the entire NLK realm or to one of its two sub-systems. Didactics and methodology of all training units are based on the haptic business game discussed herein. Simulations will always focus on the topic or area a training unit is dedicated to. Apart from this horizontal unitisation, a training unit is thus able to also adapt the level of professional and methodological competency communicated. Such adaptation consists of varying the scope and level of complexity of every optimising action to be taken. Players will find it increasingly cumbersome to accomplish the set targets of the game as optimisations become more comprehensive and difficult.
Participants are supported by specific theoretical instruction adapted to the scope and level of complexity of a given optimising action. At the next step, a classification is presented to allow players to keep track of how this fits into the general scheme.

Every training unit breaks down into four stages some of which are completed several times (as shown in Figure 5). At the "introductory stage", players are first of all familiarised with the environment set up for the business game. It consists of presenting and explaining the targets, key performance indicators, places of work, and actual tasks. The introductory stage is followed by the "simulation and reflexion stage" giving participants the chance to simulate and reflect the system. Reflexion is based on the game's targets and key performance indicators. After due reflexion, participants move on to the "problem comprehension and solving stage". At this stage, participants will work to establish the key issues as yet stopping the game's targets from being achieved. This is followed by developing solutions to the issues found. Another "simulation and reflexion stage" allows participants to explore the suggested solution. Achieving all of the targets starts off the "terminal stage" at which the topics taught and learnt are briefly summarised.

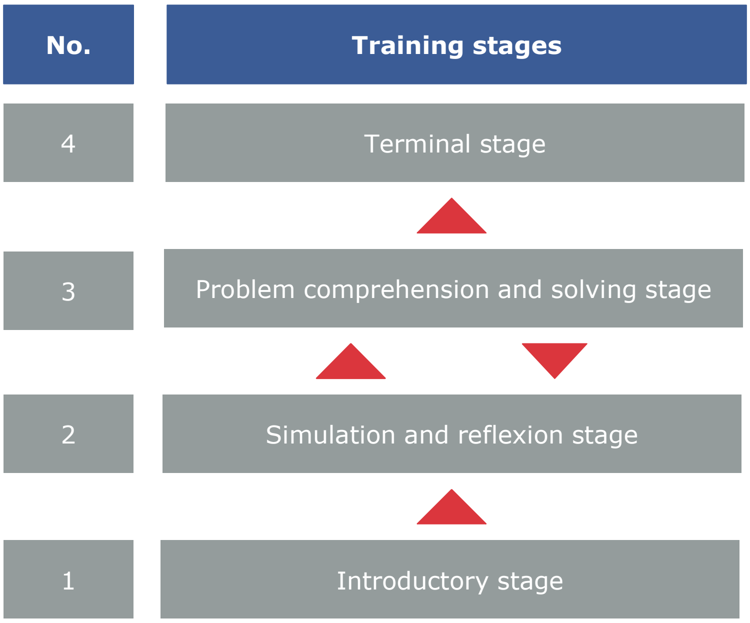

Figure 5: Training unit stages

At present, three training units have been designed and evaluated for the previously developed business game. Two of these are dedicated to the inbound area, the third one to the in-house area. When evaluating these training units, the business game method proved to be an excellent basis of an adaptive training concept. Further training units are currently under construction.

CONCLUSION

Many automotive manufacturers wish to establish a synchronised value chain. Its implementation largely depends on how well the personnel's skills and abilities can be trained. Best practice is to develop training concepts that back up the gradual introduction of a synchronised value chain by means of long-term reorganisation projects. This publication discusses these necessities taking the Volkswagen Group's new logistics concept as an example of how an adaptive training concept may be planned and designed on the basis of a generic concept. Major findings are the choice, implementation and application of business games as the paramount didactic methodology of an adaptive training concept.

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EXAMINING HOW MACRO-LEVEL SUPPLY CHAIN INFRASTRUCTURE AFFECTS TRADE OUTCOMES

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ABSTRACT

Recent empirical studies of global logistics and market performance in emerging economies have led to mixed results regarding logistics infrastructure capability as a factor determining foreign market entry. Evaluating country markets is a daunting task as companies extend their supply chain footprint into foreign markets in search of high quality low-cost materials (sourcing), lower production costs (producing), and new consumers (distributing). This research adopts the macro-level perspectives recently reported in the literature and operationalizes constructs representing the suggested dimensions. We link macro logistics system complexity, trade factors, as they are essential components in the market selection decision. Relationships between logistics infrastructure and trade performance are examined using OLS regression. We find statistically significant relationships for certain dimensions of logistics to trade performance. Our findings shed new light on the relative differences among countries regarding several dimensions of logistics infrastructure.

INTRODUCTION

Global competitiveness and the diffusion of electronic commerce across diverse industries have extended across borders the functions of sourcing, producing and distributing products and services (Cohen and Mallik, 1997). Distributing products across these diverse markets has become imperative for corporate profitability, but there are vast differences among countries in terms of transport time, international shipping, risk, market access, and logistics infrastructure (Arvis, Mustra, Ojala, Shepherd, and Saslavsky, 2010). The World Bank estimated that 20% of the consumer population does not have access to reliable infrastructure and other basic services (World Bank Group, 2004). Kinra and Kotzab's (2008a,b) stream of work suggests that such differences are fundamental to the supplier selection, facility location and resource allocation problems in the context of macro-level supply chain decisions, and decision makers are not willing to delay action in the hope that uncertainties and inefficiencies will abate. A better understanding of these interrelationships may inform how decision makers formulate strategies for managing and integrating the material, information and revenue flows across the international supply chain.

Academic attention to emerging market countries (EMs) in this context has not kept pace with logistics trends in international expansion (Quinn and Hilmer, 1994; and others). While researchers do not agree on the extent to which environmental, economic, and transport related factors impact trade, there is little doubt that trade is influenced by transport infrastructure (Wiley, 1999) through its extensive impact on efficiency (Gorman, 2006; Wang and Cullinane, 2006). Recently there has been renewed interest in advancing the understanding of these relationships.
The perspectives outlined above have at least two common threads: (1) given the expanding complexities of global supply chains and trade, lowering unit sourcing and manufacturing costs does not necessarily translate directly into lower total landed costs per unit (e.g., the total per unit costs associated with importing, exporting, transportation, customs clearance and processing of goods from distant markets), and (2) consumer and industrial demand create trade flow between countries to fill the shortfall in domestic production and supply. However, the increased trade flow volume can itself directly affect supply chain costs, increase uncertainty, increase congestion and lessen the efficiency of logistics and trade infrastructure.

Uncertainty affects managing and integrating the material, information and revenue flows across the international supply chain; efficiency differences derive from disparate infrastructure endowments and regional diversity across countries. Tirschwell (2007) and Bowe (2006) observe that domestic and global conditions promoting trade and commerce are clashing with *obsolete infrastructure* and *uncertain market potential*. We infer that patterns of trade development are influenced in part by macro-level (rather than firm-level) logistics infrastructure, therefore, research should include factors related to public infrastructure. The paper is organized as follows. The next section positions this study within two important research streams related to a country's market potential and logistics infrastructure. This sets the stage for the proposed conceptual framework. Methodology is presented next, followed by a discussion of results and the conclusions.

LITERATURE BACKGROUND

Two diverse but content-related streams of earlier work provide the foundations for the current research on market potential and logistics infrastructure. One stream of work adopted the macro-level view of market potential for EMs and developed economies, often using clustering techniques. The second focused on the impact of a country's logistic gestalt. For purposes of unifying the discussion, we use the terms 'markets' and 'countries' interchangeably to refer to sovereign nations because these literature streams use both terms, but our interest lies in country-level application. Relevant studies from both streams are reviewed below.

The Market Potential of Countries or Markets

The first stream of work adopted the country-clustering lens (or country ranking lens) and assessed market potential. Some clustering methods (Cavusgil, Kiyak, and Yeniyurt, 2004; Huszagh, Fox, and Day, 1985) and market potential weighted indexing methods (Cavusgil, 1997) were used to develop macro-level insights to EMs. Liander, Tepstraa, Yosihino and Sherbini (1967) reported a seminal study of international market selection and analysis; although contributing new insights, the study was criticized for the lack of methodological rigor by Sethi and Holton (1969). Sethi (1971) then incorporated 29 political, cultural and socioeconomic indicators as drivers of international marketing decisions. The author argued for segmentation into clusters by similarity so that more uniform marketing decisions could be applied to groups of customers (or countries) and concluded that countries should not be classified on development alone.

Since these early studies, clustering methodologies based on social and economic dimensions have become prevalent in the marketing domain (Huszagh, Fox, and Day, 1985; Cavusgil, 1990; Cavusgil et al.,2004; others). For example, Cavusgil (1990) offered a market-oriented clustering study based on social factors such as population growth, median age, number of children per household, participation of women in the work force, infant mortality rate, life expectancy, and GNP per capita. The result was five clusters (e.g., Dependent Societies, The Seekers, The Climbers, and others) and implications for each cluster were offered. Cluster membership by any given country was dynamic, depending on the pace of innovation and industrial sector evolution globally. In another study, Cavusgil et al. (2004) demonstrated the combined use of clustering and indexing procedures for foreign market assessment. Clustering allows countries to be categorized homogenously, while indexing permits relative comparisons of EMs.

Global Logistics Investments/Expenditures

The second stream of work on foreign markets adopts the logistics expenditures/ infrastructure lens (Bowersox, 1992; Bowersox and Calantone, 1998; Bowersox, Calantone and Rodrigues, 2003; Rodriguies, Bowersox and Calantone, 2005). Heskett, Glaskowsky, and Ivie (1973) first developed a methodology for estimating country-level logistics cost, applying it to the U.S. Total logistics cost was defined as the sum over four activities: Transportation, Inventory, Warehousing, and Order Processing. Annual U.S. logistics estimates appear in the State of Logistics Report (Wilson, 2006).

One major challenge in estimating global logistic expenditure is that the data required for direct measurement are not available consistently for developed nations, and generally not available for emerging and transitioning countries (Bagai and Wilson, 2006). Primary and secondary data must be matched in country-level analyses, but the availability of such data often varies extensively by country and/or region of the world. The first study of global logistics expenditure by Bowersox (1992) estimated global logistics costs based on four components: Total Gross Domestic Product (GDP), Government Sector Product, Industrial Sector Product, and Total Trade Ratio. Follow-up studies (Bowersox and Calantone,1998; Bowersox, Closs, and Stank 1999; and Bowersox, Calantone, and Rodrigues, 2003; Rodrigues, Bowersox, Calantone, 2005) refined the estimation method by using an Artificial Neural Network model or by including supply chain infrastructure variables related to cost and information/ communication systems. Their most recent 2002 estimates are that global logistics expenditures are 13.8% of world GDP. Interestingly, they found that logistics efficiency increased in developed regions, but not in the rest of the world.

This stream of logistics work highlights the necessity for logistics infrastructure investment and efficiency improvements throughout developing nations, but is silent on other institutional considerations such as national account remittances, for example. These gaps, which our research attempts to address, limit implications for improving trade flows and country-specific logistics infrastructure. For example, a recent survey by Barloworld Logistics (2006) notes that 80% of retail products imported to sub-Saharan Africa enter through South Africa. In many African EMs, access to rural consumers both grows markets and increases logistical complexity and cost.

Integrating the Two Research Streams

Viewed separately, these two streams of work have each provided interesting lines of academic inquiry and also highlight the challenges companies face when evaluating new market opportunities. Clearly, as Clark (2003) suggest, there is a relationship between supply chain-related infrastructure and costs and the capacity of a country to attract international trade and participate in the global economy. The current research explores more explicit dimensions of macro-level logistics infrastructure along with market potential information (Orozco, 2002; Gorman, 2006). An integrated conceptual framework that bridges the market clustering or ranking literature and the logistics cost/infrastructure literature is proposed in the next section. This framework proposes performance relationships between the macro input factors and the country-level trade output performance dimensions, and addresses the following key question:

What impact does infrastructure have on trade activity performance such as export/import ratios at the country-level?

This kind of integrative work represents the logical next research direction; initial macro-level studies have just started appearing (Kinra and Kotzab, 2008a,b). While there has been some academic interest in this area (Garrison and Souleyrette, 1996; Haas, Murphy, and Lancioni, 2003; Berman, 2007), there are no other published studies of EM potential and logistics infrastructure from the perspective taken here.

CONCEPTUAL FRAMEWORK

The first proposal is that there is a direct relationship to trade performance from country macro factors concerning logistics infrastructure and development (Kinra and Kotzab, 2008a,b; Weber and Weber, 2004). This is our baseline proposal. Thus:

H1: Macro input factors focusing on logistics infrastructure and development are related to trade performance.

More specifically, H1a- H1f concern the following trade-related *dependent variables*:

- H1a: Airfreight ton-kms (airfrt)
- H1b: Transportation Services (Trnsptsvc)
- H1c: Commercial Services Ratio (Servratio)
- H1d: Hi-technology exports Ratio (Hitechratio)
- H1e: Food exports vs. imports Ratio (Foodratio)

- H1f: Fuel exports vs. imports Ratio (Fuelratio)

All variables in the model are defined in Table 1. Thus six linear models of the direct relationships between country-level infrastructure dimensions and trade performance factors will be estimated. Each of these seven serves as a dependent variable in **Equation 1** below to test Hypothesis 1, as illustrated for H1a: Airfrieight (Airfrt):

Equation 1

$$Airfrt_j = \beta_0 + \beta_1 * \mathrm{Re}\,mit_j + \beta_2 * RurlDens_j + \beta_3 * RoadDens_j + \beta_4 * RailDens_j \quad (1)$$
$$+ \beta_5 * Lnxdys_j + \beta_6 * Telemobl_j + \varepsilon_j$$

TABLE 1: DEFINITION OF VARIABLES

Variable	Category	Measurement Description	Role in the Models
Airfrt	Trade	Air freight shipments in million tons per km	Equations 1, dependent variable
Trnspsvc	Trade	Ratio of exported-related vs. import-related transportation as % of commercial services	Equations 1, dependent variable
Servratio	Trade	Ratio of exports vs. imports in current (2004) US $	Equations 1, dependent variable
Hitechratio	Trade	High-tech exports as a % of manufacturing exports	Equations 1, dependent variable
Foodratio	Trade	Ratio of food exports to imports as % of merchandise exports (imports)	Equations 1, dependent variable
Fuelratio	Trade	Ratio of fuel exports to imports as % merchandise exports (imports)	Equations 1, dependent variable
Remit	Development	Workers' remittances as a % of GDP	Equations 1, independent variable
RurlDens	Logistics Infrastructure	Rural population per sq. km of arable land	Equations 1, independent variable
RoadDens	Logistics Infrastructure	Kilometers of roadways per 1000 sq-km	Equations 1, independent variable
RailDens	Logistics Infrastructure	Kilometers of usable rail per 1000 sq-km	Equations 1, independent variable
Lnxdys	Logistics Infrastructure	Natural log of the average time (days) to export a standard shipping container	Equations 1, independent variable
Telemobl	Logistics Infrastructure	Number of main line and mobile phone subscribers per 1000 people	Equations 1, independent variable

In Equation 1 there are six *independent variables* (see Table 1). Workers' remittances (Remit), as defined by the International Monetary Fund (IMF), is the transfer of disposable income mainly from foreign nationals and migrant workers in developed countries to family members in their home (EM) countries. The IMF and the Inter-American Development Bank view such financial transfers as drivers of consumption (and production) in the receiving country (Orzco, 2002) since recipients spend domestically upwards of 60% of remittances on consumer goods and services. Remittances can deepen the trade, transportation and telecommunication links between sending and receiving countries. Rural density (*RurlDens*), road density (*RoadDens*), and rail density (*RailDens*) capture the concentrations of potential consumers, road infrastructure, and rail infrastructure, respectively. *Lnxdys* is the natural log of average export clearance time for containers, while *Telemobl* captures the concentration of cell phone and landline usage. These are used as indicators of logistics infrastructure capability.

THE DATA

Quantifying foreign market opportunity is a primary concern for academics, practitioners and policy makers, and a diverse set of approaches have been reported (Helsen, Jedidi and DeSarbo, 1993; Rodrigues et al., 2005). In this study, macro-level trade proxies are used to represent the countries' economic perspectives. When using secondary data, there may be questions surrounding reliability and authenticity. Nevertheless several supply chain scholars and strategy scholars relied upon similar data, such as world development or competitiveness indicators reported by the same or equivalent government and non-government sources. We operationalize many of the construct dimensions reported in Kinra and Kotzab's (2008a) conceptual framework for exploring logistics macro system complexity. For illustrative purposes, input factors were collected for the year 2003. To ensure reasonableness of their relationships to trade output, the trade performance factors were collected for 2004 to create a one-year lag. All data were matched by country. A correlation analysis was conducted; the matrix is reported in Table 2.

TABLE 2: CORRELATION MATRIX

N=89	1	2	3	4	5	6	7	8	9	10	11	12
1. Telemobl	1											
2. Lnxdays	-.649**	1										
3. RailDens	.435**	-.280**	1									
4. RoadDens	.481**	-.473**	.118	1								
5. RurlDens	-.003	.062	-.138	.077	1							
6. Remit	-.113	.093	-.159	-.024	.127	1						
7. Airfrt	.385**	-.282**	-.163	.373**	.196	-.025	1					
8. Trnsptsvc	.084	.081	.290**	.086	-.024	.067	-.006	1				
9. Fuelratio	-.116	.079	-.171	-.112	-.012	.025	-.032	-.043	1			
10.Servratio	.268*	-.291**	.138	-.012	-.225*	-.211*	-.093	-.082	-.111	1		
11. Foodratio	-.179	.051	-.002	-.242*	-.115	-.013	-.147	-.115	-.145	.062	1	
12. Hitechexp	.308**	-.284**	-.012	.266*	-.011	.104	.416**	-.037	-.131	-.013	-.080	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

RESULTS

Regression Results for H1: Equation 1

Table 3 reports results for the OLS regressions for five of the seven dependent variables; Foodratio and Fuelratio are not shown because these regressions were nonsignificant (p>.10). Tonnage of airfreight moved was positively related to road density (RoadDens, p=.007), and negatively related to both railroad density (RailDens, p=.012) and customs clearance time (Lnxdys, p=.066). The value of transportation services (Trnspsvcratio, overall R^2= 0.074) was significantly influenced by railroad density (RailDens, p=.006) but explanatory power was low. Trade in commercial services was negatively related to rural population density (RurlDens, p=.043) and shipping container customs clearance time (Lnxdys, p=.007). Finally, export/import ratios of high-technology manufactured products (Hitechratio overall R^2=0.097; p=.025) was positively related to subscriber density only (Telemobl, p=.080).

TABLE 3: RESULTS FOR REGRESSIONS FOR EQUATION 1*

	AirFrt	TrnspSvc Ratio	Serv Ratio	Hitech Ratio
Remit	n.s.	n.s.	n.s.	n.s.
RurlDens	n.s.	n.s.	-.208 (.043)	n.s.
RoadDens	0.304 (.007)	n.s.	n.s.	n.s.
RailDens	-.258 (.012)	.290 (.006)	n.s.	n.s.
Lnxdys	-.210 (.066)	n.s.	-.278 (.007)	n.s.
Telemobl	n.s.	n.s.	n.s.	.264 (.080)
Adj.R- Squared F-value Significance	**.187 7.775 p=0.00**	**.074 7.993 p=.006**	**.107 6.287 p=.003**	**.097 2.575 p=.025**

*Betas, with p-values in parentheses; n.s.=nonsignificant (p>.10)
Foodratio and Fuelratio are not shown because these regressions were n.s.(p>.10)

DISCUSSION AND CONCLUSIONS

More than 80% of the world's population resides in countries classified as EMs and they account for a growing share of world output and trade activity. Distinguished by the rapid rate of trade and commerce harmonization, these economies have very high growth rates. With market selection opportunities come significant uncertainties with respect to the logistics infrastructure expectations and needs of MNCs. This paper proposed relationships to trade performance from logistics infrastructure, and explored these relationships using secondary data from eighty-nine economies. OLS regression was used to demonstrate the importance of logistics infrastructure in determining trade performance. Although there is valuable prior work investigating port efficiency, road networks, and inland transport (for example), this is the first study to use a new research lens and to put this lens to a test using macro-level secondary data. While previous research confirmed the contribution of logistics capability to performance at the firm level, we have offered insights into the connection between macro logistics capability and performance of national environments or countries, as recently called for by Kinra and Kotzab (2008a,b).

Interpretation of Structural Differences Among Countries

This discussion presents some interpretations of the results obtained in the study. There are several differences between countries along the dimensions considered. Differences in terrain impact size, the location of shipping ports, and the access to population centers via air or land transport. Improving roadway and railway network densities can influence in turn the modal distribution of imports to local consumers as well as producers' abilities to export their goods. The dependent variables export/import ratio, high technology export percent, and fuel ratios were negatively related to some dimensions of logistics infrastructure. As rural areas become less densely populated, commercial services trade exports increase. Public policies incentivizing increased remittance flows increase collectible duties by home country institutions. These transfers of disposable income are drivers of consumption and production in the receiving country (Orzco, 2002); in particular, consumption tends to be more sensitive and fall faster in EMs when there is a decline in remittances. This means that the government's capacity to conduct countercyclical fiscal policy can be severely constrained because of a loss in tax revenues derived from consumption and import activities financed by remittances.

CONCLUSION

We presented a discussion of logistics and trade. Improving *macro* logistics capability has become an important development policy objective for many governments and industry-based organizations. The performance of trade-related infrastructure is considered critical in attracting and sustaining business activity. Decision makers must understand the national environment as they design and execute supply chain strategies. This study offers insights and motivates the need for more academic research on other perspectives related to measuring and comparing macro logistics infrastructure, and trade performance. This might set the stage for bringing together policy makers and leaders in the private sector for collaborative investments aimed at further facilitating trade and improving the scope and efficiency of logistics.

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A STUDY ON DELINEATING THE “EASE OF DOING BUSINESS” CONSTRUCT WITHIN THE SUPPLIER-CUSTOMER INTERFACE

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ABSTRACT

Purpose of this paper
The purpose of current research is to provide an insight into the “ease of doing business” construct from supplier-customer perspective. This study is built on to examine an extension and modification of the ‘ease of doing business’ construct as suggested by Stading and Altay (2007) (p.37) in an Asian context.

Design/methodology/approach
An analysis of survey responses from supply managers in the automobile industry was used to test the proposed “ease of doing business” construct (EODB), which includes three dimensions – Information and Material Services, Financial Contract Services and Personal Relations Services. Personal interviews, and a review of the literature on relationship marketing in business-to-business transactions was used to develop a conceptual model for profiling relational interactions associated with a successful supplier-customer interface.

Findings
This study demonstrates an application of the EODB model to explaining the supplier-customer interface performance in a different cultural setting. The attributes supported by this research provide the means for managers to improve and grow business with customers in two major Asian economies’ automotive industries.

What is original/of value in paper?
Increasingly, Asia is emerging to be the sourcing hub for global supply chains. This study will enable purchasing and supply management professionals outside Asia to understand the determinants of “Ease of Doing Business” Construct in an Asian context, which will be valuable to them when sourcing from Asian suppliers.

Research limitations/implications (if applicable)
The initial indications from this study show that customer relationship management (CRM) attributes, like negotiating contracts and providing technical services, influence this rating. These two findings, EODB being tied to the percent of business conducted with a supplier and consisting of CRM-like attributes, together, strongly indicate that EODB may be tied to customer satisfaction. This is a suggestion that should be further investigated in the future.

Practical implications (if applicable)
The attributes supported by this research provide the means for managers to improve and grow business with customers in Asia.

Keywords:
Ease of Doing Business, Supplier-Customer Interface Performance, Customer Satisfaction, Automotive Industry, Asia.

INTRODUCTION

This study proposes that the EODB construct contributes to measuring customer satisfaction and is a direct result of the services provided from a supplying organization. Lloyd (2003) argues that EODB could be a mainstay of an organization’s customer relationship strategy. Independently, Lacobucci, et al., (2003) proposed that the extent to which a customer perceives a company as one that is easy to do business with should be a function of high quality and enhanced customer service. Response levels are affected by the strategic attributes of three relational determinants: Information and Material Services, Financial Contract Services and Personal Relations Services. The existence of these three attributes could be interpreted as service excellence (Johnston 2001). According to Johnston (2004), service excellence includes EODB. All three proposed determinants have an effect on EODB, and they subsequently converge towards a common definition when considered by customers. Swaddling and Miller (2002) warn that, despite many attempts to correlate customer satisfaction and a customer-repurchase decision, this correlation is complex and not yet fully understood. They argue that linkages are not yet in place to warrant a role in strategy formulation. They suggest that EODB may play a contributory role in establishing that link and that an EODB construct with theoretical underpinnings is necessary.

LITERATURE REVIEW

The relationship between customer service and customer satisfaction is rich and deep. The introduction of the SERVQUAL measure stimulated a stream of continuing research measuring consumer perceptions and satisfaction with service quality (Parasuraman, et al., 1988; Parasuraman, et al., 1991). This literature stream emphasized the role of customer service psychometric properties, including such factors as reliability, responsiveness, assurance and empathy. The customer service literature specific to logistics includes traditional measures of success which centre on delivery, including availability, timeliness and delivery quality (e.g. Mentzer, et al., 1989; Dahlstrom, et al., 1996; Emerson and Grimm 1996; Morris and Carter 2005). These dimensions can be expanded to include a comprehensive list of supplier evaluation criteria in the areas of customer relationship and communication factors (Simpson, et al., 2002). Frazier (1983) argued that the value of these relationships is demonstrated when suppliers use support services. Supporting this view, Hunt and Jones (1998) suggested that subsidiary factors, such as after sales support and total service capability, play an important part in selecting suppliers. They added that these factors highlight criteria which may affect ease of doing business between customer and supplier.

Managing the supplier-customer interface has theoretical linkages to sustainable competitive advantage (Tscng and Huang 2007). Supply chain revenues are not optimized in the absence of loyalty, satisfaction and anticipation of customer needs (Verhoef 2002). Elements of these determinants include long-term commitment of a customer to a supplier and favourable attitudes towards that supplier on the part of the customer (Cronin and Morris 1992; Dick and Basu 1994; Morgan and Hunt 1994). It is through this commitment that the repurchase intention and the customer's willingness for relationship renewal is reinforced (Kumar, et al., 1995). As a stop-gap, managers already accept the application of a poorly defined concept of EODB as a minimum predictive measure for those more difficult to quantify dimensions of longitudinal commitment and repurchase intention (Stading 2000).

Information and Material Services

Customer satisfaction is a complex construct and has been defined in various ways (Besterfield, 1994; Barsky, 1995; Kanji and Moura, 2002; Fecikova, 2004). Recently, researchers have argued that there is a distinction between customer satisfaction as related to tangible products and as related to service experiences. This distinction is due to the inherent intangibility and perishability of services, as well as the inability to separate production and consumption. Hence, customer satisfaction with services and with goods may derive from, and may be influenced by, different factors and therefore should be treated as separate and distinct (Veloutsou et al., 2005). Managing information in a supply chain has a number of benefits and is important in building supply chain relationships (Manoochehri 1984; Russell and Krajewski 1992). The first hypothesis in the present study considers the individual association between EODB and the management of information needed to help materials flow more efficiently. In a supply chain, contact points between the customer and the supplier are critical in building a solid relationship. These contact points and supplier functions are associated with daily or routine order processing, supporting the availability of inventories and the making on-time deliveries. Managing these contact points falls inside the sales function of a supplier with responsibilities for such elements as pricing information and direct quality quotes to the customer. Daily contact points influence the customer's perception of how easy it is to do business with a supplier. These are important attributes for suppliers in maintaining relationships with customers and should be managed carefully (Verwijmeren, et al., 1996; Shin, et al., 2000; Goodman 2004). The attributes of this determinant in the EODB framework are structured around recurring arguments which support availability and responsiveness in the customer service and customer satisfaction literature (e.g., Bitner 1992; Dadzie et al. 2005). Supplier availability and responsiveness can make an impression on a customer in various ways. Hence,

Hypothesis 1: *The information and material (IM) services determinant is positively related to the EODB, such that the daily service contact points strengthen the EODB rating.*

Financial Contract Services

Part of a supplier's responsibility in the supply chain includes customer awareness and the sharing of programmes which result in mutual cost savings and financial efficiencies gained through supply chain improvement projects. This is important for maintaining customer relationships (Milgrom and Roberts 1988; Newnan 1991). Savings, however, are not necessarily realized, shared or recognized without contracts. Contracts of various kinds (formal, informal, policies, etc.) are instrumental in realizing shared benefits between customers and suppliers. Negotiation and implementation of financial arrangements between supply chain partners easily affect customer-supplier relationships. Contract negotiations and those supplier functions that are associated with various points of shared benefits affect a customer's satisfaction level with a supplier and can affect a customer's perception of the ease of doing business. The first hypothesis in the present study addresses the management of contracts. Financial contracts focus on areas of potential contention, such as credit terms, product quality non-conformance issues and the subsequent handling of potentially returned material. The speed and ease of producing those contracts is addressed within the contract turnaround and negotiation process. These logistical issues are important for suppliers in realizing savings and maintaining relationships with customers (Berry 1980; Collier 1987; Bowen, et al., 1989; Goodman 2004). Hence,

Hypothesis 2: *The financial contract (FC) services determinant is positively related to the EODB, such that those services strengthen the EODB rating.*

Personal Relations Services

The importance of personal interaction in creating satisfied customers has been recognized in the customer service literature (Crosby and Stephens 1987; Dwyer, Schurr and Oh 1987). It has been shown that future sales opportunities depend mostly on the quality of the relationship (Crosby, et al., 1990). It is at the individual level that the quality of the relationship between supply managers and suppliers is affected (Brennan and Turnbull 1999). Components of relationship commitment include extent to which partners are willing to share confidential information and level of investment in the relationship, including both current and future investment (Gundlach and Achrol 1995). The components of the commitment dimension stem from the importance of a relationship as measured by how hard a partner is willing to work at preserving the relationship (Morgan and Hunt 1994). Ability to answer customer questions from a technical perspective should influence a customer's perception of that supplier (Hartley, et al., 1997). The third determinant of the EODB framework proposed in this study is the effectiveness of the Personal Relations Services. Services of individual attention with attributes like *on-location (outside) sales support or technical support* can foster important relations with suppliers. These types of services are a potential source of sustained competitive advantage (Sheth and Parvatiyar 1995; Hartley et al. 1997; Shin et al. 2000). In addition, supplier functions that impact on personalized services, such as order follow-up, customization or Web based e-services, can influence a customer's perception of a supplier's EODB (Collier 1987; Goodman 2004; Zahay and Griffin 2004; Dadzie et al. 2005). The following hypotheses relate to the individual association between EODB and those services which cater to the customer at a personal level. Hence,

Hypothesis 3: *The personal relations (PR) services determinant is positively related to the EODB, such that those services strengthen the EODB rating.*

The determinants affecting the perceived measures of EODB begin with the transference of necessary information between customers and suppliers; they include the financial alignment of these provisions and the technical support and follow-up for the product or service. These are considerations in building a framework for EODB. The hypotheses presented in this research are tested to identify the significant contributions of each attribute to the EODB (Dess and Davis 1984; Johnson and Fornell 1991).

METHODOLOGY

This study seeks to isolate those attributes of EODB which supply managers use to evaluate suppliers. The identifiable benefits of this research include understanding customer behaviour patterns predicted by the EODB customer response. Given that EODB predicts behaviour patterns, identifying which of those attributes influences the EODB response subsequently affects how managers can utilize this measure to grow their business with a given customer.

Process

Measuring the proposed construct establishes the foundation for theory development around that concept. A construct is needed for theory construction when a concept moves from case studies and anecdotes to testable models (Bagozzi and Fornell 1982; Sheth and King 1994). Practical case studies of EODB, as well as anecdotes and construct measures already exist. Therefore, constructs developed in an earlier study by Stading and Altay (2007) should be extended and tested. In the present studies this is done, applying those constructs in an Asian context to contribute towards the development of grounded theory on EODB.

Survey

A customer survey was designed based on the findings of the pilot study and sent to procurement professionals of 60 selected companies that purchase components in the automotive industry. The supply managers were asked to evaluate the importance of different aspects of EODB using a 6-point rating scale. These EODB survey questions were aligned to the determinants and attributes specified in the hypotheses. In addition, when considering a supplier, respondents were asked to indicate the nature of their relationship and the level of trust involved. These responses were used to measure commitment to their relationships. After an initial contact by telephone a total of 60 respondents out of 200 (100 each in Thailand and South Korea) accepted our invitation to participate in the survey. Accordingly, survey instruments were sent out to all these respondents. 52 were surveys returned, but only 48 of them had usable responses. Out of the total usable samples 30 (62.5%) were from Thailand and 18 (37.5%) from South Korea. Over 60% of the respondents had more than 10 years of experience in their professional procurement positions. Professional supply managers typically purchased through a variety of mechanisms, including annual contracts, competitive bid processes or simply re-ordering as needed. All respondents indicated that they use multiple suppliers when purchasing automotive components. Usable responses represented 80% of the companies that had the surveys mailed to them. The following industry segments were represented by the responses: 35% body parts, 24% contract manufacturers, 16% audio components and 15% from industrial and manufacturing control industries. The remaining 10% of respondents were from a variety of other industries.

Non-response bias

Non-response bias can exist with survey research, even with relatively high response rates (Lohr, 1999). One commonly employed means of assessing non-response bias is to compare the answers of early survey respondents to those of late respondents (Lambert and Harrington, 1990). The assumption here is that late respondents are more characteristic of non-respondents than are early respondents (Armstrong and Overton, 1977). The study used a naturally occurring breakpoint between the two response waves of the survey to represent early versus late respondents, and computed a multivariate t-test along the key study variables to assess whether significant differences existed between the two groups. The results suggest that early respondents did not demonstrate statistically significant differences from late respondents.

Key Informant Issue

The study took two measures to ensure that survey respondents were knowledgeable (Campbell, 1955) and appropriate, or key, informants. First, it addressed the survey to purchasing managers and executives, as the results of the pre-test and pilot test indicated that personnel at the manager level or higher were capable of answering the study's questions (John and Reve, 1982). In addition, the survey included questions that addressed the respondents' knowledge and capacity to answer the scale items that measured the study's constructs (Kumar et al., 1993).

FINDINGS

The findings of the study are presented on the basis of two types of analysis: (1) Descriptive Analysis, and (2) Inferential Analysis. The descriptive part of the analysis provides an overview of the data. The average response to the scales varied from a low of 1.71 to a high of 3.06, which means that the average responses show the relative importance of each of the dimensions of EODB this study measured. The study also found the measurement scales to be reliable. According to Nunnally (1978), the cut-off criterion for Cronbach's Alpha should be 0.70. All of the constructs in this study met the minimum reliability requirements, alpha ranging from a low of 0.725 to high of 0.826. A comparison of the Cronbach's value and the correlations among the variables revealed that the Cronbach's Alpha values are bigger than correlations among the variables. Hence, it can be said that there is decomposition validity of the scales (Gaski, 1984). When the results of correlation between the variables are taken into account, both between the variables and with EODB, there is a positive value at $p < 0.01$ level. These results may therefore be considered significant in statistical terms.

Inferential analysis provides findings and discussion based on the results of the test of the hypotheses. The study tested the hypothesized model using multiple regression analysis. The main objective of this test was to examine the predictive power of the independent variables in explaining the dependent variable.

ANALYSIS AND DISCUSSION

Jain (1994, p. 173) suggested, the goodness of fit of the multiple regression model is measured by R^2. R-square commonly referred to as the coefficient of determination, which tells us how well the regression equation fits the observed data (Jain 1994, p. 168). The variance explained (R^2) by the model is a good indicator of the fit of the data to the hypothesised model. In this study, R^2 is 0.564, and this can be interpreted as stating that the amount of variance explained by the regression model is 56.40%, which is acceptable in behavioural research. The result from the regression analysis indicates that the regression equation fits the observed data well. Jain (1994, p. 173) suggested that, "the closer R-square (coefficient of determination) is to 1 the better is the fit of the model to the observed data". Also, the regression model suggests that two out of the three predictor variables (*Information and Material Services* and *Personal Relations Services*) are positively and significantly associated with the criterion variable (EODB). That means it found two of the three hypothesized paths to be substantiated. All of the variables also show acceptable amount of variance being explained by them. The assumptions of regression analysis were checked prior to conducting the test and found the data to be normally distributed. The model has no problem of multicollinearity. That is, the VIF (collinearity index) suggests that there is no multicollinearity (association between the explanatory variables) between the predictor variables. As Jain (1994) suggested, a maximum VIF greater than ten is thought to signal harmful collinearity. This is not the case in the present study. The results from testing the hypotheses are also displayed; $p < 0.05$ is taken to represent significant relationships. Interestingly, two out of the three hypothesized relationships were found to be significant at the $p < 0.05$ level. The exception was Financial Contract Services, for which the relationship has not been confirmed. Among all the hypothesized paths, Personal Relations Services were found to be the strongest predictor of EODB, followed by Information and Material Services. The EODB construct will continue to evolve as future research examines various aspects of this construct. This may produce different results in different settings such as different types of businesses, different countries or different cultures. This study presents findings which disagree with those found in an earlier study conducted by Stading and Altay (2007) based on US samples. In their study, all three of the determinants of EODB were supported. These were Information and Material Flows, Financial Contract Services and Personal Relations Services. This implies that the US respondents differ from the Asian respondents on how they perceived Financial Contract Services and how this construct was associated with the ease of doing business construct. The results of the present study support linking two of the three proposed determinants of EODB. Attributes showing positive association with the EODB include relational aspects of doing business, such as negotiating contracts, providing technical support and providing customization for the customer. As a note of caution, the predictors that were not supported should not necessarily be interpreted as being of less importance to customers. Interestingly, the Web e-services attribute loaded on the Financial Contract Service dimension. This was unanticipated, but it should probably have been expected. The Web appears to be playing a growing role not only for communicating financial terms, but also for providing the means for business to business transaction. A Web-based e-service is certainly a dynamic and evolving field and will undoubtedly continue to grow in significance in future studies.

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A MULTI AGENT BASED SYSTEM FOR COLLABORATIVE SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The high level of complexity of supply chains and the inherent risks that exist in both the demand and supply of resources (especially in economic downturns) are recognized as major limiting factors in achieving high levels of supply chain performance. Modern IT decision support systems are fast becoming an indispensable tool for designing and managing complex supply chain systems. This paper proposes a multi-agent based framework for supply chain management with the objective of enhancing collaboration in agile supply chains. The framework supports the fulfilment of production, event and disruption risk management constituted by coordination, communication and task agents.

INTRODUCTION

The increasing call for mass customization in many industries has made today's global supply chains very complex, requiring a multitude of parallel information and physical flows to be controlled to ensure high customer service levels. This increased complexity enhances the level of uncertainty and risks that companies are faced with (Manuj and Mentzer, 2008). For the level of uncertainty to be reduced, organizations need to design and manage agile supply chains in a way that they can responsively fulfill customer's demand within the life cycle of the product. In order to minimize their working capital, and at the same time to achieve responsiveness, inventories are being postponed and situated as close as possible at the upstream of the supply chain.

Constructive collaboration among business partners in supply chains is vital in any attempt to achieve responsiveness, agility, to mitigate risks and ameliorate disruptions and to offer a high customer service level (Hallikas et al*.*, 2004). The use of Information Technology (IT) tools is considered a principal facilitator for the realisation of this collaborative perception for the management of agile supply chains. Conventional IT however, which is based on legacy systems has not provided sustainable solutions for collaborative Supply Chain Management (SCM). Its design ideology does not meet the high level of agility required for decentralized control (Karwowski et al*.,* 2007). It lacks real-time adaptability, it focuses predominately on dyadic contexts of collaboration (Akkermans et al., 2003), it is characterized by inflexibility in terms of reconfiguration of the supply chains, high development and maintenance costs, and limited computational capacity to manage the high level of complexity of agile supply chains (Botta-Genoulaz, et al*.,* 2005).

The use of multi-agent modelling (a sub category of artificial intelligence) can be an alternative decision making tool for collaboration within supply chains. In computer science, an agent can be defined as a software entity, which is autonomous to accomplish its design objectives, considered as a part of an overall objective, through the axiom of communication and coordination with other agents. Through this paradigm of software architecture, supply chains can be viewed as composed by several autonomous decision making entities (agents), each responsible for specific activities and performing different roles and each interacting and cooperating with other agents in order to solve problems beyond their individual knowledge or expertise, in order to achieve higher performance for the entire system (Stone and Veloso, 2000). Through their inherent learning capability, multi-agent systems (MAS) can demonstrate efficiently the proactive and autonomous behaviour of the participating agents in mitigating risks and rectifying supply chain disruptions in real time (Kwon et al., 2007, Lu and Wang, 2007) and can promote high level of cross organizational collaboration under a computational and cost efficient manner (Swaminathan et al, 1998).

In this paper, a multi-agent based framework is proposed to promote collaborative SCM under the reality of the modern agile manufacturing supply chains. The framework supports the fulfilment of production, event and disruption risk management constituted by coordination, communication and task agents and draws on principles and theories of SCM, agent-based simulation and Computer Science.

For the development of the MAS framework, the paper is organised in four sections. In the first section the usefulness of MAS for supply chain production management is justified through a brief review of the expansive literature on SCM and a discussion of the application software agents to different supply chain problems. The second section presents the analytical process for the development of the framework and its features in detail. The third section presents the decision support process based on the proposed framework for the management of risk with a hypothesised scenario. The paper concludes with a discussion of the limitations and implications and potential extension of the research.

LITERATURE REVIEW

The use of IT in SCM has always been an important facilitator of effective SCM, aiming to accomplish a trilogy of objectives (Simchi Levi et al., 2008): (i) to collect information in order to provide visibility among partners, (ii) to access data stored in the system from "a single point of contact" and (iii) to analyze data and plan activities, concerning the whole supply chain.

In order to achieve these objectives a wide variety of means have been leveraged: e-commerce B2B systems, ERP, and Advance Planning Systems (APS) (Moyaux and Chaib-draa, 2006). Through the adoption of an e-business approach, a supply chain can become more flexible, effective and faster in terms of response (Cheung et al. 2008). However, successful e-business requires state of the art computational systems, which can deal with the high complexity of processes that take place. The use of ERP is the most common software choice for managing and organizing a company's operations (Moyaux and Chaib-draa, 2006). An ERP system facilitates the management of data concerning manufacturing, distribution, human resources and finance within an organization and can be used as a platform to integrate and manage core business processes within an organization, embracing SCM, CRM (Botta Genoulaz et al., 2005) and APS systems. The more advanced ERP systems have also the ability to deliver services for collaborative planning, forecasting and replenishment (CPFR), enabling partners to plan their sales and production under a more synchronous regime (Davenport and Brooks, 2004).

Conventional ERP and APS systems provide a high level of process integration; however this integration is fragmented either to the internal business processes or to a dyadic context of co-operation (Akkermans et al., 2003). Their computational realization of different types of relationships among partners is also limited (e.g. CPFR, vendor/ buyer relation). Thus, there is an inflexibility to simultaneously facilitate all these different "types" of collaboration and furthermore to provide efficient transition from one type to another. Another disadvantage of APS is their inflexibility to meet supply chain reengineering purposes. Many organizations in order to be dismantled by the complex and especially the time and money consuming character of this procedure, they tend to adapt their operations to the idiosyncrasy of their ERP system. As a consequence, ERP defines the processes that organization will have, imposing in some situations competitive advantages originated by the distinctive character of business processes to be lost.

Traditional ERP and APS systems are inflexible to provide the truly realization of the "extended enterprise", at least with their existing design (Akkermans et al., 2003). After many years of development, the only major advancement that approaches the "extended enterprise" is their capability for interconnection of specific supply chain operational processes under a real time regime through Internet based applications (Botta – Genoulaz et al., 2005). The target of holistic cross - organizational collaboration however is still part of the research agenda.

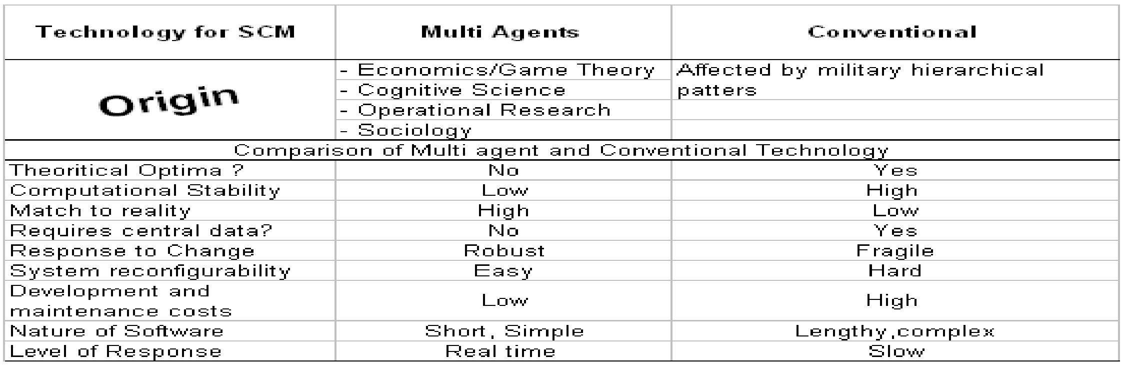
A considerable amount of time and funds is required in order to yield benefits from those technologies to transform conventional e-business systems into collaborative SCM systems, underlying that only organizations that can afford the required high level of investment will be able to achieve responsiveness, and overall to reinforce their competitive advantage. Supply chains constituted by small organizations or the small parties in a supply chain would face significant constraints to gain benefits from e-business, even if ERP systems manage to totally realize the concept of the "extended enterprise".

For the benefits of e-business to be materialised therefore there is a need for information systems that are characterized by low investment costs, easily adaptive to changes and by high level of computational efficiency to manage the complex and decentralized nature of supply chains, providing concurrently high level of cross organizational collaboration, which conventional ICT systems at the moment cannot meet. Multi-Agent technology offers the perspective to overcome these shortcomings of existing conventional supply chain technologies, offering a new approach for effective SCM and accordingly for the realization of the "extended enterprise". Gupta, et al. (2005) for example proposed an ERP system based on multi- agent technology for enterprise wide integration.

The agent based technology is acknowledged as one of the most promising technologies for SCM (Brooks and Davenport, 2004) due to its vital characteristics of:

- *Autonomy*: agents are aware of their environment operating without human intervention to some extent in order to fulfil their objectives (Jennings and Woodridge,1995)
- *Social ability*: an agent can interact with other agents or humans through the use of an agent communication language (Moyaux and Chaib-draa, 2006).
- *Reactivity*: agents can perceive their environment and respond to specific changes in this environment (Parunak, 1999)
- *Pro-activeness*: agents do not simply respond to changes in their environment, but can take action under proactively.

The inherent distributed nature of agent-based technology (in that a problem solution is distributed into different agents) gives the significant advantage of easiness in dealing with the high level of supply chain complexity in contrast with conventional IT (Akkermans et al., 2003). This is enhanced by the fact that each of the agents has a specific expertise and a computational efficiency in dealing with this complexity in combination with easiness of development in a short time frame (Lu and Wang, 2007). With this approach, re-configuration of the whole supply chain system can become a reality in a timely fashion under a low-cost regime. Furthermore, these benefits can be materialised by incorporating existing legacy systems. For example, an expert system for inventory management or an ERP system can be integrated with agent software. Table 1 below summarises the major differences and benefits of MAS over conventional ICT tools for SCM coordination.



Technology for SCM	Multi Agents	Conventional
Origin	- Economics/Game Theory	Affected by military hierarchical patters
	- Cognitive Science	
	- Operational Research	
	- Sociology	
Comparison of Multi agent and Conventional Technology		
Theoritical Optima ?	No	Yes
Computational Stability	Low	High
Match to reality	High	Low
Requires central data?	No	Yes
Response to Change	Robust	Fragile
System reconfigurability	Easy	Hard
Development and maintenance costs	Low	High
Nature of Software	Short, Simple	Lengthy,complex
Level of Response	Real time	Slow

Table 1 - MAS Vs conventional technology for SCM

MAS have been used in modelling a multitude of supply chain phenomena: for the identification of negotiation problems in supply chains (Chen et al., 2004), in production and control processes (Caridi and Cavalieri, 2004) in distribution (Swaminathan et al, 1998), and for inventory and demand forecasting (for a thorough literature review of MAS application on SCM see Beamon, 1998). Agent based technology has also been utilised for the management of disruptions within a supply chain in some studies. Kimbrough et al (2002) for example use it for the reduction the bullwhip effect through modelling a supply chain with agents. Kwon et al. (2007) propose an agent based framework based on experimental design that deals with supply and demand uncertainty and Bansal et al. (2005) provide a generalized collaborative framework for disruption management oriented to the reality of refinery supply chains. Table 2 below summarises major research projects for the use of MAS in SCM along with their main conclusions

Project	Problem	Approach	Conclusions
Dragon chain (Kimbrough, S.O., et al. 2002)	Bullwhip	Learning via Genetic algorithms, in order to achieve the optimal level of inventory	· Agents can identify demand · They can theoretically reduce the Bullwhip effect · They have the ability to achieve effective solutions to complex problems · Agents through the use of learning algorithms can achieve solutions that approach to optimal, even if there is no high level of information sharing · Through a high level of information sharing, significantly optimal solutions can be achieved for order policies
Agent Building Shell (Fox et al. 2000)	Coordination	Knowledge Query Manipulation Language for communication among agents	· Critical issues such as disruption management and formation of Virtual Enterprises are addressed
MetaMorph II (Maturana, F., et al. 2000)	Coordination	Hybrid architecture in an heterogeneous environment	· Software and robotic agents can be coupled together in an orchestral manner
Netman (Moyaux and Chaib-draa, 2006)	Organizational coordination	Contract and convention driven coordination. Agreement and transaction formalism (CAT)	· A mixture of contract and convention elements can establish the realization of a responsibility network
BPMAT (Moyaux and Chaib-draa, 2006)	Which elements are common to all supply chains?	Modelling both centralized and decentralized supply chain through re-usability of components	· A re-usable framework for supply chain simulation, managing issues related to configuration, coordination and contracts within a supply chain.
MASCOT (Hildum et al., 2003)	Increase of agility	Mixed-initiative agent wrapper	· Adjustable autonomy of agents · Tradeoffs from potential decisions are calculated by the system · Easiness for integration with legacy systems
DASCh (Parunak, 1998)	supply chain modelization	Delays and uncertainties are modelled as shipping agents	More suitable for decentralized supply chains
AGORA (Divitini, M., et al. 2001).	Virtual enterprise modelization	-	· Activities of the Virtual Enterprise can be monitored · History of the VE can be reviewed

Table 2 - Research in the use of MAS modelling for SCM

These papers that deal with the application of MAS in disruption management focus on particular supply chain risks and/or contexts, but do not explore the learning process of the agent-based models to ameliorate abnormalities in supply chain processes at an operational level and to integrate decisions across the supply chain. Their approach to SCRM is limited as they do not provide the basis for an integrated SCM framework for decision making. The majority of the projects also deal with the issue of re-usability of the agents (e.g. ABS as an agent development framework and BPMAT as a simulation tool). However, they lack of standardized methodology, in expressing those re-usable agent components, which might be interpreted to incompatibilities to the re-usability of existing components by agent systems with different design ideology. Finally, by taking into consideration the lack of customer sensitivity mechanics, in the majority of the research projects, these models exhibit an inability to provide a “truly agile” supply chain, imposing thus concurrently constraints to the level of cross organizational collaboration. In this paper, previous works are synthesised and extended through the development of a framework for SCM under the reality of agile manufacturing supply chains, with an overall objective of accommodating a high level of cross organizational collaboration.

THE DEVELOPMENT OF THE FRAMEWORK FOR A SCM SYSTEM

For the development of the framework, an analytical sequential approach has been adopted. First the organizational design of the framework was formulated and embedded in an overarching agent-based SCM framework (an artificial society constituted by software agents). Then the roles for each of the agents within the disruption framework were defined, followed by a detail description of the responsibilities for each of these roles. Finally, the interactions among these agents were modelled by analyzing a risk identification and mitigation processes.

As the research focuses on agile supply chains, in the model of supply chain network that is to be used for the analysis of the proposed framework, wholesalers and retailers have been replaced by logistics service providers (LSP) to emphasize the information sharing among the supply chain partners. Based on this, a typical supply network is adopted composed by second and first tier suppliers, manufacturers, contractors, LSPs and the ultimate consumer (Figure 1).

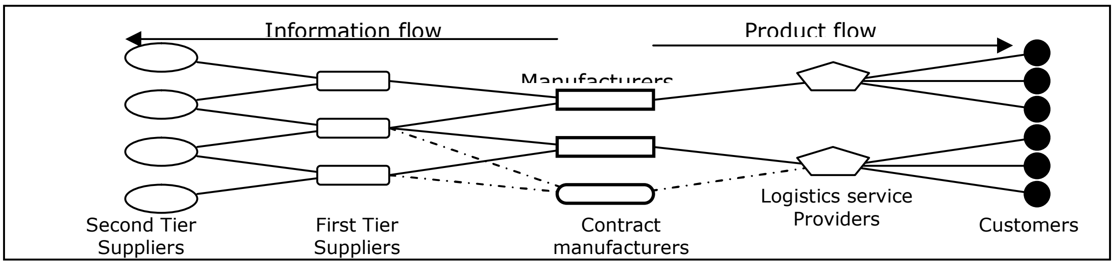


Figure 1 - Model of Supply Chain Network

In Figure 2 the basic components of the generic multi-agent based model for SCM are presented. Three modules constitute it: a) agents responsible for production fulfilment processes (e.g. order management, manufacturer, procurement, logistics, subcontractor and the suppliers' agents), b) supply chain events and c) disruption risk management processes. The system functions as follows: the production fulfilment module coordinates the supply, production and delivery processes of the supply chain. The monitoring module overlooks the smooth functioning of the production fulfillment process and synthesizes the supply chain events with the disruption management processes. The disruption risk management module is triggered by a potential disruption that occurs during the order fulfillment process. This is the case when a monitoring agent through the analysis of the supplier's production process identifies patterns of information which considers as unusual and hence reason for potential disruption. As the selected supply chain model is considered as customer driven, the order acquisition is taken as the start of the information flow for an order in the framework.

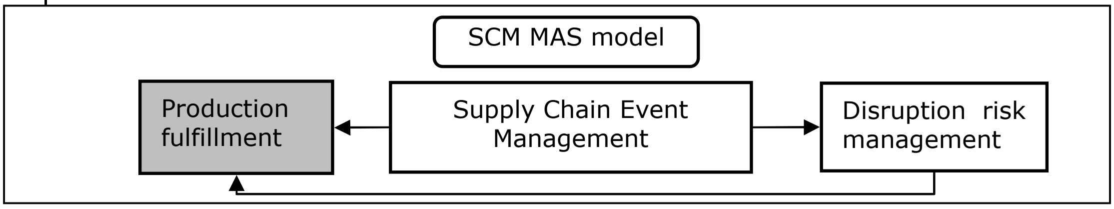


Figure 2 - The capabilities of the proposed model

This paper focuses on the production fulfilment process of the entire system and conceptualises and analyses the agent-based processes involved for the coordination of the order, supply, production and delivery processes of an agile supply chain.

For the development of the framework the following assumptions have been adopted.

- Redundant suppliers, contractors and logistics service providers exist.
- In the case that demand cannot be met, contractors are employed.
- Information is distributed symmetrically among partners.
- Contractual agreements with detailed specifications exist between parterns.
- Logistics Service Providers are situated nearby suppliers and contractors.
- No finished or WIP inventory exist, on behalf of the manufacturer
- Agents can take decisions both in operational and tactical echelons

The framework structure is illustrated in detail in Figure 3**.** The dotted lines separate the manufacturer's environment from this of its partners (e.g. suppliers, LSPs). In the analysis below, a further assumption is taken; that the agent system exists in the side of suppliers and contractors. For LSPs a modified version of this system can be created as LSPs do not produce anything. A multitude of agents co-exist in the environment of the manufacturer, facilitating the processes of production fulfilment, event and disruption risk management. The production fulfilment process is facilitated by a list of agents: an order management agent, a coordination agent, a production planning agent, a procurement management agent, a inventory management agent, a manufacturing management agent, a logistics management agent and a contract manufacturer agent. Additionally, the monitoring agent, the communication agent and the disruption risk management agent facilitate the event and disruption risk management processes.

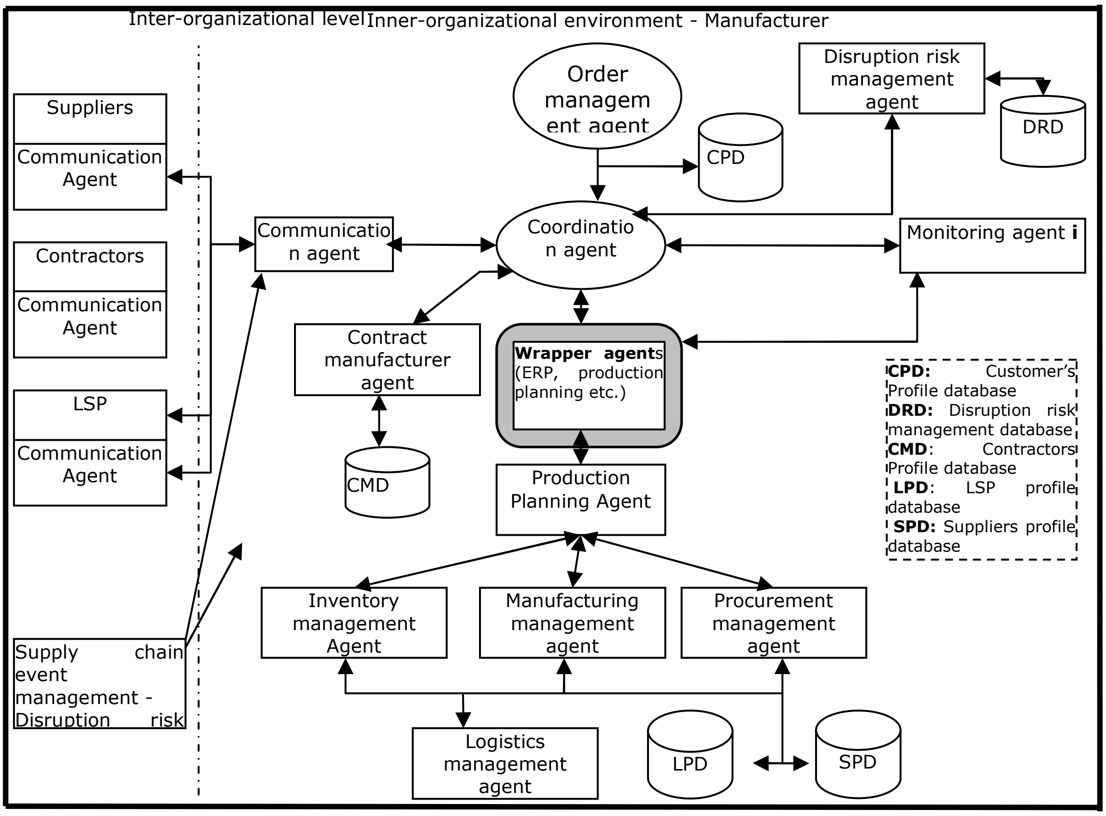


Figure 3 Agent Society of the proposed MAS framework

ROLES OF THE AGENTS

Order management agent: it responds to customer requirements, transferring them to proper task agents via the facilitation of coordination agent. It is responsible for receiving customer orders, requests for returns, cancellations and modifications, providing concurrently on-demand status for customer orders. It decomposes an order into order quantity (Q_{rt}), required delivery time (D_t) and location (L_t). Moreover, it manages the relationship with the customer in order to achieve maximization of the sales and a higher customer service level. In particular, it processes all the collected orders and subsequently extracts inferences identifying customer preferences and profiles. This information is stored in a customer profile database, for further analysis, to assess a customer's net present value in order to initiate corresponding strategies. This agent therefore has the necessary functionalities to promote customer sensitivity.

Coordination agent: it synchronizes the processes of production fulfillment, supply chain event and disruption risk management. It interacts with other agents for collaboration and communication, it reacts to requests, receives feedback from other agents, and assigns tasks to corresponding agents. This agent facilitates the coordination of agents.

Production planning agent: it is responsible for acquiring the orders from order management agent. Under the constraints of production and supplier lead times, production capacity (P_c), and customer's required delivery time (D_t), it generates the production plan. It aims to optimize production cost on behalf of the organization, having as a constraint a specific customer service level, illustrated upon the parameter of delivery time.

Procurement management agent: It decomposes an order quantity (Q_{rt}), into materials requirements, in order to establish a sourcing plan. It sends these requirements to suppliers, it informs the production planning agent when the delivery of materials is confirmed. It is capable for the supervision and evaluation of supplier performance as well as suppliers' selection. This information is stored to a supplier profile database, in order to consolidate the responsiveness of procurement activities in the future.

Inventory management agent: It provides “visibility” concerning either returned goods customers, or for materials whose their transformation to finished goods has been cancelled due to customers’ order modification. The main objective is to reduce obsolescence.

Manufacturing management agent: it provides feedback (e.g. capacity availability) to the production planning agent and executes the manufacturing processes. It decomposes manufacturing tasks, and then distributes them to the appropriate workshops.

Logistics management agent: it is responsible for the coordination of logistics processes with the objective cost optimization given the constraints of required delivery time (D_t) and delivery cost (D_c). It retrieves profiles of LSPs, from the LSPs’ database, in order to select a suitable LSP. It also receives feedback from customers concerning their performance.

Contract manufacturer agent: it is responsible for selecting reliable contractors on behalf of the manufacturer in case available capacity does not exist in order to meet excessive demand. It retrieves profiles of contract manufacturers from the corresponding database (contract manufacturer profile database), to responsively fulfill needs for contracting.

In Table 3, analytical information concerning each agent is presented.

	Agents	Responsibility	Event Trigger	Inputs	Constraints	Output	Interaction
Production Fulfilment	Coordination agent (CA)	Coordination of: · Production fulfilment · Event management · Disruption risk mgmt.	Customer’s order				OMA, PPA, DRA, CMA, IMA
	Order management agent (OMA)	Order acquisition		· Order quantity · Delivery time · Delivery Location	-	· Price · Delivery time · Delivery location · Potential discounts	Coordination agent
	Production planning agent (PPA)	Production Plan		· Order quantity · Delivery time	· Production capacity · Suppliers lead time · Required delivery time	Production plan	
	Manufacturing management agent (MMA)	Execution of manufacturing processes	Production Planning	· Order quantity · Delivery time	· Capacity · Status of manufacturing machines	Available capacity	Production planning agent
	Inventory management agent (IMA)	Visibility of inventories	Inventories that are about to become obsolete	Time frame for obsolete inventories	-	Notification for the inventories that are about to become obsolete	Production planning agent, disruption risk management agent
	Contract manufacturer agent (CMA)	· Contractor selection · Negotiation	Insufficient capacity	· Order quantity · Required delivery time	· Production capacity · Suppliers lead time	· Price · Delivery time · Delivery location	Coordination agent
	Procurement management agent (PMA)	· Negotiation · Supplier Selection	Insufficient inventories, supplier Disruption	· Order quantity · Delivery time	· Suppliers lead times	Confirmation of the procurement agreement	Production planning agent
	Logistics management agent (LMA)	· Negotiation · LSP selection	· Distribution · Supplier · Contractor Disruption	· Delivery time · Delivery cost	· Transportation lead times	Confirmation of the transportation agreement	Procurement management agent

Table 3 The roles of agents in the framework

A detailed analysis of the interactions and processes among the agents using scenario planning is provided below.

Scenario A: Available manufacturing capacity exists

Step A.1: Under this scenario, the procurement management agent collects all the requests for raw materials from the production planning agent and then decomposes them into different categories of components, generating a procurement plan. Then, this information is sent to suppliers along with the required delivery time. If a suitable supplier confirms the procurement request, the procurement management agent will inform the production planning agent to initiate production planning. If the procurement requests cannot be fulfilled by suppliers, then a negotiation will begin using the available profiles of suppliers situated in the corresponding database. In both cases, the production planning agent will be informed about the confirmation of the procurement agreement to initiate planning. *Step A.2:* The manufacturing management agent will decompose manufacturing tasks and then will distribute them to the appropriate workshops. By the time the required components arrive, production begins. *Step A.3:* When the production of the specific order is finished, the logistics management agent will be informed, in order to send logistics information to LSPs concerning the required delivery time for the specific order. If the logistics request is confirmed by a suitable LSP, shipping of the order is initiated. If not, negotiation with LSPs will begin. *Step A.4:* After the confirmation of the agreement by the "winner" LSP, the monitoring of the order along the transportation chain begins.

Scenario B: No available manufacturing capacity exists

*Step B.1:*_Under this scenario the production of a specific order is not feasible either due to excessive demand, or production disruptions. The coordination agent is informed about this inability (by the production planning agent) and requests from the contract management agent to assign the production of this order to a suitable contractor based on previous trading information, given the product quantity (Q_f) and delivery time (D_t). In the case (that none of the contractors can meet this agreement), a negotiation begins with the available contractors stored in the contractors profile database. *Step B.2:* After the confirmation of the agreement by the contractor, and the selection of suitable LSP for the transportation of raw materials, monitoring of the order along the supply chain begins. It should be noted, that LSPs are chosen for the transportation of raw materials from the supplier to the manufacturer, however it was not included in the analysis above, for simplification of the process. In the same fashion, the production planning agent can send a request to inventory management agent before the production planning, in order to utilize inventories for production that may become obsolete. Figure 4 shows the example of the interactions among the agents at the production fulfillment process.

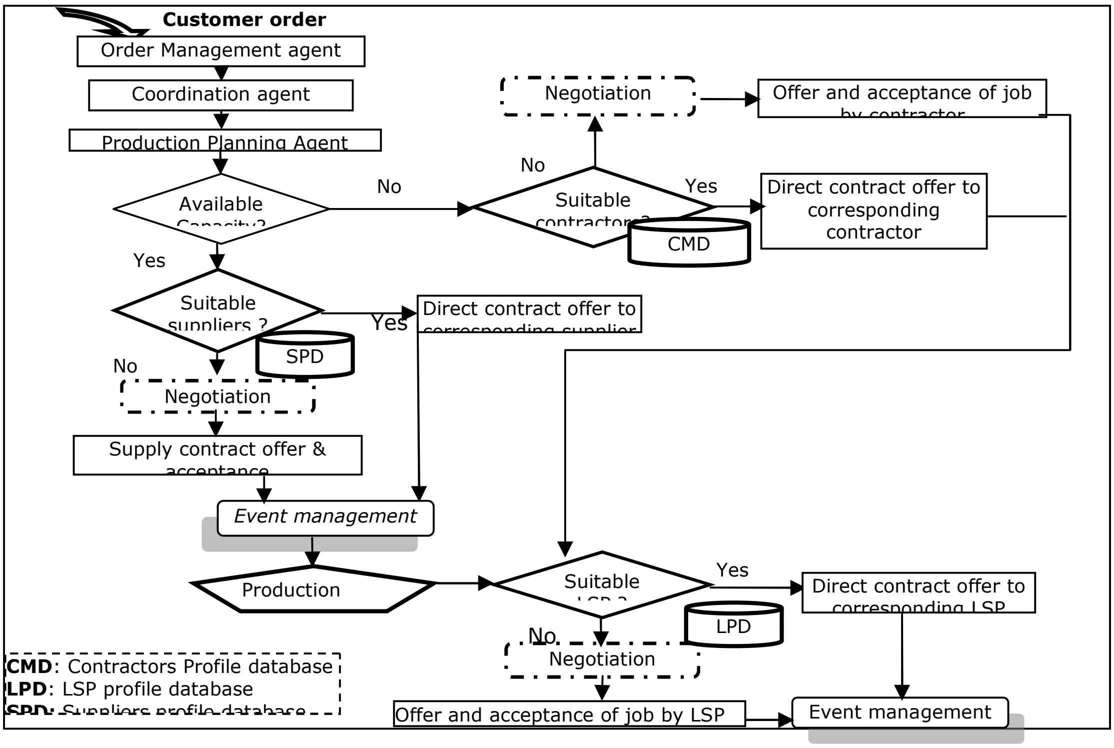


Figure 4 - Interactions among agents at production fulfillment process

DISCUSSION – ANALYSIS OF THE POTENTIAL ADVANTAGES AND DISADVANTAGES

One of the potential advantages of the proposed framework is that it provides integrated capabilities for production, supply chain event and disruption risk management under a collaborative basis. It enables an organization to inform its customers about the precise delivery date, taking into consideration transportation and production lead times. For instance, when a customer places an order, suppliers and logistics service providers are contacted in real time in order to provide specific delivery date.

The existence of a supply chain event management system provides the perspective for the reinforcement of the collaboration among partners. In particular, after a customer confirms its order, a monitoring procedure is initiated across the partners that are linked to the fulfillment of this order. A monitoring agent is generated to each of the partners and when an abnormal event is identified to a specific supplier, a procedure for corrective action is initiated through the disruption risk management agent. The proposed framework has also the potential to provide customer sensitivity, essential ingredient for a truly agile supply chain (Christopher and Towill, 2001), through the identification of trends of customer needs by the analysis of customer profiles situated in customer profile database.

Despite the fact that the framework can address the systems risk through the initiation of backup agents, it is incapable of providing any security to the agents. Agents can be harmed by malicious attacks from other agents, masquerade as the agents of supply chain partners (Sycara and Wong, 2000). The framework is also suitable for application only by manufacturing organizations (production planning and manufacturing management agents cannot be used within the reality of a service organization).

It is suitable for application only in agile supply chains due to the fact that its mechanics are oriented to provide a high customer service level, which is a market winner in this type of supply chains. The proposed framework is technically incapable to provide the customer capabilities for "customization" of the final product, according to its preferences. A limitation is that eventually the service for supply chain event management has a monitoring cost per order 45€ (Bodendorf et al. 2006). Thus, there is an inability in economic terms, to monitor all the customer orders.

SUGGESTIONS FOR FURTHER IMPROVEMENTS

In this section, suggestions for further improvements to the proposed framework, which could enhance its capabilities and particularize some of its mechanics are discussed.

Layered technological infrastructure coupled with Semantic Web technology

One of the major improvements is to enhance the framework with semantic web technology in order to consolidate the capabilities. The semantic web is considered as an emerging expansion of World Wide Web with the ability to apprehend and fulfill the commands of human and computational entities to use content of the web, through a standard semantic format for information and services (http://www.w3.org/RDF/FAQ). This will enable both human and agent entities to make inferences, facilitating intelligent and responsive decision making concerning especially supply chain events (Soroor et al., 2008). Figure 6 illustrates a first instance of the technological infrastructure, which could be used in order to support semantic web technology as services for supply chain event management and production planning. The suggested technological infrastructure is constituted by layers, because it is considered as the most suitable for systems aligned with the concept of the "extended enterprise" (Davis and O' Sullivan, 1999). With this technological infrastructure, several benefits can be accomplished:

- Access from a multitude of sources such as PDA, mobile phones, notebooks and desktop computers, which fulfils the need for real-time and mobile SCM (Soroor et al., 2008). This capability is attributed through the **presentation layer** of the system.
- Standardized communication formats, having the capability to manage different types of information through the *communication layer*. This layer is responsible for the transformation of the information received through access layer into a standard format (Lo et al., 2008).
- Process integration among systems for SCM, ERP and CRM systems consolidating the capability for the organization so as to conduct e-business (Lo et al., 2008)., through the *application layer*.
- *The ontology layer* utilizes semantic web technology in order to consolidate the level of information integration from the upstream to the downstream of the supply chain, under a cost efficient regime (Bodendorf et al., 2006; Lo et al., 2008).
- A complete database so that the upper organizational echelons are facilitated to establish more complicated tasks (Lo et al., 2008), through the *database layer*. This database will store information related to suppliers, LSPs, customers and disruption risk management.

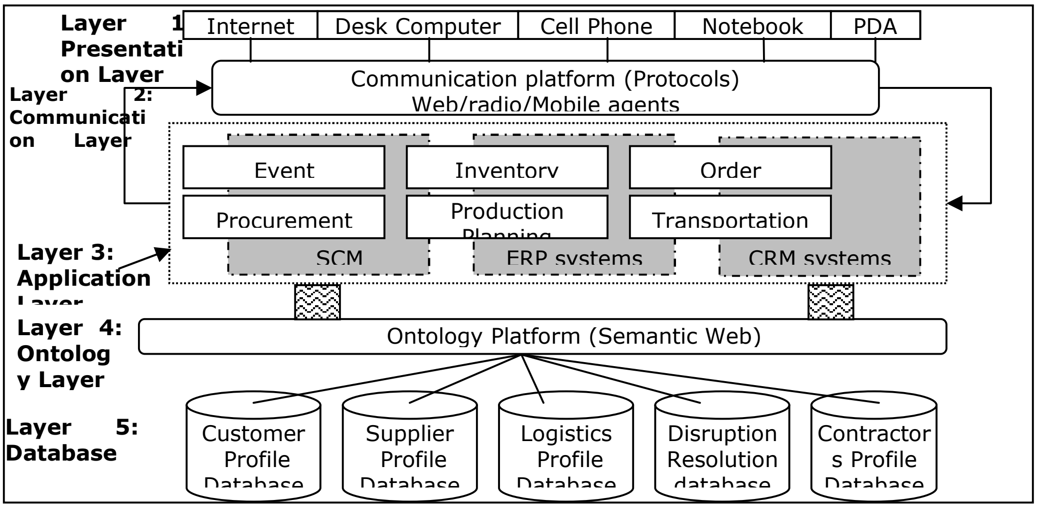


Figure 6 - Layered technological infrastructure (adapted from Davis and O' Sullivan, 1999; Soroor et al.2008; Lo et al., 2008)

In order to evaluate the business value of the proposed framework, multi agent simulation could be used. Janssen (2005) uses a similar approach in order to estimate the business value, of an agent based approach that used for the modeling of a retail supply chain.

CONCLUDING REMARKS

In recent years supply chains, due to the increasing supply chain complexity and demands for more agility that increase supply chain risks. There are certainly many benefits from the utilization of ITin supply chain risk management initiatives. Inter-Organisational ICT tools offer opportunities to effectively support the management of supply chain activities, to communicate and share information in a speedy and reliable way, to reduce information asymmetries across the supply chain and to lead to the identification of events that have the potential to create disruptions in supply chain processes. Multi-agent technology seems as a promising opportunity in order to meet the need of modern SCM for high level of cross organizational collaboration and decentralization of operations. This paper presents a comprehensive multi-agent based conceptual framework that provides the potential for high level cross organizational collaboration, through production fulfilment, supply chain event and disruption risk management.

The advantages of a multi-agent SCM model over conventional ICT tools for risk management are multitude. The real time adaptability and the learning capability through algorithms that is embedded in the model can lead to a more efficient coordination of activities amongst supply chain partners. This in turn can lead to more effective SCM. Due to its simple and straight forward programming effort (with the use of freely available developing tools for MAS) (Stone and Veloso, 2000), the model has the potential to incorporate conventional supply continuity planning systems as well with the use of "wrappers", and/or be part of existing risk assessment tools like critical path analysis tools or geographic information systems as it can be built in mobile software environments. As the framework focuses on demand driven supply chains, the adaptation of the proposed framework to the single character of a supply chain (e.g. lean, agile) is considered as a paramount factor for its success. Future work to this study is currently directed on the performance of the proposed framework using agent-based simulation.

REFERENCES: are available from the authors upon request.

SECTION 3 – SUPPLY CHAIN PERFORMANCE ASSESSMENT

EVALUATING SUPPLY CHAIN PERFORMANCE: AN EMPIRICAL ANALYSIS OF THE GREEK DAIRY SECTOR

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INTRODUCTION

In the supply chain management literature, performance measurement is an important improvement tool towards supply chain excellence. Nevertheless, it has not attracted much research interest (Chan and Qi, 2003) resulting in the lack of relevant performance measures and the lack of applying holistic measurement systems. In order to create a more cohesive perception of the chain performance, firms need to reconsider the impact of their performance on the whole supply chain and obtain a comprehensive overview of the whole chain (Lai et al., 2002). The objective of this study is to empirically evaluate an agri-food supply chain and given the scarcity of empirical evaluation studies regarding agri-food supply chain performance, this study focuses on performance measurement of the Greek dairy supply chain. We aim to give insights of performance differences between several chain levels. To our knowledge, these issues have not been examined in the past for firms representing the Greek or the European dairy sector.

LITERATURE REVIEW

Nowadays, customers' requirements are increased and consumers demand products that satisfy their individual needs and better quality. In addition, manufacturers are focused on reducing production and operational costs, achieving better lead times and lower inventory levels. Long term strategic partnerships with key suppliers and collaboration in key processes are important in order to overcome these pressures (Chan and Qi, 2003). Supply chain management is a key tool for the firms to achieve improved competitiveness and their organizational goals (Lee, 2000) and in order to improve supply chain effectiveness, firms should monitor and measure supply chain performance. In the present dynamic context, the competitiveness of a supply chain depends on evaluating and improving supply chain performance (Cai et al., 2009). According to Mentzer and Konrad (1991), performance measurement is the analysis of the effectiveness and efficiency in accomplishing a given task. It gives managers access to important feedback information related with performance and progress monitoring which enables them to enhance motivation and communication and discover system inconsistencies (Waggoner et al., 1999). Supply chain performance could be evaluated under different perspectives and thus, many firms find it difficult to measure their performance on a supply chain basis (Lai *et al.*, 2004). Traditionally, supply chain performance measures focus on reducing costs or improving efficiency (e.g. lead times, inventory turns, service levels) (Ramdas and Spekman, 2000). There are four main categories of individual measures of supply chain performance: quality, time, cost and flexibility (Cai et al., 2009). According to the literature, the use of individual performance indicators is inadequate for supply chain performance measurement (Beamon, 1999). These traditional performance metrics have the crucial limitation of focusing on the unit and not on the whole chain (Lai *et al.*, 2002). For the above reasons, the emerging stream of literature on supply chain management suggest that supply chain performance is not only quantitative but also qualitative (Shepherd and Gunter, 2006), have multiple dimensions (e.g. time and speed, agility and flexibility, quality and productivity) (Lai *et al.*, 2004), and motivate firms to focus on chain performance (Bechtel and Jayaram, 1997). In the supply chain literature, there are very few research papers regarding performance measurement. For example, Beamon (1999) reports three main performance measure types: resources (cost), output (customer responsiveness) and flexibility (how well the system reacts to uncertainty). Gunasekaran *et al.* (2001) propose a framework for performance measurement where metrics are classified into strategic, tactical and operational levels of management. Regarding performance measurement in agri-food supply chains, relevant research papers are even fewer. Aramyan et al. (2006) propose a conceptual framework of agri-food supply chain performance indicators taking into account the exceptional specifications of agri-food chains (e.g. seasonality in production, product safety, sensory properties and others). That framework includes four types of performance indicators: efficiency, flexibility, responsiveness and food quality.

METHODOLOGY

The Greek dairy sector has a key role in the Greek food sector and key products include butter, cheese, yoghurt, cream and milk. It contains some of the larger food manufacturers in the country and the Greek dairy chain is also characterized by high competition between its members. (ICAP, 2007). The data collected in this study consist of questionnaire responses from managers in the Greek dairy supply chain. The sample represented breeders, small dairy manufacturers, large dairy manufacturers, wholesalers, retailers and catering firms. We examined small and large dairy manufacturers separately as the analysis showed a significantly different performance between them; overall, the study focused on answering three broad questions:

- How do firms in the Greek dairy sector evaluate their supply chain performance regarding specific performance indicators?
- Are there any differences in the supply chain performance between the six firm categories of the Greek dairy sector?
- In which performance indicator each firm category overperforms or underperforms?

A structured questionnaire was used to reveal perceptions on supply chain performance and included four categories of performance indicators widely used in supply chain performance literature (Aramyan *et al.*, 2006; Shepherd and Gunter, 2006): efficiency, flexibility, responsiveness and product quality. According to Lai *et al.* (2002), efficiency refers to the proper utilization of the resources and could be measured with several types of costs and profits (e.g. operating costs). In our study we included six efficiency indicators: production/ operational/ raw materials cost, storage cost, delivery and distribution cost, waste, financial cost and gross sales. Flexibility is a critical supply chain performance indicator and measures the capability to provide individual services or products to the customers (Gunasekaran *et al.*, 2004). The flexibility indicators included in our questionnaire were flexibility in extra volume orders and flexibility in delivering in extra point of sales. Customer responsiveness is one of the dominant performance measures in supply chain models (Beamon, 1999) and we used three responsiveness indicators: responsiveness in the arranged lead time, responsiveness in delivering the arranged point of sale and responsiveness in delivering the ordered type of product (exact code, quality, etc). Product quality is also an important and widely used criterion for measuring supply chain performance (Chan and Qi, 2003; Beamon, 1999). Six product quality indicators were included in our instrument: Raw materials' quality, Quality of the firm's product, Product's conservation time, Consistency in following a traceability system, Storage and delivery conditions and Quality of the firm's products packaging. Two total evaluation questions were added: the first one examined the opinions about firm's overall performance and the second one had to do with the perceived market's opinion about the firms' performance. The measurement items for efficiency were assessed as a percentage of the firm's turnover. The measurement items for flexibility, responsiveness, product quality and total evaluation were assessed on a seven-point scale (1= Very satisfying performance to 7= Very unsatisfying performance).

A total of 257 questionnaires were answered but eight of them were not usable. The profile and characteristics of firms are displayed in Table 1.

Table 1: Profile of the respondent firms

Type of firm (N=249) and (% of whole chain)	Breeders	Small dairy manufacturers	Large dairy manufacturers[1]	Wholesalers	Retailers	Catering firms
	26 (10,44%)	67 (26,91%)	11 (4,42%)	70 (28,11%)	49 (19,68%)	26 (10,44%)
Number of employees (Mean)	Family-based	45	28	17	11	27
Level of turnover (more frequent responses in relevant groups)	30.000-40.000[2]	500.000-1.000.000	> 1.000.000	> 1.000.000	200.000 -500.000	500.000 - 1.000.000
Size of storehouses (Mean)	74,6[3]	1522	1678	1450	509	1109
Number of trucks (Mean)	4[4]	7	11	8	4	5

***Notes**: 1: Number of large dairy manufacturers is low but they show a significantly different behaviour from the other chain members, 2: annual income, 3: farm size in hectares, 4: Number of agricultural trucks*

RESULTS / ANALYSIS

Supply chain performance

Table 2 provides a summary of the means and standard deviations for all 19 measurement items. The results show that regarding efficiency, the producing/ operational/ raw material cost is the higher cost (approximately 50% of the firm's turnover). Logistics and distribution costs (Storage costs, delivery costs and wastes) are quite low. The flexibility indicators have quite high scores (2,50 and 2,77 respectively) and present a moderate performance in the specific area. On the contrary, the responsiveness indicators show that the dairy chain responds well to the market's demand (all three indicators have a score <2). The answers of the 249 firms show that the Greek dairy chain is supplied with fine raw material (1,47) and supplies that market with quality products (1,88). The overall performance from the firm's and the market's point of view is almost identical (2,13 and 2,16 respectively) and could be improved.

Table 2: Performance of the Greek dairy supply chain

Performance indicator[1]	Score Mean (SD) (N=249)	Performance indicator[2]	Score Mean (SD) (N=249)
Producing/ operational/ raw material cost	49,33 (29,70)	Flexibility in extra volume orders	2,50 (1,55)
		Flexibility in delivering in extra points of sales	2,77 (1,77)
Gross sales	11,99 (10,64)	Responsiveness in the arranged lead time	1,60 (0,91)
		Responsiveness in delivering in the arranged point of sale	1,76 (1,30)
Storage cost	5,63 (7,67)	Responsiveness in delivering the ordered type of product (exact code, quality, etc)	1,60 (0,94)
		Raw materials' quality[3]	1,47 (0,69)
Delivery and distribution	6,14 (8,01)	Quality of my firm's product	1,88 (1,66)

cost		Product's conservation time	3,24 (1,97)
Waste	3,94 (4,06)	Show consistency in following a traceability system	1,98 (1,54)
		Storage and delivery conditions	1,63 (1,12)
Financial cost	9,71 (13,32)	Quality of my firm's products packaging	2,39 (1,90)
		Total evaluation of firm's performance	2,13 (0,97)
		Total evaluation of firm's performance from the market's point of view	2,16 (1,00)
***Notes**: 1:% of turnover, 2:Seven point Likert scale (lower values indicate better performance), 3: the question concerns only small and large dairy manufacturers*			

The results of Table 2 show that the Greek dairy supply chain is focused on the production operation. Even though dairy is a high sensitive and perishable product the logistics and distribution costs are quite low. The 249 dairy companies appear highly responsive in the market demands but on the contrary they are not so flexible in their customers' requirements. The phenomenon indicates that dairy firms are willing to fulfil the arranged transactions but they don't seem capable of offering extra services to their customers. As a result, in the case of a rapid demand change, the chain's underperformance in terms of flexibility could create a bullwhip effect. Furthermore the consistency in following a traceability system was expected higher taking into consideration that it is a food supply chain. Overall, the Greek dairy supply chain performs quite well according to its members but there is room for improvement. In order to find any significant differences in the performance of the Greek dairy supply chain members we performed a one way analysis of variance (ANOVA, see Table 3).

Table 3: Difference between dairy chain members' performance

Performance indicator	Breeders Mean(SD) (N=26)	Small dairy manufacturers Mean(SD) (N=67)	Large dairy manufacturers Mean(SD) (N=11)	Wholesalers Mean(SD) (N=70)	Retailers Mean(SD) (N=49)	Catering firms Mean(SD) (N=26)	ANOVA *F-statistic*[4]
Producing/ operational/ raw material cost[1]	59,74 (25,14)	60,62 (24,98)	64,00 (28,81)	35,26 (32,94)	45,83 (32,34)	32,07 (15,18)	5,158
Storage cost[1]	3,8 (6,57)	7,00 (9,30)	6,50 (4,36)	4,55 (4,99)	2,30 (2,43)	10,57 (11,15)	2,639
Delivery and distribution cost[1]	3,31 (5,13)	7,31 (8,29)	12,33 (15,37)	5,66 (7,36)	2,76 (2,98)	10,71 (11,66)	2,804
Flexibility in delivering in extra points of sales[2]	3,58 (2,23)	2,71 (1,65)	2,09 (1,89)	2,27 (1,36)	3,61 (2,06)	2,19 (1,02)	5,757
Responsiveness in delivering in the arranged point of sale[2]	1,81 (1,23)	1,88 (1,45)	1,18 (0,40)	1,56 (1,00)	2,19 (1,75)	1,38 (0,57)	2,426
Raw materials' quality[2,3]	-	1,53 (0,72)	1,09 (0,30)	-	-	-	3,995
Product's conservation time[2]	4,00 (2,33)	2,56 (1,69)	3,64 (2,42)	2,93 (1,76)	3,38 (1,88)	4,78 (1,83)	6,246
Quality of my firm's products packaging[2]	2,50 (1,84)	1,77 (1,01)	1,73 (1,79)	2,35 (1,93)	3,23 (2,37)	2,84 (2,27)	3,900
Total evaluation of firm's performance[2]	2,46 (1,42)	2,22 (0,95)	1,36 (0,51)	2,09 (0,85)	2,24 (1,01)	1,81 (0,63)	2,942
***Notes**: 1:percentage of turnover, 2:Seven point Likert scale (lower values indicate better performance), 3: the question concerns only small dairy manufacturers and large dairy manufacturers, 4:p< 0,05*							

The significant differences in the efficiency performance of the Greek dairy supply chain members appear in the producing/ operational/ raw material costs, the storage costs and the delivery and distribution costs. The producing/ operational/ raw material cost is significantly higher in the first tiers of the chain (breeders: 59,74% of the firm's turnover, small dairy manufacturers: 60,62% large dairy manufacturers: 64,00%) which indicates that these are the stages where the product value is created and the product takes its final form. On the contrary, the tiers closer to the final consumer (wholesaler, retailers, catering) have lower participation in the value creation procedure. Catering companies have the higher storage costs (10,57% of the firm's turnover) and have high turnovers followed by the small dairy manufacturers and large dairy manufacturers (7,00% and 6,50% of the firm's turnover respectively). Wholesalers and retailers have significantly different storage costs (4,55% and 2,30% of the firm's turnover respectively) partly because this sample mainly includes national wholesalers operating in big urban centers while retailers are from rural areas. Breeders have the lower storage costs (3,8% of the firm's turnover) since they keep their product for a very small time period before small dairy manufacturers buy it. Small dairy manufacturers have high delivery costs because they collect raw materials (milk) from the breeders' farms on their own (7,31% of the firm's turnover). Retailers' scores show low delivery and distribution costs (2,71% of the firm's turnover). Overall, the results indicate that retailers have little participation in the logistics operation of the Greek dairy supply chain. On the contrary, the results also indicate that the specific operation is carried out by the small dairy manufacturers and the dairy large dairy manufacturers. Based on the above, it is evident that the chain performance could be improved. For example, the performance during the delivery of dairy products in extra point of sales has significant differences between the chain's members. As seen on Table 3, wholesalers, large dairy manufacturers and catering companies are more flexible in the specific area (scores: 2,27, 2,09 and 2,19 respectively) since they have higher delivery capabilities as a part of their operation. Between the two chain members that process the raw material (small dairy manufacturers and large dairy manufacturers), the large dairy manufacturers evaluate significantly higher their supplies in milk (score: 1,09) than the small dairy manufacturers (score: 1,53). One plausible explanation is that large dairy manufacturers have bigger power in the chain due to their size and their order levels in milk quantities and they can have access to the best quality. A crucial element in the chain performance regarding quality is the product's conservation time (has the worst mean score between the quality indicators: 3,24). The breeders have the second worst score (4,00) since they don't have the proper storage capabilities and they must sell their product almost immediately to the dairy manufacturers. The results indicate that the small dairy manufacturers control better the product's conservation time (score: 2,56). Then as we get closer to the final consumer the specific indicator deteriorates significantly where wholesalers perform better than retailers and retailers perform better than catering companies (scores: 2,93, 3,38 and 4,78 respectively). In addition, large dairy manufacturers perform significantly worse (score: 3,64) than small dairy manufacturers. The ANOVA analysis of the efficiency performance indicated that the product value is basically created by the small dairy manufacturers and the large dairy manufacturers.

Outline of the dairy supply chain members

We tried to create an outline for each member of the Greek dairy supply chain regarding their performance by using one sample T-test. With the T-test analysis we discovered the statistically significant differences between a single chain member and the whole chain behaviour (including the other cross-examined member).

Table 4: Significant differences between the dairy chain members' performance and the average chain performance

Performance indicator	Breeders Mean (N=26) *(T-test)*	Small dairy manufacturers Mean (N=67) *(T-test)*	Large dairy manufacturers Mean (N=11) *(T-test)*	Whole-salers Mean (N=70) *(T-test)*	Retailers Mean (N=49) *(T-test)*	Catering firms Mean (N=26) *(T-test)*	Dairy chain Mean (N=249) *(T-test)*
Producing/ operational/ raw material cost		60,62 *(3,033)*		35,26 *(-2,378)*		33,07 *(-4,405)*	49,33
Gross sales				7,76 *(-3,182)*			11,99
Storage cost[1]					2,30		5,63

					(-6,128)		
Delivery and distribution cost	3,31 *(-2,203)*				2,76 *(-5,192)*		6,14
Waste					2,96 *(-2,119)*		3,94
Financial cost				6,25 *(-2,527)*			9,71
Flexibility in extra volume orders						2,04 *(-2,115)*	2,50
Flexibility in delivering in extra points of sales				2,27 *(-3,065)*	3,61 *(2,862)*	2,19 *(-2,886)*	2,77
Responsiveness in the arranged lead time						1,35 *(-2,668*	1,60
Responsiveness in delivering in the arranged point of sale			1,18 *(-4,740)*			1,38 *(-3,352)*	1,76
Responsiveness in delivering the ordered type of product (exact code, quality, etc)			1,18 *(-3,429)*				1,60
Raw materials' quality		1,53 *(0,683)*	1,09 *(-4,170)*				1,47
Product's conservation time		2,56 *(-3,261)*				4,78 *(4,036)*	3,24
Show consistency in following a traceability system			1,09 *(-9,780)*				1,98
Storage and delivery conditions			1,18 *(-2,465)*				1,63
Quality of my firm's products packaging		1,77 *(-4,992)*			3,23 *(2,342)*		2,39
Total evaluation of firm's performance			1,36 *(-5,038)*			1,81 *(-2,594)*	2,13
Total evaluation of firm's performance from the market's point of view			1,55 *(-2,964)*				2,16

Table 4 presents the significant differences that breeders show in their performance. The breeders' delivery and distribution cost is significantly lower (score: 3,31) than the average chain cost (mean score: 6,14). As a result, the specific cost rolls over to the following chain tiers (small dairy manufacturers and large dairy manufacturers) who present high delivery and distribution cost (see Table 3). The producing/ operational/ raw material cost is significantly higher (score: 60,62) for the small dairy manufacturers (see Table 4) and this indicates that there is more value adding procedures in the manufacturers' operation. They control the product's conservation time (score: 2,56) and they package their products (score: 1,77) better than the whole chain in average. As a result, the next tiers don't have to contribute considerably in the packaging. Table 4 clearly shows that in the Greek dairy supply chain, the large dairy manufacturers perform better. In particular they respond better in delivering the products in the arranged point of sale (score: 1,18) but also in delivering the ordered products (score: 1,18). They manage to supply their production with the best raw material (score: 1,09) and they show high consistency in following a traceability system (score: 1,09). The results indicate that the large dairy manufacturers are the ones who lead the Greek dairy chain's traceability system and press the other members to the specific direction. The large dairy manufacturers' performance is evaluated much higher (scores 1,36 and 1,55) than the chain's average (means scores: 2,13 and 2,16 respectively). As seen on Table 4, wholesalers of the dairy supply chain underperform in gross sales (score: 7,76) while they present lower producing/ operational/ raw material cost (score: 35,26) and financial cost (score: 6,25). The only indicator in which wholesalers perform better than the average (mean score: 2,77) is the flexibility in delivering in extra points of sales (score: 2,27). On Table 4, the significant differences between retailers' performance and the average Greek dairy chain's performance are also presented. It is worth mentioning that retailers have lower logistics cost (Storage cost: 2,30, delivery and distribution cost: 2,76 and waste: 2,96 respectively) than the chain in average (means scores: 5,63, 6,14 and 3,94 respectively). This indicates that retailers have low contribution in the chain logistics system. In addition, they underperform in delivery flexibility and packaging. The catering companies in the Greek dairy supply chain overperform in the issues of flexibility and responsiveness (Table 4). Even though flexibility scores are above 2 (2,04 and 2,19), they are significant lower than the chain average (2,50 and 2,77). This is due to the nature of their business and their delivery capabilities.

CONCLUSIONS

The findings reveal that the chain is focused on production and that its members don't put much effort on logistics issues. The Greek dairy supply chain responds really well to the market needs and the chain members outperform in the specific element. On the contrary they underperform in the flexibility measures. This means that the chain tries to respond well to the ordered but it lacks the extra services needed. The results of the study indicate that the final products are produced and packaged by the small dairy manufacturers and the large dairy manufacturers. The other chain members have low participation in adding value to the final product. This is an interesting result that dairy firms should notice and try to add value in every chain stage. The dairy surplus value (and profits) seems to be captured mainly from large dairy manufacturers and secondly from small dairy manufacturers. In addition, the chain logistics operation is being carried out by specific members (small dairy manufacturers, large dairy manufacturers and catering firms) while retailers have a very low participation. Retailers should be more active in the chain logistics management since they have the consumer information and could contribute to the better satisfaction of the market demand. Overall, the results indicate that large dairy manufacturers overperform in the Greek dairy supply chain. Small dairy manufacturers and catering firms come second. It is worth mentioning the underperformance of retailers in many of the performance indicators. An important contribution of this study is the empirical measurement of supply chain performance in the dairy sector. The results provide a starting point and an initial benchmark for firms of that dairy sector in their attempt to improve supply chain performance. However there are several limitations to this study. We used a limited number of performance indicators. Further research should assess the performance of the specific supply chain with a wider measurement instrument. Moreover, we invited the respondent firms to self evaluate their perceived supply chain performance and it is possible that the results suffer from respondent bias. The results of our study refer to a single point in time and to the Greek dairy chain. Future research could assess supply chain performance in the dairy sector in a longitudinal basis and a cross-country basis as well in order to track the changes and the differences of performance in this chain.

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A MODEL TO SELECT SPECIFIC MEASURES FOR ADAPTABILITY OF LOGISTICS AND PRODUCTION SYSTEMS

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ABSTRACT

The dynamics and volatility of both procurement and sales markets require intelligent logistics and production concepts as well as adaptable organizational structures and changeable systems. Besides, the management of a company aims at the avoidance of every kind of waste as well as continuous optimization of the concepts, structures, and systems. In this context adaptability becomes more and more important.

In order to determine component failures or external changes of a logistics or production system at an early stage, different methods can be used. These methods have a certain statistical uncertainty. Due to this insecurity, the response time for the implementation of countermeasures in order to prevent failures and/or bottlenecks is not sufficient. The measure selection model is a tool which enables managers to quickly extract the most promising and effective measures from a pool of options and thereby significantly reducing the necessary response time. In order to ensure the best achievable results the selection process includes the criteria time, costs, and interdependencies as well as the impact of selected measures on the systems future ability to react to change.

This paper presents a theoretical concept to derive as well as to select appropriate measures for adaptability of logistics and production systems.

BASIC INFORMATION

A procedure model is an organizational framework which determines in particular activities of planning and their order. (Balzert, 2001) Following the definition of a model, a procedure model can be considered as an image of the current state (Töllner et al. 2011, p. 8ff). It assists at arranging a complex sequence of actions and enables keeping an overview of the course of events (Filß et al., 2005, p. 184). A structured approach for developing complex solutions is of importance. The act of systematically selecting optimization measures can be considered as a complex issue, especially a multitude of factors have to be taken into consideration and have to be arranged. A procedure model helps with the selection of holistic target-specific measures. On the basis of an object and phase-oriented structure (cf. Haberfellner et al. 2002, p. 528) of the procedure model, it is possible to explain this issue in a systematic way. The measure selection model comprises a repository of measures, a flexibility matrix, and a rating system (cf. Figure 1).

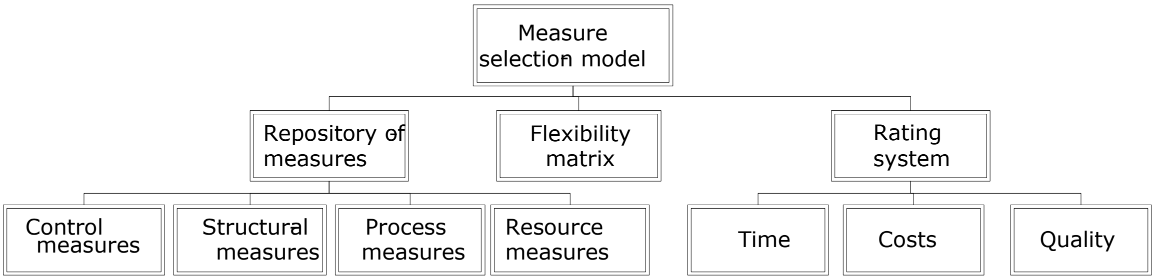


Figure 1: Object-oriented structure of the measure selection model

The repository or portfolio of measures comprises all measures for optimizing and adapting socio-technical systems and arranges them according to class and type of growth (growth vs. decline). The Dortmund process chain model, which makes a holistic modeling and analysis of processes possible on the basis of the process parameters control, structure, process, and resources, each with their own potential classes, (cf. Kuhn 1995), serves as a basis for determining and allocating measures for the individual process parameters and potential classes. In this way, the problem of assigning responsibilities for each level with regard to implementing and coordinating a measure is solved as well. The flexibility matrix offers information concerning flexibility potential of the resources (employees, tools, supplies for work, etc.) with regard to the practicability of the measures by means of the resources. The rating system as a further element of the measure selection model helps with analyzing the measures on the basis of the aforementioned criteria. The evaluation of the specific targets concerning costs, time, quality, and sustainability is of importance here.

The procedure model for selecting measures comprises seven phases (cf. Figure 2).
The individual phases contain so-called measure filters with which the relevant measures can be filtered out of the repository of measures. In the first phase, the problem is specified and all relevant measures are collected for the modification planning. Afterwards, the flexibility potential of the resources has to be determined. It gives information about the maximum scope of the actual implementation of the measures (1st phase: F-filter).

In principle it is possible that some of the determined bottleneck processes can be improved by means of alternative measures. In this case, the optimum has to be determined within the logistical triangle (quality, costs, and time). On the basis of this analysis with regard to time (deadline), costs (financial consequences) and quality (contribution to target achievement), the most effective and efficient measure among the available alternative measures can be determined. In the second phase, the realization time (short-, middle- or long-term) is assigned to the measures (T-filter). After assessing the realization time, the financial consequences of the individual measures have to be assessed, so that the user or decision maker can carry out a cost-calculation of the relevant measures (3rd phase: C-filter). Finally, the individual contributions of the alternative measures with regard to the target achievement have to be determined (4th phase: Q-filter). The individual measures have a different focus within the target triangle. Some measures for example are to be implemented primarily economically and in the short run, e.g. the in-house exchange of workers, while others are characterized by a high contribution to the target achievement along with high costs, like e.g. hiring (cf. Nyhuis et al. 2008, p. 332). For this reason, it should be strived for an optimum of the target criteria.

In the next step, all relevant measures are analyzed with regard to their influences or interdependences among themselves (5th phase: I-filter). According to the selected measure, it is afterwards possible to examine the sustainability as well as the need for further training with regard to the employees. The two final filters (S-filter and FT-filter) are in this regard only optional filters.

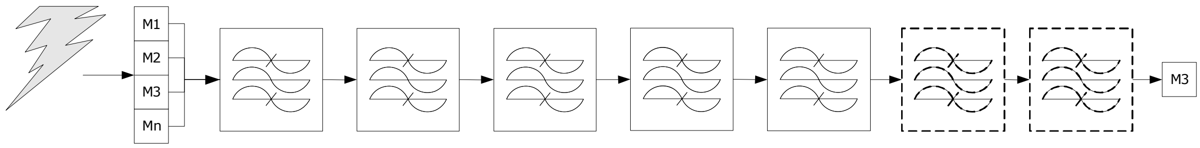


Figure 2: The schematic measure selection model

In addition to the available alternative measures this process can also be passed by individual, specifically selected measures, so that they can be evaluated in a holistic way. Figure 2 shows the schematic measure selection model with the individual filters, which the measures run through, so that in the end only the relevant measures are left. The complete filter process is supported by means of different tools. These tools are among other things sensitivity analyses and operational networks (for determining possible measures) as well as discrete event-orientated material flow simulators (for examining the target achievement).

MODEL DESCRIPTION

The measure selection model enables the user on the basis of the actual situation to select appropriate measures, which are supposed to counterbalance the modifications and system load fluctuation within his system (intralogistics or production system). In the following, this model is described in detail.

The identification of problems and measures

Before the measure selection model can be used, it is crucial to know, what the problem is. For this, it is necessary to record in detail, what kinds of problems exist. By means of the Dortmund process chain model (cf. Jungmann/Uygun 2011), the problem can be precisely located (e.g. problem concerning control, staff, source, etc.). In addition, it is of importance, how the problem develops. There can be acute (seasonal, etc.) or chronic problems (sustained trend, etc.). In case of neglecting the problem development, serious wrong decisions can be made. There is a multitude of measures for optimization or modifications due to market fluctuations. At first, it has to be analyzed, for which type of growth measures have to be identified. In principle there are three types of growth (growth, stagnation or decline), out of which basically only the positive and negative types of growth are relevant. For each one of these types, there are different measures. A good possibility for deriving measures is the examination of company resources and their capacities. A popular aggregation of such measures is those of the capacity coordination (Wiendahl et al., 2004, p. 147ff.; Schuh/Roesgen, 2006, p. 48ff.; Nyhuis et al. 2008, p. 332), which are rather meant for production than for intralogistics plants. Nonetheless are many measures (especially measures concerning staff) also meant for intralogistics systems (cf. Figure 3). Three principal types are described: capacity adjustment, capacity levelling, and system load adjustment.

Capacity adjustment

Adjustment of equipment
- In case of growth
  - Procurement of equipment
  - Renting of equipment
  - ...
- In case of decline
  - Leasing out of equipment
  - Shutdown of equipment
  - Offloading of equipment
  - ...

Adjustment of staff
- In case of growth
  - Additional working shift
  - Overtime
  - Internal human resources reserve
  - Employment of staff
  - Personnel leasing
  - ...
- In case of decline
  - Minimization of the working shift
  - Short-time work
  - Dismissal of staff
  - ...

Capacity levelling

Order planning
- In case of growth
  - Contracting out of orders
  - ...
- In case of decline
  - Acceptance of an externally processed order
  - ...

System Load adjustment

Technological adjustment
- In case of growth
  - Switching to other equipment
  - Upgrading of equipment
  - ...

Time adjustment
- In case of growth
  - Prioritizationof orders
  - Acceptance of a delay in delivery
  - ...

Figure 3: Exemplary measures for the capacity coordination within intralogistics systems (cf. Wiendahl et al., 2004, p. 148)

For the anticipatory change planning of intralogistics systems (cf. Kuhn et al. 2009), for example, other measures rather than tactical and operational ones have to be additionally examined in order to gain a complete overview of the available measures. For this, the decision of taking the process parameters (resources, control, structure and process) and the accompanying potential classes of the Dortmund process chain model (Kuhn et al., 1995) as a basis is favourable one. Since this process chain model makes a holistic examination of the processes possible, it is a well founded basis for deducing and allocating measures. On this basis, holistic and complete measures for the specific system (intralogistics or production system) can be identified. Measures for particular resources for example can be deduced. For the staff, e.g. adjustments concerning the employees (local, time, quantitative, qualitative adjustment, etc.), for the work equipment, capacity adjustments and levelling as well as system load adjustments (cf. Figure 3) can be carried out. A list of measures (repository of measures) which is compiled in this way is the basis of the measure selection model (cf. Figure 1). The next steps of the procurement model deal with the development of specific concepts for the holistic evaluation of resources and measures. These concepts are supposed to enable the user on the one hand to autonomously evaluate a measure and on the other hand to evaluate several alternative measures within a network of measures. In principal it is possible that a process can be optimized or adjusted by means of several alternative measures, which makes an evaluation of the alternatives necessary.

Flexibility potential of the resources: the F-filter

After the tended measures have been identified, the actual potential concerning the implementation of the measures has to be analyzed on the basis of the flexibility potential of the resources. For this, the maximum flexibility of the resources to implement these resources has to be determined. For example, no additional working shift can be scheduled, if there are restrictions on the part of labor unions. Thus, the staff as a resource would be characterized by a low flexibility potential for this measure. In a first step, the factors which influence the flexibility have to be identified in order to find out, what the flexibility of a resource (flexibility potential) is in general composed of. This includes for example the range of applications, employees’ qualifications, legal restrictions or physical aspects (cf. Jacob, 1990; Kobylka, 2000; Hildebrand et al., 2005). After having identified the absolute flexibility of the resource, its specific potential of implementing a certain measure has to be determined (specific flexibility). A measure can be stillborn, only partly, or completely realizable.

Realization time of the measures: the T-filter

The identified measures are characterized by different realization times. For this, the provisioning time, implementation time and if necessary the resolving time have to be examined. Some measures can be supplied and implemented within a short period of time, while others can rather be realised on a long-term basis (cf. Nyhuis et al., p. 332). The individual measures have to be analyzed against this background. By means of combined use of the measures on the basis of examining the interdependences, the individual implementation time can be affected. A measure which has to be implemented on a long-term basis can be modified by combining it with other measures to the effect that it can be used on a middle or short-term basis. The implementation times can also be reduced by being willing to accept higher costs. A measure which is rather to be implemented on a long-term basis can also be realized at an earlier point of time by accepting higher resources expenditure (cf. Figure 4). Structural modifications within an intralogistics system for example can usually be realized only in the long-term, but by means of more intensive planning and increased labor utilization their implementation can be accelerated.

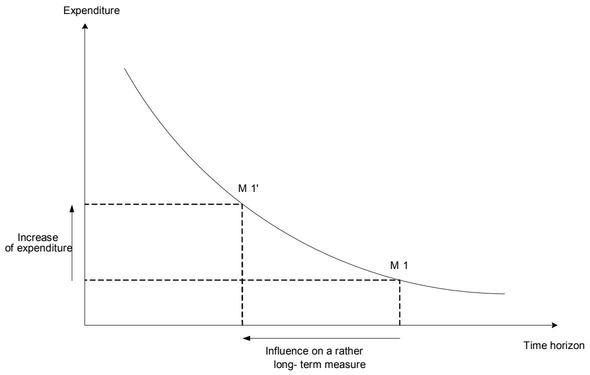


Figure 4: Time-expenditure-curve (Uygun & Luft 2010)

This stage in the process on the basis of the T-filter reveals how quickly a measure can be implemented. In addition to the increased resources expenditure, improvements in time can also be reached by taking the interdependencies of the measures as a basis.

Financial consequences of the measures: the C-filter

The introduction of one or several measures for counterbalancing fluctuations within an intralogistics system involves costs per se, which can considerably influence the decision for or against a measure. The costs of a measure comprise those for provision, introduction, implementation, and if necessary cancellation (cf. Figure 5). In some cases, a measure has to be made available before implementation (procurement, etc.). Since this requires a lot of organization or planning, this type of costs has to be taken into consideration as well. Subsequently follows the introduction (installation, training, etc.). During the implementation, operating costs can arise (energy, allowance, etc.). If necessary, a measure can be cancelled, which results in additional costs (compensation, etc.).

Cost			
Provision	Introduction	Implementation	Cancellation
Resources Procurement etc. Structures ... Control … Processes ...	Resources Installation Training etc. Structure ... Control … Processes ...	Resources Energy Allowance etc. Structure ... Control … Processes ...	Resources Getting rid of Compensation etc. Structures ... Control … Processe ...

Figure 5: Costs components of a measure

In general, the realization time and the costs of a measure are inversely proportional. The earlier a measure is planned to be used, the higher is the price, since for example more resources are necessary for the implementation. When introducing several interacting measures, the accumulated costs can in comparison to an isolated and independent introduction of these individual measures in principal be lower or equal and in exceptional cases even higher. This depends on, how the measures interact.

Contribution to target achievement: the Q-filter

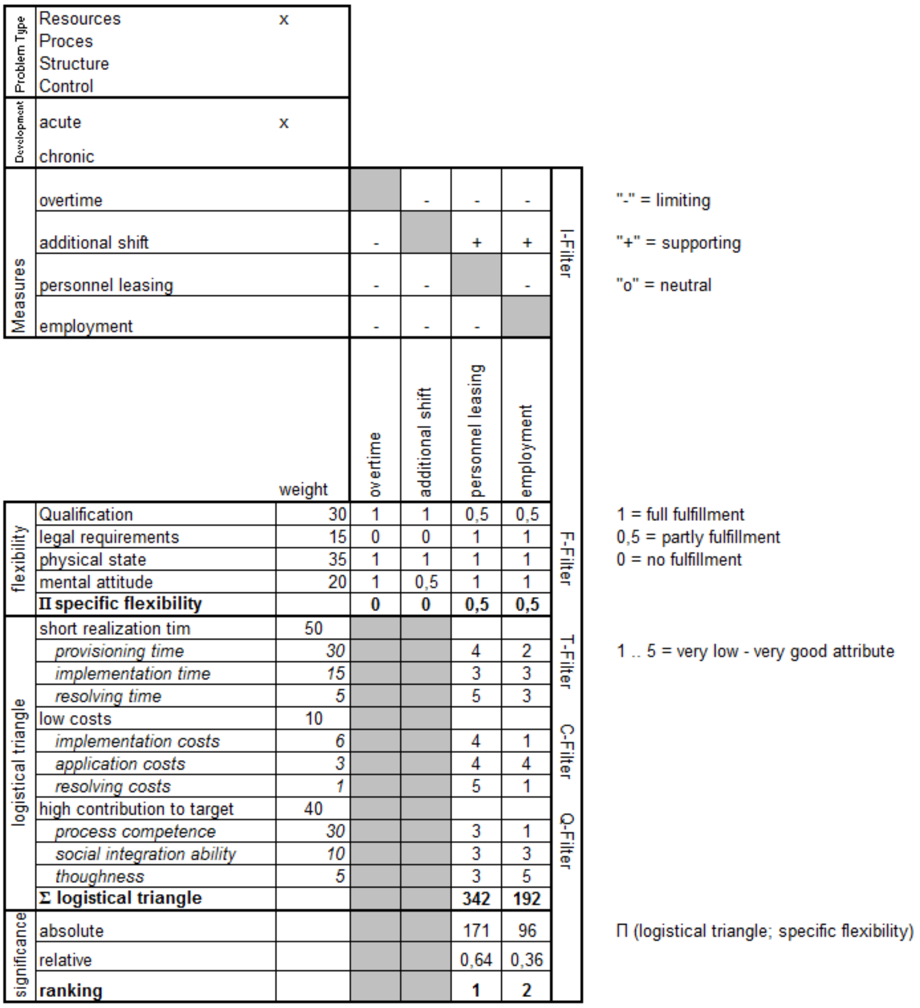
The quality of a measure is measured on the basis of its contribution to target achievement. For this, it is necessary to evaluate the individual measures case-specifically. The contribution to target achievement of the individual measures has to be analyzed in detail. In case of overload for example subcontracted workers can be employed or a further shift can be made by the permanent workforce. The target achievement of the latter alternative is from the aspect of the higher professional and methodical expertise as well as social competencies of the own employees, but also because of the learning curve phenomenon graded as more suitable in this case. In general, the appraisal of the contribution to target achievement is strongly subjective. The procedure model can be concentrated in a comprehensive multidimensional matrix.

Interdependencies of the measures: the I-filter

The measures of the repository or portfolio which were identified in the preceding section influence each other, in which the influence of a measure can be complex. At first, the polarity of the influence has to be determined in order to gain a consistent and coherent mix of measures. In principle a measure can influence one or several other ones in a positive/qualifying, neutral or negative/limiting way. If for example in recessionary times a structural adjustment in form of a reduction concerning the existing space is made, the Make to Stock production strategy is according to the principle of compensation (no cutback in production in the hope that there will be increased sales after the recession) correspondingly only partially applicable. On the other hand, if for example new equipment should be bought, makes this the measure of employing new employees possible. When introducing measures which have a positive influence, the direction of the influence is also of importance for determining the order and sequence of implementation. A measure can influence or support other measures (active influence), be influenced or supported by other measures (passive influence) or it can simply be neutral.

The influences of the measures are not only to be found in pairs, but they form a network within the totality of measures. The assessment of the influence of individual measures differs. Therefore, the assessment of the influence has to be examined in more detail in a further step, so that an optimal introduction result can be reached; on the one hand by means of synergies of the interacting measures and on the other hand by means of introducing the measures in a time-efficient way on the basis of examining the procedure model for selecting measures: assessment of the influence. For the latter, an influence quotient can be introduced, which is the quotient of the number of measures which are influenced by the respective measure and the number of measures which influence the respective measure. For example, a value beyond 2 indicates that the measure is active, a value between 1 and 2 indicates the neutrality of the measure and a value smaller than 1 indicates passivity (Kortmann/Uygun, 2007, p. 635ff.). In this way, indications of the order of implementation can be gained. Measures which are active should be implemented at first and passive measures at last. Measures which interact only slightly with other measures can be implemented at any time. All measures have to be analyzed against this background. When selecting a certain measure out of the portfolio of measures, it can be recognized by this analysis, which supporting measures are available and can still optimize the result. By additionally examining the direction of influence, an optimal order of implementation can be guaranteed.

The following figure 6 demonstrates the design by an exemplary case study. Here, an acute problem occurs as to employees due to increase in system load. There are four measures identified, which run through the aforementioned filters. In the end, the measure personnel leasing seems to be the best alternative.



Problem Type	Resources	x
	Proces	
	Structure	
	Control	
Development	acute	x
	chronic	

		overtime	additional shift	personnel leasing	employment
Measures	overtime		-	-	-
	additional shift	-		+	+
	personnel leasing	-	-		-
	employment	-	-	-	

		weight	overtime	additional shift	personnel leasing	employment
flexibility	Qualification	30	1	1	0,5	0,5
	legal requirements	15	0	0	1	1
	physical state	35	1	1	1	1
	mental attitude	20	1	0,5	1	1
	Π specific flexibility		**0**	**0**	**0,5**	**0,5**
logistical triangle	short realization tim	50				
	provisioning time	*30*			4	2
	implementation time	*15*			3	3
	resolving time	*5*			5	3
	low costs	10				
	implementation costs	*6*			4	1
	application costs	*3*			4	4
	resolving costs	*1*			5	1
	high contribution to target	40				
	process competence	*30*			3	1
	social integration ability	*10*			3	3
	thoughness	*5*			3	5
	Σ logistical triangle				**342**	**192**
significance	absolute				171	96
	relative				0,64	0,36
	ranking				**1**	**2**

"-" = limiting

"+" = supporting

"o" = neutral

1 = full fulfillment
0,5 = partly fulfillment
0 = no fulfillment

1 .. 5 = very low - very good attribute

Π (logistical triangle; specific flexibility)

Figure 6: Exemplary design of the measure selection model (Uygun & Luft 2012)

The discretionary filter of sustainability and further training

Sustainability is important for many companies. Sustainability has become one of the most important targets in order to survive on the market. For this reason, the discretionary filter is the sustainability filter. In addition to the C-Filter social and ecological aspects of the individual measures have to be evaluated in order to reach nonetheless the desired sustainability targets in consideration of the present bottleneck situation. Some measures could be cost efficient, but pollutive, e.g. outsourcing of processes. So, an optimum has to be achieved.

Similarly, the further training filter is a verification of in how far the employees have to be trained. Measures – often long-term measures – make possibly "greater" restructurings which have to be taken part in by the employees necessary. In order to guarantee this, it is sometimes necessary to train the employees. By buying and implementing new highly-developed machinery for example, the workers have to be trained, which can last a long time.

CONCLUSION

The procedure model for selecting measures or the measure selecting model makes a well structured and all aspects comprising processing and evaluation of measures for the optimisation of company systems possible. This model can be used by all entrepreneurial systems (intralogistics, production systems, etc.), which require an optimisation or improvement. The measures which are assigned to the process parameters and potential classes make with this an exact definition of the competencies and responsibilities in the phase of implementing a measure possible. The examination of the specific resource flexibility makes the identification of the specific implementing potential of the resources concerning a certain measure possible. On the basis of these analyses, individual measures which are adjusted to the needs can be defined by means of the subsequent evaluation according to costs, quality and time. The description of this measure filter model clarifies for the interdisciplinary understanding, that this as a procedure model represents a structured assistance system when deriving relevant capacitive adjustment measures. The exemplary implementation of this procedure model on the basis of an intralogistics system makes it possible for readers outside the field to understand a model from engineering science, so that a contribution to the promotion of the interdisciplinary model understanding is made.

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A REVIEW OF STUDIES ON THE FACTORS AFFECTING SUPPLY CHAIN INTEGRATION AND PERFORMANCE

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Literature Review

ABSTRACT

This paper reviews the supply chain integration literature systematically in order to offer insights for organisations wishing to improve integration within their supply chain and to identify areas for future research. Following a systematic approach for the literature review, an analysis of 177 papers was completed on different themes of supply chain integration, including types and antecedents of supply chain integration, and the relationship between supply chain integration and performance. Although internal and external integration has been researched extensively, in the literature to date few studies analysed internal and external integration simultaneously and investigated the relationship between these two types of integration. Our findings suggest that more research is needed to explore the links between internal and external integration as these are typically studied independently. There is widespread support in the literature for the need for trust, conflict and communication for effective integration, but to date research has focussed primarily on the direct effects of these antecedents on integration. Additionally, there have been inconsistencies regarding the relationship between integration and firm performance, particularly regarding the measures used. This is one of the few studies to conduct a systematic and broad based review on supply chain integration. This review enables us to present evidence regarding different types of integration that have been identified, the antecedents of integration, the relationship between integration and firm performance and integration and functional performance. This in turn leads to a number of future research directions (such as exploring the links between internal and external integration) that can assist academics to shape and further develop theory in this area.

INTRODUCTION AND RESEARCH APPROACH

Within the supply chain management literature, integration has been conceptualised in different ways e.g. as *internal* integration of operations and processes across functional boundaries (and with business strategy) and as *external* integration of linking external customers and suppliers into product development and manufacturing processes (Frohlich and Westbrook, 2001). From this, a consensus has emerged that better supply chain management and integration can help stakeholders in a variety of ways including improving their competitiveness, using resources more efficiently, improving relationships between supply chain members, more precisely controlling the flow of materials and information through the supply chain, reducing inventories, compressing lead times, and so on (Ellram, 1991; Cooper et al., 1997a), although some researchers question the level of empirical evidence available to support such claims (Fabbe-Costes and Jahre, 2007). We explore this further by way of a systematic literature review, which has four main objectives:

1. To identify the different types of integration within the supply chain, both internal to an organisation and with external partners in the supply chain.

2. To explore the antecedents of supply chain integration.

3. To explore the relationship between integration and functional performance and firm performance.

4. To identify areas for further research.

Within this systematic review of the evidence, a number of themes are pursued. First, the review seeks to identify the different types of integration (for example, internal, external, horizontal, and vertical etc.) and to identify which parts of the supply chain are integrated (suppliers, customers, logistics, information, functions etc.). Second, it seeks to identify the antecedents of integration (for example, trust, communication, conflict) and finally how integration influences firm and functional (purchasing and production) performance. The first step in the systematic review was to identify the keywords with which to search the library databases. The authors brainstormed an initial list and then checked this list with colleagues active in the field. This identified keywords such as supply chain, logistics, integration, antecedents, external integration, internal integration, collaboration, partners, and performance. These were used as the basis for search strings. An initial analysis was performed on the articles found to identify further keywords, such as information flows, upstream, downstream, and buyer-supplier.

The second step was to search 5 key databases (EbscoH (3079), Science Direct (5222), SCOPUS (27703), Social Sciences Citation Index (3766) and Web of Science/Web of Knowledge (3766)) using the search string supply chain? AND integrat?. A detailed protocol was then developed to use the more detailed search strings arising from the keywords generated in the first step. This guided the searching of the citation databases Science Direct and Web of Science/Web of Knowledge and led to 589 articles being found. The citations identified were reviewed using first the exclusion criteria and then the inclusion criteria to reduce the number of citations and to ensure that the review was based on the best-quality evidence (Tranfield et al., 2003). This meant that papers prior to 1980 were excluded, as very little was published before the 1980s in supply chain integration. Papers focusing on information technology integration between functions and within the supply chain were also excluded as this was not within the intended purpose of the review. Operational research papers on the topic were also excluded. Studies covering only traditional manufacturing systems, where the scope is not board enough from a supply chain perspective, were also excluded. A detailed assessment was made of the articles that were shortlisted via this process and further articles were added in consultation with colleagues at this stage, further validating and cross-checking the list of articles to be included as a result of the systematic review. These articles were then assessed against quality criteria including theory robustness, implications for practice; methodology and data to support arguments (as we were predominantly interested in including empirical rather than theoretical or conceptual articles), generalisability and contribution (see Pittaway et al, 2004 for a full description of these quality criteria). Following this process, 177 articles were selected and their abstracts were coded and themed according to the content to provide the structure for the literature review.

The review sourced articles from 59 journals. These broadly fell into the categories of Operations Management and Information Management; Marketing; and General Business and Management. The top ten journals by number of publications on supply chain integration represented approximately 60% of the total number of articles reviewed and were Journal of Operations Management, Journal of Supply Chain Management, Journal of Product Innovation Management, Journal of Business Logistics, Journal of Marketing, International Journal of Logistics Management, International Journal of Operations and Production Management, Decisions Sciences, International Journal of Production Economics and Industrial Marketing Management. In terms of year of publication; 12 articles were published in the 1980s, 63 in the 1990s and 102 in the 2000s. The most popular years were 2000 (15 articles), 2005 (12 articles) and 2006 (18 articles). The papers were then qualitatively categorised (as per our objectives) into different themes. The results are presented in Table 1, which shows 6 themes are related to different types of supply chain integration; 2 to the antecedents of supply chain integration; and 4 to the relationship between integration and performance.

Coding	*Theme*	*Description/Focus of Articles*	*No. of papers*
1	Logistics Integration	Internal and external logistics integration and forward, backward or reverse logistics	9
2	Information Integration	Information flows between functions or between organisations in the supply chain	14
3	Process Integration	Integration of internal and external business processes between functions and organisations	7
4	Internal Integration	The integration between internal functions within an organisation e.g. R&D/ Manufacturing, Marketing /Manufacturing, HR /Manufacturing, Purchasing /Manufacturing etc	26
5	External Integration	The integration between an organisation and key stakeholders e.g customers, suppliers	47
6	Scope and level of Integration	Studies looking at the scope and level of integration	15
7	Antecedents of Internal Integration	Factors supporting integration between functions e.g. communication, trust, conflict, etc	23
8	Antecedents of External Integration	Factors supporting integration between supply chain organisations e.g. communication, trust, conflict etc.	31
9	Internal Integration and Firm Performance	How internal integration affects firm performance	6
10	External Integration and Firm Performance	How external integration affects firm performance	3
11	Overall Integration and Firm Performance	How internal and external supply chain integration affect firm performance	7
12	Integration and Functional Performance	How internal and external integration affect functional performance	17

Table 1: Papers by theme

FINDINGS

The systematic review revealed that internal integration is found to positively affect external integration and vice versa (Stank et al., 2001; Giminez and Venture, 2003 and 2005). A firm usually achieves a high degree of internal integration before implementing external integration (Gimenez and Venture, 2003). Integration between two functions facilitates integration between two companies. External integration also has a positive impact on internal integration. Companies realise that collaboration and integration among different functional areas enhances the success of an externally integrated relationship. Moreover, internal integration in logistics-production and external integration positively influence one another in a stronger way than in the case of internal integration in logistics-marketing and external integration. However, to achieve high levels of external integration, companies realise that integration in logistics-marketing is also important (Gimenez and Venture, 2005). Owing to space limitations, only an extract of the results can be presented here. Hence Table 2 shows some of the key references by type of integration (more available in the full paper).

Type of Integration	***No. papers***	***References***
Logistics Integration		
Internal and external logistics integration	8	Paulraj and Chen (2007); Romano, (2003); Gimenez and Ventura (2005); Alvarado and Kotzab (2001); Chen et al (2007)
Forward logistics integration	6	Tan (2001); Romano (2003); Paulraj and Chen (2007)
Backward or reverse logistics	1	Bernon and Cullen (2007)
Information Integration	10	Clemons and Row (1992); Lee and Whang (2000); Mentzer et al (2000); Saakajarvi and Talvinen (1993); Wang et al. (2005); Saeed et al. (2005)
Process Integration	7	Lambert and Cooper (2000); Cooper et al. (1997b); Croxton et al (2001); Romano (2003); Danese et al. (2006)
Internal Integration		
R&D and manufacturing	6	Felfernig (2007); Lau et al. (2010); Dröge et al. (2000); Swink (1999); Swink (2000)
Marketing and manufacturing	10	Prabhaker et al. (1995); Kahn and McDonough (1997); Boyer and Hult (2005)
Human resources and manufacturing	3	Pagell (2004); Youndt et al (1996); Bose et al. (2008)
Purchasing and manufacturing	4	Narasimhan and Das (2001b); Handfield et al. (2009); Forslund and Jonsson (2009); Yeung (2008)
External Integration		
Customer integration	11	Sheu et al (2006); Enkel et al. (2005); Griffin and Hauser (1996); Groves and Valsamakis (1998)
Supplier integration	15	Fliess and Becker (2006); Rai (2006); Saeed et al. (2005); Das et al. (2006); Yeung et al. (2009)
Integration of suppliers into new product development process	12	Burt and Soukup (1985); Ragatz et al (1997); Swink (1999); Shin et al. (2000); Petersen et al. (2003); Lettice et al. (2009); Wynstra and Pierick (2000)
Higher level of integration with suppliers / customers in the supply chain	13	Anderson and Katz (1998); Hines et al. (1998); Johnson (1999); Frohlich and Westbook (2001); Vickery et al. (2003); Dröge et al. (2004); Rosenzweig et al. (2003)
Scope and Level of Integration	12	New and Ramsay (1997); Dröge et al (2004); Frohlich and Westbrook (2001); Mentzer et al (2000).*

Table 2: Classification of references by type of integration

(* Owing to space restrictions not all references are listed in this abridged version of the paper. Please contact the authors for full details if more information is required)

CONCLUSIONS AND DISCUSSION

In line with Pittaway et al. (2004), we found that a limitation of systematic reviews arises from the different conventions regarding publishing according to sub-disciplines and author preferences. Hence it is possible that some potentially relevant supply chain integration studies may not be included in this review. Similarly, as we relied on journal abstracts to make quality assessments, some articles may have been excluded if the abstract and keywords were unclear. Nonetheless, we were able to identify key themes in the literature and areas for future research.

The systematic review of the literature has shown that interest and research in supply chain integration has grown since the mid-1990s and continues to do so. Research has focused on both internal integration between functions and external integration between a firm and its suppliers or customers. Although internal and external integration have been researched extensively, only a few studies have analysed internal and external integration simultaneously and investigated the relationship between these two types of integration (Stank et al., 2001; Gimenez and Venture, 2003, 2005 and 2006). Further research could investigate this relationship based on a combination of both tactical and strategic levels of integration into one single construct. This would help provide a more holistic view of supply chain integration, which in turn would provide clearer guidance to organisations to enable them to better understand the links between internal and external integration.

There has been significant research interest in the antecedents of internal and external integration. This research shows that there are a wide range of factors thought to affect the ability to integrate effectively. Some of the relationships are still controversial, such as that between communication and integration. There is also a potential for future research to better understand the impact of new communication media on supply chain integration and whether it can help to support two-way rich communication effectively. Trust is often cited as an important determinant of integration. Trust is also considered to lead to better communication (Anderson and Narus, 1990). It would therefore be useful to research whether trust also mediates the relationship between communication and internal and external integration as well as having a direct impact on integration. Similarly, conflict is considered to have a negative impact on integration. One of the reasons for this is that conflict potentially reduces communication which in turn reduces the level of integration (Mollenkopf et al., 2000). It would therefore be interesting to explore the mediating role of conflict in the relationship between communication and internal and external integration.

Although the relationship between integration and firm performance has been of interest to several researchers, there have been inconsistencies between them on some points. The first difference is on the integration construct. While some authors referred to integration as logistics programmes or logistics integration (e.g. Ellinger, 2000; Vargas et al., 2000; Sanders and Premus, 2005), others studied integration in terms of supply chain integration in general (e.g. Vickery et al., 2003; Rosenzweig et al., 2003 Li et al., 2006). Second, items used to measure firm performance are different among authors. Some studies used agility to assess firm performance (Paulraj and Chen, 2007); whereas business performance was used to measure firm performance in other research, e.g. product development performance (Kahn and Mentzer, 1998) or sales growth (Rosenzweig et al., 2003). Market and financial performance were two other popular constructs used to measure firm performance (e.g. Ellinger et al., 1999; Vargas et al., 2000; Li et al., 2006; Vickery et al., 2003; Rosenzweig et al., 2003; Dröge et al., 2003; Frohlich and Westbrook, 2001). Third, the most important difference among the existing studies on the relationship between integration and firm performance is the way that integration was supposed to impact on firm performance. Some authors found a direct association between integration and firm performance (Rosenzweig et al., 2003; Vargas et al., 2000). Others found that the interaction of internal integration and external integration also impacted firm performance (Dröge et al., 2004). However, Sanders and Premus (2005) did not find that external integration directly impacts firm performance. Instead, they found that it indirectly affects firm performance via internal integration.

Further research should assess the reliability of a range of performance measures for integration studies and more fully explore the relationships between different types of integration and both functional and firm performance. Finally, future research on the mediating effect of purchasing and production performance between integration and firm performance is required to seek to explain the inconsistency of results we have encountered in this literature review.

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PERFORMANCE INDICATORS FOR SMALL FARMERS IN AGRICULTURAL FRESH FOOD SUPPLY CHAIN

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ABSTRACT

In agricultural fresh food Supply Chain, it is not popular to share Point Of Sales data among the chain especially, at farming stage. Most independent farmers do not refer the data at planning and farming. There are many reasons for this, e.g. production lead-time is rather long. However, this also causes inefficient production and limitation to cost reduction in fact. In this research, we assume that Key Performance Indicators which has been used in another segment are not suitable to manage business of farming stage in agricultural fresh product Supply Chain. Standing at beginning stage of this research, we focused on direct selling model of the product between farmers and consumers. We have already proposed an information system in the model and operated the system at an actual farmer's market. In this paper, we show several analyses focused on elasticity of price based on shelf time. We show some characteristics on the indicator according to variety of breed and yearly change.

Key words: Fresh Foods, Supply Chain Management, Decision Support System

INTRODUCTION

In modern Supply Chain, it is popular to share retailer's Point Of Sales (POS) data among Supply Chain members for analysing and understanding consumers demands and needs. The findings from the analyses are usually utilized to redesign inventory points and production schedules. In the agricultural fresh food segment like production of fresh vegetables and fruits, however, this analysis is not effectively carried out, especially at farming stage, according to the following reasons: 1) there are rather many members in the whole Supply Chain. Therefore, it is difficult to obtain consistent consensus and to implement integrated information systems to share the data. 2) There are many small sized enterprises, e.g. family business, at the farming stage. In this stage, there is less utilization for information system and lack of know-how for utilizing the findings. Namely, production plan for agricultural fresh foods is determined without the findings derived from Point Of Sales data. 3) Production Lead-time of fresh vegetables is rather longer, e.g. one year for most fruits, compared with process of another stage. Therefore, it is difficult to adjust the plan to consumers demand fluctuations. 4) As origin of the product is living plant, it is difficult to estimate and control rigorous harvest figures before production.

Agricultural food is essential for human beings to maintain a healthy life. It is important to deliver the food to consumers at reasonable price and therefore necessary to improve efficiency of Supply Chain. To enhance efficiency of agricultural fresh food Supply Chain, carefully selected indicators and benchmarks are necessary, where indicators are easily understandable and applicable for farmers. Purpose of this research is to identify these indicators. Furthermore, the indicators may be classified into some categories. Some indicators should be share in the whole supply chain and another are utilized in limited process or stages. We have focused on direct selling model in fresh agricultural product supply chain. We have developed an information system for farmer's market where trade is established between consumer and farmer. In this paper, as a first step to find practical indicators for fresh agricultural product Supply Chain, we present some indicators which are utilized direct sales between consumer and farmers. This paper consists of following sections. Outline of the farmer's market and its information system as research method in section sales information systems for farmer's market. Analyses focusing on shelf time and pos data are presented in section data analysis on shelf time. finally we conclude this paper in conclusion.

SALES INFORMATION SYSTEMS FOR FARMER'S MARKET

Farmers' markets have become an important distribution channel for agricultural fresh products in Japan for the last 20 years. Farmers sell their products directly to consumers at a store. Because the person who made the product might be readily known or identifiable, the products satisfy consumers' demands for food safety. Such stores are called Sanchoku, which means direct sales at production areas.

The farmers' markets require the efforts of customers, farmers, and a manager who is a representative of farmers and the shop. Inside the shop, there are shelves, each of which is assigned to a farmer. The farmer prepares and manages his products on the shelf for sale. Customers move inside of the shop and select some favoured products from these shelves. They make payments to a cashier, as in a supermarket, while the farmer is able to work and spend time performing farming tasks. Occasionally, the farmer visits the store to confirm the inventory. If the stock level dips below a certain level, then the farmer can replenish the products. After closing the store, the manager calculates the total sales for the day and informs each farmer of the total sales.

Shop is usually managed by independent farmers, the farmers' cooperative union (Japan Agricultural Cooperatives, or JA), a municipal government, or other entity. We specifically address the farmers' cooperative union type because the others generally employ specialists for shop management. At the farmers' cooperative union type of operation, farmers must determine their own production, shipment, sales, and other operation parameters. However, the core competence of farmers is agricultural production, especially medium-scale and small-scale farmers. Therefore, they have insufficient knowledge and methods to manage their businesses in farmers' markets. A certain amount of support for their shop business is necessary to manage and run the store. Utilization of an information system can be a smart solution.

The shop also engages in store-level competition with other farmers' markets, supermarkets, and conventional retail shops. One difficulty in managing the shop is satisfying both levels of management: the farmer level and shop level. Furthermore, member farmers can be regarded as rivals at the farmer level management. However, they must cooperate to execute shop level management.

Akasawa Farmers' Market: Place of Case Study

As a case study, our theory and information system are evaluated at an actually existing farmers' markets. The store is located in a suburb of Morioka city, from which a 30 min car drive from the city centre to the market. The market is established and managed by a farmers' cooperative union and the chair of the union becomes a management leader. The registered farmers are about 130, i.e. 130 families. Annual sales at the store reach about 200M JPY, or 1.9M Euro, implying that the management

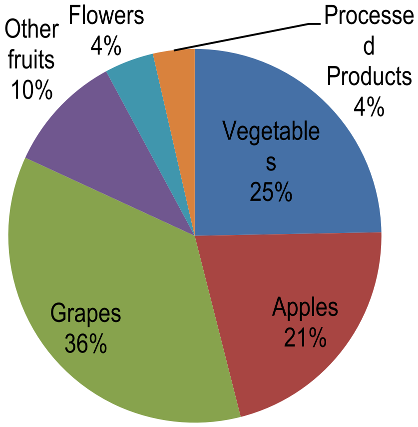

Figure 1: Main sale items and annual amount (2008)

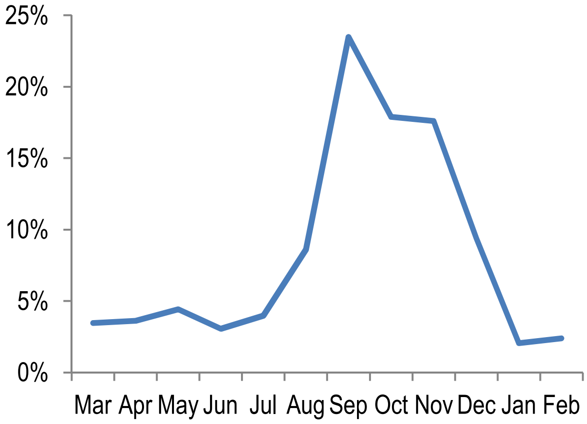

Figure 2: Monthly sales (2008)

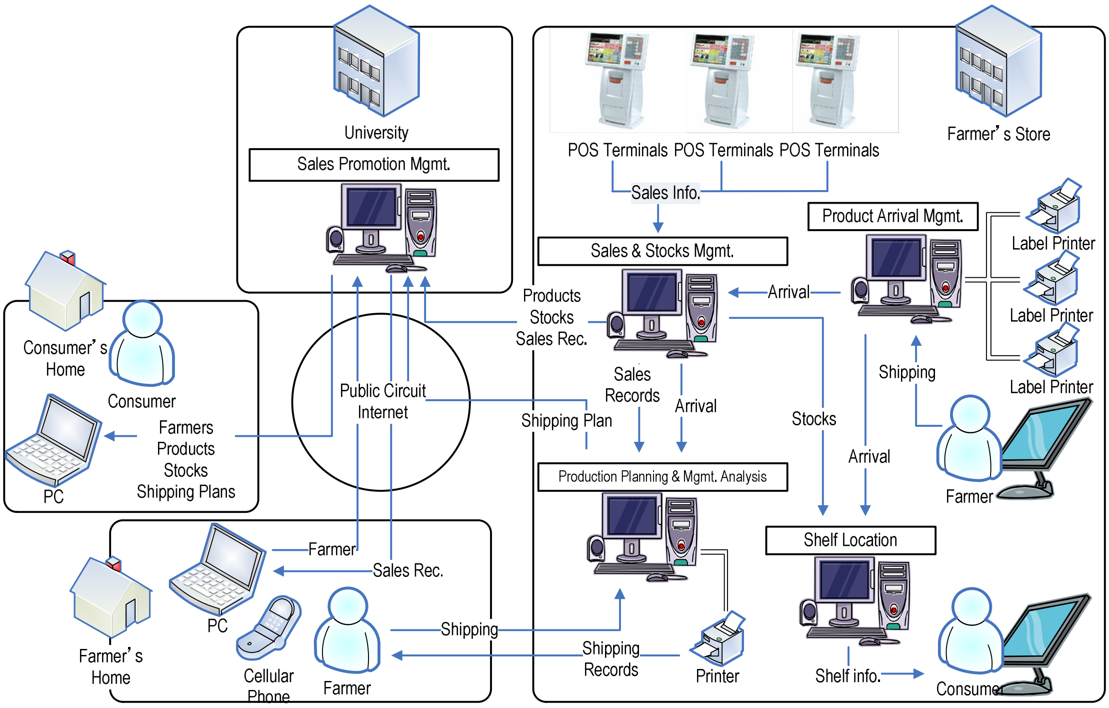

Figure 3: Implementation of Information System on Farmer's Market

scale of the market is middle-sized. Most farmers run small businesses as retired workers. They ship their products both through regular distribution channels through the Japan Agricultural Cooperatives and the market. The market staff members are chosen from among homemakers as part-time workers. Most work as cashiers.

Figure 1 portrays percentages of items in the 2008 annual sale. Main products are green vegetables, apples, and grapes, where apples and grapes constitute over half of all sales. Figure 2 presents percentages of each month in the annual sale. Over the 70% of sales are obtained during September–December: the high season of grapes and apples. At the store, problems of stock shortages and excess supply become more severe than at other farmers' markets. Solutions for this were anticipated.

We developed and implemented an information system for sales and inventory management at the farmers' markets (Hanzawa et al. 2007, Kasai et al. 2009). The system is designed to realize and sup-port farmers' business through such activities as sending e-mail messages occasionally to let farmers know about current sales tendencies and releasing current inventory levels to consumers through web pages. The system has the following modules: Product Arrival Management, Sales and Stocks Management, Sales Promotion Management, Production Planning and Management Analysis. See Shimokawara et al. (2011) for detailed function and implementation.

DATA ANALYSIS ON SHELF TIME

Product freshness is an important advantageous point of farmers' markets. Some products are harvested a couple of hours before their display in the store. To use that advantage, it will be important to manage shelf time as a point of inventory control. We have proposed a new idea for this purpose (Takeno et al. 2010). The idea is a candidate for the indicator to control fresh agricultural Supply Chain. Here, we show some outcomes of analyses on this candidate.

Definition

Takeno et al. (2010) shows idea of Price elasticity based on shelf time as an indicator to determine price of fresh agricultural product. Figure 5 presents the concept of price elasticity of demand based on shelf time. Horizontal and vertical axes respectively show the sales price and shelf time at the shop. The demand curve shows the relation, as shown by consumers, between the price and shelf time. At higher prices, the shelf time is longer because the consumer feels that the price is high. However, at lower prices, the shelf time is shorter. The supply curve shows decision of farmers. However, it is difficult to adjust the amount of supply in the short term: the curve is regarded as a rather rigid line. The point at which the demand curve and the supply curve cross is a theoretically ideal price point.

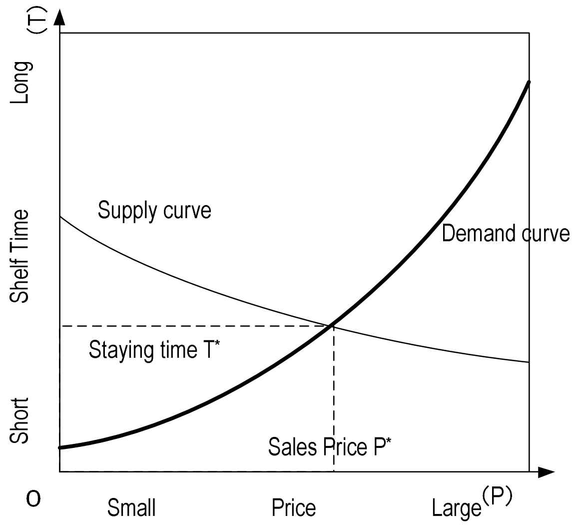

Figure 5: Price elasticity of demand based on shelf time

Product (Item)	Unit of sale	Variation of package size
Japanese Radish	A piece	Small
Chinese Cabbage		
Prune	Filled in a plastic container	
Campbell Grape		Middle
Tomato	Filled in a plastic bag	Large

Table 1:Characteristics of targeted items

We have analysed the sales data at the farmer's market in which both arrival time and sales time have recorded. The analysis is executed following process: 1) selects records which has the identical item name and the same unit of package, 2) calculate mean shelf time for records which has the same price, and 3) draw the figure. Characteristics of targeted items are summarised in Table 1. We have obtained the whole POS data included more than 900 items but focused on these 5 items. Japanese Radish and Chinese Cabbages are sold on each piece. As products are natural made, size of product varied on every piece. Column of Variation of Package Size is obtained our subjective observation at the market. Note that there are several variations in size of plastic containers and bag used in the market.

Effect of Breed and Package

We have calculated mean Shelf time of items during September 2008 – August 2009. Here, we show outcomes of five characteristic examples. Figure 6 shows a relation between the price of a package of prunes and the mean shelf time. The mean shelf time is the mean of the shelf time for which the price and unit, i.e. package or weight, are identical. The points on the figure are not point elasticity of demand, but they show the relation between the price and shelf time. According to the figure, farmers can determine the price of their product at a suitable shelf time. If a farmer sets a higher price, then the stock level will be maintained at a higher level. However, the farmer can reduce the amount of stock in a short time if the price is set lower. For fresh agricultural products, the display time is a rather limited and fixed time depending on each product to maintain its quality. The farmer determines a price considering the conditions presented above.

Figure 7 and Figure 8 present examples of a piece of Japanese radish and Chinese cabbage respectively. Figures show same tendency with the case of a package of prune. However, varieties in Shelf time are rather mild than it, i.e. presented week curve. Figure 9 presents an example of a packaged tomato. The figure shows no identical tendency with above three. As package size of tomato is varied larger, product with low price is may not be reasonable, e.g. product with high price with more high volume may exist.

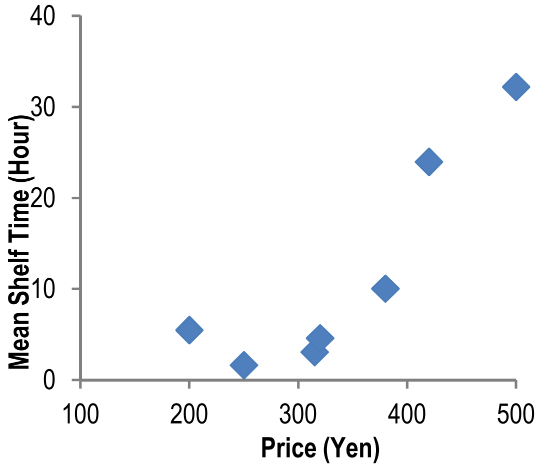

Figure 6: Mean Shelf time and price of a package of prune

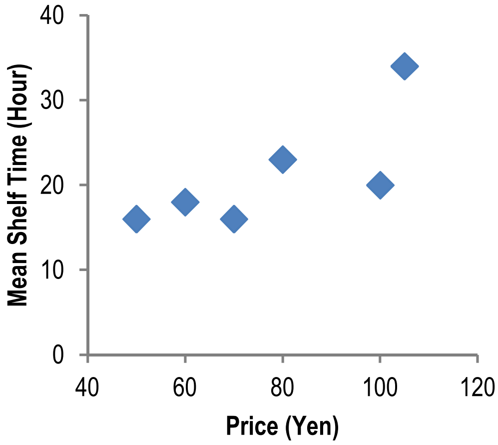

Figure 8: Mean Shelf time and price of a Japanese radish

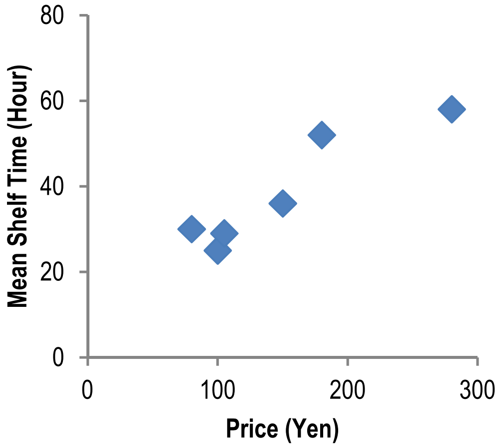

Figure 7: Mean Shelf time and price of a package of Chinese cabbage

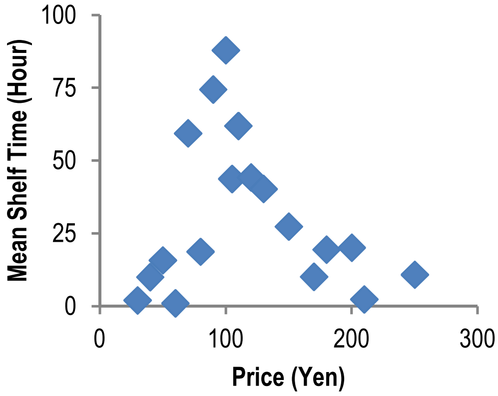

Figure 9: Mean Shelf time and price of a package of tomato

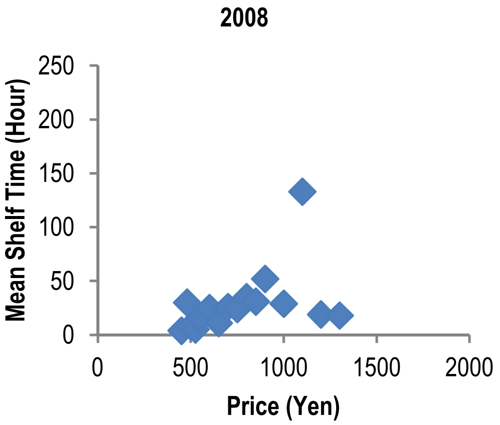

Figure 10: Mean shelf time and price of a box of Campbell grape on 2008 season

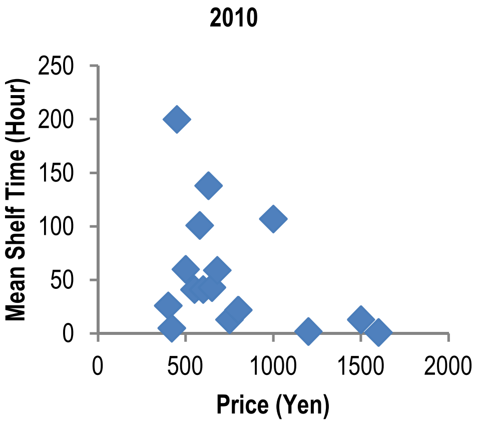

Figure 12: Mean shelf time and price of a box of Campbell grape on 2010 season

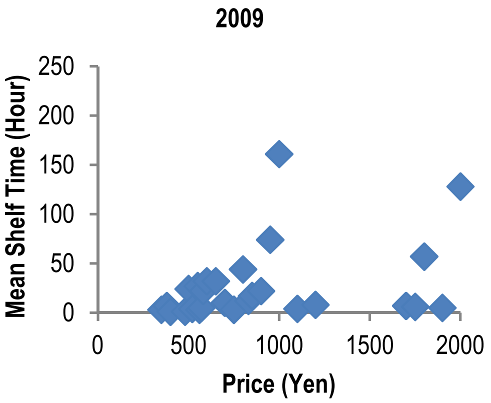

Figure 11: Mean shelf time and price of a box of Campbell grape on 2009 season

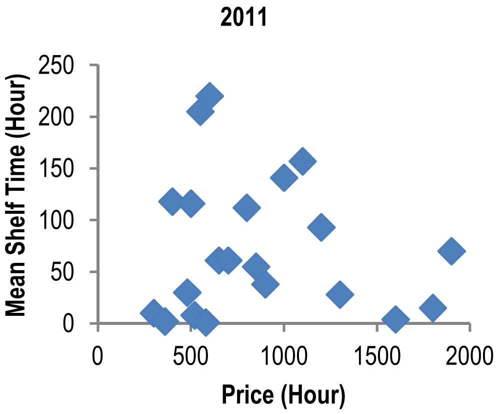

Figure 13: Mean shelf time and price of a box of Campbell grape on 2011 season

Effect of Yearly Variation

To see effects of yearly variation, we have stratified the data of Campbell grape on each year. Figure 10 to 13 are outcomes of this analysis. It is difficult to see common characteristics among the figures. Figure 11 shows ideal curves for two price zones, 300-1000 yen and 1000-2000 yen respectively. Figure 10 also shows an ideal curve limited to less than 1000 yen price zone. However, such relationship cannot be observed on figure 12 and 13. According to the external environment, e.g. escalating gasoline price, the curve can be changed. Furthermore, farmers ambitious efforts such as creating niche products may confuse outcome of this analysis. Therefore, long-time observation is necessary to see the tendency.

Discussions

According to the outcome of the case study, we identified a property of elasticity on the relation between the price and shelf time for some items. Therefore, the existence of price elasticity of demand based on shelf time is not contradicted. However, the property is not observable in any case. To obtain the ideal curve on the relation, further experimentation with intentional price setting is necessary.

A packaged of tomato can be characterized in variation of packaged size, in other word, contains of a package is differ in each package and variation of it is large. However, a package of Prune shows remarkable outcomes and distinguished from case of Japanese radish and Chinese cabbage. For Campbell grapes, two years show the curve however another is not. According to the analysis on yearly variation, number of raw data may affect shape of the curve. The ideal curve should be regarded as an outcome of convergence.

CONCLUSION

As a first step to illustrate indicators for decision making in fresh agricultural production, we have focused on direct selling model. We have presented farmer's market as a research object and introduce outline of business, information system operated and concept of Elasticity of price based on shelf time. By analysing the POS data of the market and arrival time, we have presented relationship between mean shelf time and price. According to the outcome of analyses, we have found that some products shows curve of elasticity of price based on shelf time and others are not. The tendency can be seen yearly variation: it can be seen in 2 cases out of 4. The tendency has been easily affected by outer environment and it is expected to that the ideal curve can be observed in state of convergence.

We have planned to carry out an interview and questionnaire to the farmers. However, it has not carried out yet. Through the questionnaire, we investigate farmer's decision making process and parameters. Developing a decision-support system to determine a suitable price of agricultural products for farmers is the next step of our research project. Furthermore, analyses of sales data, especially of different items, and development of a human interface with emphasis on information variety are planned. Presenting applications of the new elasticity in other product segments also poses an important objective.

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HOW DO LOGISTICS SERVICE PROVIDERS MEASURE SUSTAINABILITY OF THEIR OPERATIONS?

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INTRODUCTION

Faced with mounting environmental, social and economic pressures, most Logistics Service Providers (LSPs) recognise the need to make their operations more sustainable both in a short- and longer-term. Corporate Social Responsibility (CSR) policies are now an industry-wide standard. Are these policies well implemented and executed or are they just wishful declarations? How is sustainable performance measured and reported in the logistics sector? These are the topical issues that this paper addresses.

CSR policies and programmes emerged in the second half of the 20th century, as a reaction to the criticism faced by companies focusing purely on economic performance and short-term profitability. Prevention of the depletion of natural resources, air, soil and water pollution, labour practices violating human and social rights moved to the top of political agendas. As the external impacts of economic activity expanded from local and regional to global, corporations have realised they need to show concern about environmental impacts and community affairs in order to ensure own future survival and longer-term growth. CSR became 'an inescapable priority for business leaders in every country' (Porter and Kramer, 2006, p. 78).

As discussed by Dahlsrud (2006), there is a multitude of existing CSR definitions, often emphasising specific interests of their authors (e.g. focusing on the environmental or social aspects). As a result, organisations may perceive CSR differently, which, in turn, may lead to inconsistencies in implementation and reporting of their CSR performance. Markley and Davis (2007) agree that the focus on sustainability is a way to improve competitive advantage of a company and state that 'the idea behind the 3BL (triple bottom line) paradigm is that a corporation's ultimate success or health can and should be measured not just by the traditional financial bottom line, but also by its social/ethical and environmental performance' (p.766). While most companies now publish CSR reports, either within their annual reports or, for most, in separate sustainability reports, such publications rarely offer a coherent framework for objective and comparable measurement of their CSR achievements (Porter and Kramer, 2006). This study investigates the CSR-related Key Performance Indicators (KPIs) used by large, international LSPs.

The remainder of this paper is structured as follows. The next section discusses the importance of CSR in the logistics sector and introduces the problem of CSR measurement and reporting. Afterwards, the research design is described. This is followed by a discussion of the main findings of our study. The paper concludes with a summary of the work carried out to date and an insight into suggested continuation of the research project.

LOGISTICS AND CORPORATE SOCIAL RESPONSIBILITY

The concept of CSR is now well-established in both academic dialogue and business practice. There is a general agreement as to its contribution to obtaining and, more importantly, sustaining a long-term competitive advantage (Porter and Kramer, 2006, Markley and Davis, 2007). Nevertheless, there is still some uncertainty as to the actual meaning of CSR. Dahlsrud (2006) addresses this issue, and, based on a content analysis of 37 CSR definitions, identifies the five key dimensions of CSR, namely focus on social, environmental and economic aspects, interactions with stakeholders and voluntariness of actions taken. This approach is adopted in this paper.

Logistics, due to its cross-functional nature, is vital to every corporate strategy. This is particularly true for policies and actions aimed at ensuring environmentally and socially responsible business operations (Murphy at al., 1994, Wu and Dunn, 1994, Markley and Davis, 2007, Beamon, 2008). Nevertheless, many researchers note that CSR considerations within the discipline have attracted relatively little attention from the academic community (Murphy and Poist, 2002, Carter and Jennings, 2002). Even where different dimensions of CSR have been investigated to some extent in the logistics literature, these topics tend to be considered in isolation, without consideration of their relationship to one another. This gap, first noted by Carter and Jennings (2002), still exist in the subject literature, despite a further decade of research.

A term Logistics Social Responsibility (LRS) is often used by authors examining CSR issues in relation to logistics management (Carter and Jennings, 2002, Ciliberti et al., 2008, Miao et al., in press). According to Carter and Jennings (2002), LSR comprises the environment, ethics, diversity, working conditions and human rights. Environmental issues appear to be the most prominent aspects of CSR discussed in the recent academic publications (Murphy et al., 1994, Wu and Dunn, 1994, Seuring and Müller, 2008). The rise in environmentally responsible logistics operations has been a result of governmental regulations, economic considerations and increasingly strong market signals from environment-conscious consumers (Goldsby and Stank, 2000). Environmental performance of logistics is often consistent with the bottom-line impacts: 'When a firm's objectives are cost minimisation and profit maximisation, continuous improvement of the process to reduce end-of-pipe contamination and focusing on pollution prevention makes sense' (Wu and Dunn, 1994, p.22). Customers' demands also contribute to the recent interest in environmentally responsible logistics practices. González-Benito and González-Benito (2006) show, that non-governmental stakeholder pressures exert a significant influence on the implementation of environmental logistics practices. Therefore, 'to achieve business goals and objectives, a company must respond to increasing consumer demand for 'green' products, comply with ever tightening environmental regulations, and implement environmentally responsible plans as a good corporate citizen' (Wu and Dunn, 1994).

Social aspects of CSR discussed in the logistics literature include workforce diversity (Andre, 1995, Lynagh, Murphy and Poist, 1999), job satisfaction and working conditions (Min and Lambert, 2002, Johnson et al., 2011), ethics (Razzaque and Hwee, 2002, Maloni and Brown, 2006, Pretious and Love, 2006, Miao et al., in press), human and labour rights (Björklund, 2010a). Moreover, the area of humanitarian logistics has grown significantly over the last decade. However, the links between humanitarian or emergency logistics and CSR strategies of logistics operators have yet not been a subject to academic investigation.

Most studies examine CSR issues with relation to the logistics function of manufacturing or retail companies. This research focuses specifically on LSPs, i.e. organisations to whom logistics is a primary value-generating activity. As such, this study attempts to fill a gap in the literature and provide an account of CSR measurement and reporting practices in the logistics services sector.

MEASUREMENT AND REPORTING OF CSR PERFORMANCE

In recent years, the area of measuring sustainability has been given increasing attention by both academics and managers. Although various corporate sustainability performance measurement systems have been proposed (Searcy, 2012), there is no single globally agreed set of CSR-related metrics or KPIs to evaluate the sustainability of operations (Keeble et al., 2003). Virtually all companies collect at least some data reflecting their social and environmental impacts. However, only CSR-proactive businesses continuously measure, assess and monitor sustainability of their performance. Björklund (2010b) argues that a well-defined and transparent performance measurement system would be of a great benefit to companies. It would allow industry-wide CSR benchmarking initiatives, leading to an overall improvement in efficiency and effectiveness of actions aimed at CSR implementation and management.

In order to support companies in measurement, verification and communicating of their CSR performance, a number of reporting guidelines and standards have been developed. Social Accountability 8000 (SA8000) Standard, ISO 26000:2010 Guidance for Social Responsibility, ISO 14001 Environmental Management, Eco-Management and Audit Scheme (EMAS) or AcountAbility 1000 (AA1000) provide guidance on how to record and report CSR-related information. One of the most accepted and relevant frameworks for accounting and reporting corporate economic, environmental and social performance was developed by the Global Reporting Initiative (GRI) (Ciliberti et al., 2008). The G3.1 version, launched in March 2011, is the latest update of the GRI's Sustainability Reporting Guidelines and, at present, the most comprehensive sustainability reporting guidance available. The GRI has also developed supplements for several sectors to make reporting more relevant and tailored to the specific need of diverse industries. A pilot version of the Logistics and Transport Supplement, intended to be used by LSPs, is also available.

To communicate social and environmental actions and strategies to the public, companies are increasingly issuing periodical (usually annual), easily accessible CSR reports (Tate et al., 2010). Voluntary CSR reporting implies an organisation's maturity, consciousness, and willingness to become a good corporate citizen. However, research by Cerin (2002) and Kolk (2003) showed that there may be discrepancies between the actual corporate commitment to CSR issues and actions or strategies described in the reports, suggesting that some of the declarations are merely made "to appease stakeholders" (Tate et al., 2010). Ingenhoff and Sommer (2011) present an overview of the criticism towards CSR reports. The reports tend to focus on the positive aspects and hardly any incentives exist to disclose negative or potentially harmful information (Solomon and Lewis, 2002). The CSR reporting is often used as a marketing tool to enhance brand image. Companies sometimes attempt to differentiate themselves from competitors by declaring ambitious CSR measures, which may then not get fully implemented (Ingenhoff and Sommer, 2011). In order to ensure credibility of the sustainability reports and to avoid any confusion in their contents, it is recommended that businesses follow one of the reporting guidelines or frameworks discussed above. Also, a standard set of KPIs would be desirable to ensure transparency and comparability of published information.

Research Process

The study began with a comprehensive literature review on the CSR policies and practices in relation to the field of logistics. After the review was completed, corporate websites and CSR reports of large, international LSPs were analysed in order to investigate how sustainability is measured and what CSR-related KPIs are published. A database of organisations was compiled based on three independent rankings of top logistics companies. The following rankings were used:

- Inbound Logistics: Top 100 3PLs (http://www.inboundlogistics.com/cms/top-100-3pls/)
- Transport Intelligence - Global Contract Logistics 2011: Top 23 companies (http://www.transportintelligence.com/market-reports/report-global-contract-logistics-2011/272/)
- Transport Topics: TOP 50 Logistics companies 2010 (North American Revenue): (http://www.ttnews.com/log50/)

After duplicates (i.e. companies listed in more than one rating) were removed, 115 organisations were entered into the database. We only included companies with international operations, i.e. operating in more than one country, based on an assumption that they are more likely to demonstrate cross-border sustainability rather than just adherence to national regulations. Three companies were then excluded at the analysis stage: the first one because it was impossible to separate out the logistics division from other units of business in the CSR report. Two companies were part of a bigger conglomerate and their performance was included in the group report. As a result, the final number of companies studied was 112.

The corporate websites were studied in January and February 2012. The availability of the CSR-related information was reviewed and, where obtainable, CSR or annual reports were downloaded. Furthermore, in order to ensure the search results were comprehensive, the availability of corporate CSR reports was also verified at www.corporateregister.com. Out of the 112 LSPs studied, sixteen produced a dedicated CSR report and six included a CSR section in their annual reports. At the moment of data collection, for six LSPs the latest CSR report available was published in 2011, twelve companies last reported on their CSR performance in 2010, two in 2009 and the final two in 2008.

The GRI's G3.1 reporting framework was adopted to structure the CSR indicators for the purpose of our analysis. The GRI framework is internationally recognised and considered to be the most comprehensive CSR reporting tool currently available. Therefore, it was decided to build upon and enhance it rather than trying to propose an alternative framework. Seven out of the 22 LSPs studied, used the GRI G3 reporting framework, and two additionally filled in the Logistics and Transport Supplement. As a result, there was a risk that LSPs using this framework might seem more ambitious and mature in their reporting than companies using a different reporting format. In order to mitigate this risk, the relevant indicators were first identified and then structured into the GRI's format. This approach allowed us to get a broader perspective and identify indicators not yet included in the GRI framework. We also acknowledge potential bias that may have resulted from structuring the analysis around the GRI's framework in the next section of this paper.

The next issue was to decide how to define indicators. Many companies provide descriptive information about their CSR aims and actions (e.g. 'we aim to reduce our impact on the environment' or 'we participate in community projects'). In this work, only measureable outcomes were included in the analysis (e.g. 'last year, CO_2 emissions from our transport fleet were reduced by 10%' or 'we participated in three community projects). The analysis presented in this paper is based on the latest CSR report available. It is acknowledged that the latest report may not be the most comprehensive one. Where reports are published periodically, the new edition often replaces the previous one on the corporate website. As a result, access to older reports is limited and prohibits a longitudinal study.

Since the empirical data presented in this paper is obtained indirectly (i.e. from publically available resources), it may not fully reflect all the CSR actions undertaken by the companies studied. In the next stage of the project, the results will be triangulated with the findings of a web-based survey designed to collect primary data on the KPIs used both in internal CSR performance measurement and in external reporting. The survey questionnaire is currently being developed.

Empirical Findings

Although aspects of sustainability are mentioned on corporate websites of most LSPs in the database (64%), only 20% publish formal CSR reports, including dedicated CSR reports (14%) or a CSR section in the annual reports (6%). This is well below the results reported by KPMG (2011), which show that 95% of the 250 largest companies in the world now report on their CSR activities. However, the same study indicates that, at the industry level, transport sector achieves one of lowest reporting rates, with only 57% of companies publishing their CSR records. The discrepancy between ours and KPMG's results is most likely caused by a different composition of both samples (i.e. KPMG's one includes passenger and freight transport operators, whereas we focus on logistics service providers).

	LSP 1	LSP 2	LSP 3	LSP 4	LSP 5	LSP 6	LSP 7	LSP 8	LSP 9	LSP 10	LSP 11	LSP 12	LSP 13	LSP 14	LSP 15	LSP 16	LSP 17	LSP 18	LSP 19	LSP 20	LSP 21	LSP 22	% of LSPs reporting
ENVIRONMENTAL INDICATORS																							
Materials		X	X	X	X				X			X	X		X	X					X		45%
Energy	X	X	X	X	X		X	X	X			X	X		X	X	X		X		X	X	73%
Water		X	X	X		X			X		X		X		X		X				X		45%
Biodiversity				X	X				X						X						X		23%
Emissions, Effluents, and Waste	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	91%
Products and Services	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
Compliance				X	X			X	X		X		X	X	X	X	X		X		X	X	59%
Transport	X			X	X				X							X	X						27%
SOCIAL INDICATORS																							
1.Labour Practices and Decent Work																							
Employment	X		X	X	X	X	X	X	X		X	X	X		X	X					X		64%
Labour/Management Relations				X	X	X		X	X			X	X								X		36%
Occupational Health and Safety	X		X	X	X	X	X	X	X	X	X	X	X		X		X			X	X	X	77%
Training and Education	X			X	X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	77%
Diversity and Equal Opportunity			X	X	X		X	X	X		X	X	X		X			X			X		55%
Equal renumeration for women and men				X																			5%
2.Human Rights Performance Indicators																							
Investment and Procurement Practices				X	X	X	X	X	X			X			X	X	X	X			X		55%
Non-discrimination				X								X	X							X			18%
Freedom of Association and Collective Bargaining				X	X				X												X		18%
Child Labour				X	X	X			X			X									X		27%
Forced and Compulsory Labour				X	X	X			X			X									X		27%
Security Practices				X																	X		9%
Indigenous Rights				X								X					X				X		18%
3. Society Performance Indicators																							
Community	X	X		X			X	X	X	X			X		X	X	X	X	X	X	X	X	73%
Corruption	X			X	X	X			X		X	X				X		X			X		45%
Public Polic y				X	X				X			X						X			X		27%
Anti-Competitive Behavior				X											X						X		14%
Compliance				X																	X		9%
4.Product Responsibility Performance Indicators																							
Customer Health and Safety				X																			5%
Product and Service Labelling				X	X								X	X	X						X		27%
Marketing Communications				X					X												X		14%
Customer Privacy				X	X								X										14%
Compliance				X	X					X	X												18%
OTHER INDICATORS																							
Humanitarian and Emergency Logistics	X	X		X	X		X		X			X	X	X					X	X	X	X	59%
Involvement in Academic Research / Institutions				X			X		X		X		X		X								27%
Health Awareness Actions					X			X	X				X				X						**23%**

Table 1: A summary of KPIs presented in the CSR reports

The CSR-related information presented on the websites tends to be descriptive and take a form of general statements and declarations (e.g. “we work with our customers to limit the transport CO_2 emissions” or “we care about local communities”). Only a very few companies include any performance indicators in the content of corporate websites.

The CSR reports vary significantly regarding their extent, reporting format and CSR aspects addressed. The extent of reporting varied from six pages on CSR in the annual report to a dedicated 246 pages long CSR report. On average, a dedicated CSR report is around 40-60 pages long. Generally, companies with headquarters based in North America produce more descriptive CSR reports. Statements like "we recognise that the skills and knowledge of our employees are critical to the success of the organisation" or "we are committed to reducing the greenhouse gas emissions associated with our operations" are common. Reports of LSPs with headquarters in Europe and Asia are more focussed on presenting direct measurements, indicators and outputs. This is consistent with the findings presented in the KPMG’s report (2011).

All indicators in the GRI’s framework were addressed by the companies studied (Table 1). The range of KPIs varied from five to 31 and, on average, companies reported on 12 indicators. It needs to be acknowledged again that companies using the G3.1 reporting framework are likely to demonstrate a better reporting performance. This is because under some heading a statement like, for instance, "no incidents to report" is enough to be counted as an indicator, whereas companies not using the framework are less likely to include such statements. Also, to mitigate the risk of presenting companies using the G3.1 framework in a better light, we included all indicators related to a particular area (e.g. employment), even if they were presented in a different way than listed in the G3.1 framework. The analysis shows that the companies report also on other areas of CSR not yet covered by the general GRI's framework, such as humanitarian logistics (although this is covered by the Logistics and Transport Sector Supplement) and the involvement with academia. The indicators identified within these areas are discussed below.

The group of KPIs relating to the environmental impacts has the most pronounced presence in the reports studied. All companies report on initiatives to mitigate environmental impacts of their services and a vast majority presents data on GHG emissions and energy consumption (91% and 73%, respectively). 59% of LSPs demonstrated compliance with environmental standards and/or environmental certification (please note that our interpretation of compliance varies from the GRI's recommendation to report on 'monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations'). This confirms the findings of the literature review showing that the environmental aspects of CSR are of most interest to LSPs.

The group of performance indicators relating to employment practices and decent work is also commonly reported on. Occupational health and safety, as well as training and education, were most often addressed by the LSPs (77% on both subjects). This most likely relates to the fact that, due to the nature of the industry and equipment used, workers may be at a greater risk of serious accidents. As a result, the training initiatives very often targeted health and safety issues. Employment was another aspect commonly reported on (64%). Two companies did not present any records regarding labour practices and decent work. This does not indicate that this information is not available, only that it is not contained in the CSR reports.

Human rights performance is a CSR aspect not adequately addressed in many of the reports studied. The aspect most commonly reported on is the investment and procurement practices, addressed by 55% of the LSPs. 36% of the reports did not present any indicators for tracking their performance within this area. Based on our analysis, it was felt that most of the companies do not report on human rights, when they feel is not an issue for their operation. KPIs reflecting the contribution to society are present in most of the reports. However, the focus is very limited to indicators tracking community involvement (addressed in 73% of the reports) and anti-corruption (45% of the reports). Only two reports included indicators tracing the performance relating to anti-competitive behaviour and compliance.

Customers do not usually have a direct contact or presence when a logistics service is carried out. Hence, the area of product responsibility does not seem that relevant for the logistics industry. Despite this, the reports do include indicators tracking the performance within all areas. Product and service labelling is the product responsibility indicator most often reported on (27% of the reports).

More than a half (59%) of the reports studied indicated a LSP's involvement in humanitarian logistics and emergency response operations. Due to the nature of their core activities, LSPs are particularly suitable to offer physical support to relief agencies. For this reason, the GRI's Logistics and Transport supplement now includes a relevant indicator (LT15): 'provision of logistics and transportation core competences to deliver humanitarian needs locally and globally measured in terms of: e.g. tonnes carrying capacity, person months, expenditure, value, and in kind contributions in disaster preparedness and response'. Sample KPIs presented in the reports include donations of staff time, assets and transport services and contributions of knowledge, skills and resources to humanitarian relief organisations.

The analysis identified LSPs' involvement with academia as an important indicator of their social responsibility. This typically involved a contribution to academic research and/or funding of academic positions or institutions. Six companies in the sample indicated to have links with higher education institutions. Examples include collaboration with universities, contributions on research projects (monetary values and contributions in kind), sponsorships of academic posts and student training / mentoring programmes

The final group of indicators not yet present in the GRI's framework refers to employees' health support actions. This category includes initiatives aimed at both mental health and physical wellbeing. Health and safety training is not considered here, as this is subsumed under the labour practice-related GRI's indicators. Examples include actions to promote well-being, number of health trainers supporting employees, system of in-house health consultations, mental health training, stress management programmes or well-being workshops.

CONCLUDING REMARKS

Our analysis suggests that CSR is becoming an increasingly important issue for logistics companies, with a majority of LSPs mentioning CSR-related actions on the corporate websites. However, only one in five providers produces a formal CSR report and publishes at least some CSR-related KPIs. This paper provides an insight into how transparently the LSPs measure and report on the sustainability of their performance. While most companies report on categories such as environment, employment, diversity, working conditions, ethics and human rights, there is no consistency in the choice of KPIs. Even within one category, performance is measured in a number of ways. For instance, under health and safety companies report on the absolute number of accidents, hours lost due to sick absence, number of accidents per 1000 employees, etc. This suggests that not only a common reporting framework but also a standardised set of KPIs would be useful to ensure the comparability of results. This would also support development of benchmarking initiatives (Björklund, 2010b).

Three areas not yet covered by the GRI's reporting framework were identified: humanitarian logistics, academic involvement, and employees' health support actions. The academic involvement indicators promote industry participation in academic research. This enhances the body of logistics knowledge and contributes to the long-term sustainability of the logistics industry. We strongly encourage LSPs to track their academic involvement and to include relevant KPs in their CSR reports.

One question that emerges from this study is why the percentage of companies reporting on their CSR-related performance is so low. Is this because LSPs do not recognise the importance of the CSR issues or maybe due to a lack of tools / resources to manage the monitoring and reporting process? Some CSR-related KPIs may be available internally but not disclosed to the public. Hence, there is a need to establish what KPIs are being used in the internal performance tracking and what determines a set of KPIs disclosed in the CSR reports. These issues will be addressed in the next stage of the project.

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ANALYZING SUPPLY CHAIN DISRUPTIONS– PROPOSAL OF A CLASSIFICATION FRAMEWORK

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Introduction

Even though the phenomenon of supply chain disruptions is gaining increasingly attention (e.g. Craighead et al. 2007; Hendricks & Singhal 2005a; Radjou 2002), the analysis of general causal relationships between the occurrence of disruptions and its origins is scarce. Unanticipated events, such as natural disasters or labour strikes can cause companies to lose millions of dollars because required resources arrive late, are damaged or destroyed (Tang 2006). But whereas damage by some events (e.g. natural disasters) might be unavoidable, damage by others (e.g. breakdowns of process plants) could be partly prevented. Therefore, a more profound analysis and understanding of types of disruptions is required.

Furthermore, the understanding of supply chain disruptions still differs considerably. Whereas some authors speak of disruptions only when an entire geographic region is substantially damaged (e.g. Christopher & Peck 2004; Tang 2006; Stecke & Kumar 2009), other authors include operational contingencies (e.g. Hendricks & Singhal 2003; Paul 2008; Hendricks & Singhal 2008) in the category of disruptions. Thus, whereas some authors only consider low likelihood – high impact events, others also include high likelihood – low impact events. However, transferring research results from one group of events to the other bears many risks, since the two groups pose different challenges (Oke & Gopalakrishnan 2009). Furthermore, the contingencies involved in a disruption may appear to be unique and ambiguous (Cole 2010), which makes the identification of general patterns and causal relations more difficult. In order to foster the analysis of general relationships, it is therefore useful to reduce the complexity of real world phenomena, while at the same time considering all possible types of disruptions. One popular method used by researchers for the purpose of complexity reduction and identification of similarities, differences, and relationships are classification frameworks (Bailey 1994).

The objective of this paper is therefore to provide a common terminological and taxonomical framework for the analysis of supply chain disruptions. Therefore, in the second section general requirements for building taxonomies shall be described in order to provide a basis for the development of a classification framework of supply chain disruptions. This will be followed by the development of an own definition of supply chain disruptions in section three since no suitable definition could be found in the literature review. Based on this definition, a general framework for the classification of supply chain disruptions will be elaborated. In section four follows the evaluation of the classification framework in reference to a set of criteria. Furthermore, one example for a classification of disruptions in food supply chains will be given, to illustrate how the framework can be used. Finally, the fifth section gives some concluding remarks and highlights areas of future research.

Requirements for Definitions and Classification Frameworks

Research in a new field frequently starts with the identification and definition of concepts, and the development of categories or taxonomies (Oke & Gopalakrishnan 2009). This is also true for the topic of supply chain disruptions, which has recently gained a lot of interest by researchers and practitioners alike (e.g. Blackhurst et al. 2005; Kleindorfer & Saad 2005; Iakovou, Vlachos & Xanthopoulos 2010; Kumar & Chandra 2010; Bode et al. 2011). However, if the goal is to reduce the occurrence or

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impact of disruptions, it is first of all necessary to concretize and to define the term supply chain disruption.

The lack of a common understanding can be frequently found in the development of a new field of research, since the research proceeds without paying much attention to terminology (Linstone 2010). According to Chmielewicz (1979), general requirements for the development of a definition are *use of the technical terminology*, *unambiguousness*, *preciseness*, *lack of redundancies*, and *consistency*, which will be briefly explained in the following.

The definition developed should stick to the terminology of the research field in question, which also helps to maintain the use of a common terminology. In the case where a unique definition is extremely difficult, frequently the term is concretized by how it can be observed or measured (Kornmeier 2007). The criterion unambiguousness implies that the same term should not mean different things in different contexts. The definition should make clear which issue is observed, how it can be separated from similar issues, and in which context it is observed. Another important point is that the term is not used in the definition again, since therewith redundancies occur, which inhibit the explanation of the term. Finally, consistency means that different authors use the term in the same way and that it does not refer to different concepts. These criteria will be considered in the investigation of the concept of supply chain disruptions in the third section.

According to Bailey (1994), advantages of classification include the provision of a transparent and exhaustive overview of types, the reduction of complexity, the identification of similarities and differences of cases and the versatility of application. Classification can be defined as "*the ordering of entities into groups or classes on the basis of their similarity*" (Bailey 1994 p.1). Such frameworks are frequently used if large amounts of information have to be processed and analyzed (Carper & Snizek 1980). Especially in the analysis of causal relations, a classification framework may help to study rich and complex phenomena in a structured way.

Fettke & Loos (2003) name as the first step in the development of a classification framework the specification of its area of application and its purpose. This is a crucial step, since the taxonomy depends on many situation-specific factors (Bobko & Russell 1991). However, some general differences can be derived from the literature. According to Carper & Snizek (1980), taxonomies can be either based primarily on theoretical or empirical concepts. The taxonomies based on theory are derived from deduction or heuristics, and employ gathered data only to support the established framework. Empirically derived taxonomies use the data either to create or test hypotheses and require extensive statistical analyses or multivariate techniques. The developed classes should group elements in such a way that they are as similar as possible in the same class, whereas as different as possible in between classes (Bobko & Russell 1991). Furthermore, classes can either be monothetic (only containing elements which are the same on all dimensions) or polythetic, which means that the elements are not identical, but similar (Bailey 1994). Taking these guidelines into consideration, some basic decisions for the classification framework are made in the following.

First of all, the purpose of the classification framework is the differentiation between classes of supply chain disruptions based on the objectives, which were not met due to their occurrence. In order to avoid the richness of empirical data to obscure suitable classes of disruptions, the paper focuses on the development of a theoretically grounded taxonomy. Furthermore, the classes of disruptions will be monothetic, as disruptions will be classified according to their specific dimensions. These classes can later on be grouped on a more aggregated level into polythetic classes. In order to achieve this objective, the features which shall be used to distinguish between groups of disruptions have to be selected. These features therefore need to allow for clear distinctions of groups, they should result in a realistic framework, and should be able to accommodate the multidimensional nature of real world problems (Zopounidis & Doumpos 2002). How such a framework may look like will be pursued in the next section.

Terminology and taxonomy of Supply Chain Disruptions

During the literature review, no evidence was found of existing taxonomies of supply chain disruptions. Additionally, no real consent was observed regarding the term "disruption". The only agreement which seems to exist is that it represents a disturbance or breakdown of the supply chain, which in consequence is not able to fulfil its obligations. However, different ways to characterize such disruptions were observed, which shall be illustrated in the following.

Definition of Supply Chain Disruptions

One way to specify the concept is to enumerate examples of disruptions. For instance, Wu, Blackhurst & O'Grady (2007) name here among others transportation delays, port stoppages, accidents, natural disasters and part shortages as frequent supply chain disruptions. Some authors only speak of a disruption when the products are destroyed (e.g. Qi, Shen & Snyder 2009), others also include delays of products into the category of disruptions (e.g. Craighead et al. 2007; Hendricks & Singhal 2008), whereas others speak of damage, loss or delay of products (Christopher et al. 2002 as cited in Peck 2005). However, not every delay necessarily has to be a supply chain disruption, since the activities may continue in time for the production or distribution process to meet the obligations specified during the design of the process (e.g. time of delivery of the output).

Another way is to define disruptions according to their causes. Paul (2008) names three classes, i.e. operational contingencies, natural hazards and political instability or terrorism. Hendricks & Singhal (2008) propose inaccurate forecast, poor planning, part shortages, quality and production problems, equipment breakdowns, capacity shortfalls and operational constraints. However, comparing the understanding of supply chain disruptions by different authors mentioned above, a clear separation of causes and disruptions cannot be observed. Hence, in both approaches, namely enumeration of examples and enumeration of causes, a clear separation of similar concepts, as stipulated by Chmielewicz (1979), is missing. It is therefore also important to find a way to unambiguously determine the boundaries of what can be understood as a disruption.

Another approach by Hendricks & Singhal (2008), is to differentiate disruptions according to the place of origin. According to them, sources of disruptions can either be internal, customer-related, or supplier-related. To know where the disruption was caused is important for developing preventive measures. However, the allocation of disruptions has more than one dimension, since for example the geographic or institutional location both point out where the disruption took place, but on different levels of analysis.

Some attempts have already been made to provide a definition of supply chain disruptions. However, the understanding may vary significantly depending on the interpretation of the authors. For example, Hendricks & Singhal (2005b) define disruptions as "*a firm's inability to match demand and supply*" (p. 35). Based on this understanding as well as definitions provided by other authors, (Craighead et al. 2007) define supply chain disruptions as "*unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain*" (p. 132). The first definition is very broad and does therefore not fulfil the criterion of usefulness in this context. The second definition is more concrete, focussing on the flow of goods. However, it contains a circular argument and does therefore not comply with the formal requirements of a definition.

Furthermore, whereas in the first version, a disruption is a state of the company, in the second definition it is an event that impacts on the companies. These two examples show that the term is used inconsistently, which increases the risk that statements and findings from different authors cannot be transferred (Kornmeier 2007).

A definition of disruptions in flight gate scheduling is provided by Dorndorf et al. (2007): *"a situation where one or more activities in one or more of the key resource areas (e.g. crew or aircraft) have deviated from the resource plan. Subsequent activities in the affected lines of work either cannot start on time or can start on time, but only after controller intervention"* (p. 94). This definition implies that a disruption can occur in more than one area, involves activities and resources, and is a consequential deviation from the plan. The consequential deviation from the plan indicates, how the disruption could be observed and is an example of how theoretical constructs can be defined by a partly operationalization of the term as suggested by (Kornmeier 2007). Adopting this definition to supply chains, a disruption can be understood as: *"a situation where one or more processes in one or more flows have deviated from the plan in such a way that the subsequent plans cannot be met without intervention."*

In this definition, more possibilities to build classes of supply chain disruptions can be found. One would be according to the processes involved, whereas another one would differentiate between the flows facing a disruption. A third method is to focus on the part of the plan, which could not be met. This method also helps to further investigate the impact of a disruption and to differentiate between them according to their severity. However, since plans can be highly dependent on contingencies, a more general way to characterize plans in supply chains has to be found. One option is to refer to the general objectives behind the logistical plans, which will be further elaborated in the following.

Development of the Classification Framework

The general objective associated with logistics is the achievement of the 8R's. These include the provision of the right product, in the right quantity, with the right quality at the right time, to the right costs, at the right place, with the right data and with the right knowledge (e.g. Jetzke 2007). In principle, each of these goals could be left unattained by a disruption. However, these eight goals do not pertain to the same level of analysis, since quantity, quality, time and place all further specify the right product. However, the right data, knowledge and costs may also be specified by quantity, quality, time and place. For example, providing the right data too late or to the wrong addressee (wrong place) may also lead to a disruption of the supply chain. Thus, not only the right product should be specified by quantity, quality, time and place, but also the right data, knowledge, and costs.

This view is also supported by the supply chain management literature, which states that the supply chain is made up of the flow of products, as well as the flows of information, and flows of money (e.g. van der Vorst, Beulens & van Beek 2005, Tang 2006, Bode et al. 2011). These flows are interdependent and a disruption in one flow may also lead to a disruption of the other two flows. Therefore, disruptions in these three flows shall be further specified by the four dimensions of quantity, quality, time and place, as is shown in Figure 1.

	Quantity	Quality	Time	Place
Product				
Information				
Money				

Figure 1: Classification framework for supply chain disruptions (own illustration)

Following this framework, disruptions in the flows of products, information, and money can be differentiated according to whether they affect the right quantity, the right quality, the right time, or the right place. For a reduction of complexity during completion, only those flows and dimensions shall be considered, where a disruption takes place, leaving the other fields empty. Furthermore, the dimensions quantity, quality, and time can be further differentiated regarding the kind of deviation, hence more/less, better/worse, and early/late. This specification can help to evaluate the impact of the disruption and the kind of countermeasure needed. The dimension place cannot be measured in such a simple way and has therefore only one characteristic (i.e. wrong place).

The classification as proposed above is a tool, which helps to characterize disruptions. However, for a large amount of information, its handling becomes more difficult, since Figure 1 has to be filled in for every disruptive event. In order to allow for a comparison and clustering of supply chain disruptions, it seems therefore useful to codify each disruption according to the same scheme. Since in one event, more than one flow and more than one dimension can be affected, the codification should be effected always in the same manner. Hence, in order to avoid different ways of codification in different applications, the authors suggest that the code should always be developed from the top-left to the bottom-right of the framework. The classification framework including the proposed codification can be found in Figure 2.

	Quantity (qn)		Quality (ql)		Time (t)		Place (p)
	1	2	1	2	1	2	
Product (P)							
Information (I)							
Money (M)							

Figure 2: Codification for the classification framework of supply chain disruptions (own illustration)

The numbers in the cells shall indicate the direction of disruption, thus number 1 stands for less, worse, and early respectively, whereas number 2 means more, better, and late. Therewith, every supply chain disruption can be firstly located in the process flows, then specified according to the dimensions concerned, and finally regarding the direction of the effect. In order to evaluate the framework, section four will assess provide an example for its application, and will then discuss its contributions and limitations.

Options and Fields of Application of the Classification Framework

In today's food chains, food waste is a major concern: the FAO for example estimates that 1.3 billion tons of food are wasted annually (Gustavsson et al. 2011). This implies dissipation of natural resources, increased food prices and considerable profit losses. Reasons for waste can be found in damage during handling, cold chain breakdowns, contamination, or delays in handling (e.g. Gustavsson et al. 2011; Nunes et al. 2009; Vega 2008).

Such disruptions are collected in the Rapid Alert System for Food and Feed (RASFF) Portal, a database provided by the European Commission on inspections and rejections of food imports (European Commission). From this database, one example has been taken and classified according to the framework developed. The example is a border rejection of alcoholic beverages from Ghana, which has been sampled in Italy on the 8th of March 2012. According to the report, the beverages were labelled incorrectly, and were infested with insects and mould. In our classification framework, this case would be marked as follows:

	Quantity (qn)		Quality (ql)		Time (t)		Place (p)
	1	2	1	2	1	2	
Product (P)			X				
Information (I)	X						
Money (M)							

Figure 3: Example for a classification of a supply chain disruption in food chains

The quality of the product was not adequate, but worse, whereas the quantity of information on the product was also inadequate, namely lacking. Therefore, the code for this disruption would consequently be: Pql1Iqn1. If the classification would be continued for other cases, more information could be obtained regarding the most frequent disruptions and typical combinations of disruptions. Thereby, vulnerabilities of food supply chains could be identified and used as starting points for the reduction of supply chain disruptions.

Now that the classification framework has been developed, its advantages and constraints shall be discussed. Fettke & Loos (2003) suggest for the quality check of classification frameworks the criteria completeness, precision, extensibility, user-friendliness, consistency, and economic efficiency.

Completeness is given if each object may be classified in the framework independently from its specific characteristics. The classification framework is derived from general theoretical concepts and definitions, which have a higher level of abstraction than real-world phenomena. Therefore, this criterion can be assessed as fulfilled. Precision in turn is given, if the accurateness of the classification can be easily enhanced. The accurateness has already been enhanced by adding the kind of deviation. This could be continued, for example by specifying the place of disruption, as for example by integrating the section of the supply chain (geographic location) where the disruption evolves. However, the degree of specification may be negatively related to the criterion user-friendliness, since the more detailed the classification gets, the more difficult it gets to keep track of major phenomena.

The same reasoning can be applied to the extensibility of the framework. By e.g. adding other business functions, interdependencies between different organizational layers in the evolvement of supply chain disruptions could be investigated. Limitations here may lie again in the increase of complexity by adding more features. Consistency means that the characteristics of the classification framework should be free of contradictions. If a disruption occurs in more than one flow, this will be indicated by the code. The combination of disruptions in different flows are therefore cumulative and do not exclude each other. Finally, the economic efficiency depends on the costs of implementation and use of the classification framework (Fettke & Loos 2003). These costs partly depend on the area of application and how the framework shall be applied. However, provided that the information on dimensions and localizations of disruptions are available, the framework is easy to handle and does not require any technical features.

Regarding the criteria for the quality of a classification framework, this classification framework seems to comply with them and is therefore considered to be a suitable tool for the identification, description and analysis of supply chain disruptions. However, its applicability to a broad range of supply chains and its abstraction from real-world phenomena, is at the same time a limitation, since its information content is thereby reduced. Therefore, it might need more specification in a research-specific context. Nevertheless, how it can principally be applied to real-world phenomena, shall be illustrated for an example from food supply chains.

Conclusion

The purpose of this paper is to develop a clear understanding of supply chain disruptions, as well as a classification framework for the identification, description and analysis of supply chain disruptions.

Since in the literature review, no common and comprehensive definition suitable for the purpose of this paper could be found, an own definition of supply chain disruptions has been developed. The definition shall foster the transferability of findings in this field and can be used as a starting point for a further structuring of research in supply chain disruptions. The classification framework proposed is also based on this definition and may help to determine types of disruptions, their frequency and combinations. By ascribing a specific code to each disruptive event, as has been shown for the example of food supply chains, further insights could be gathered regarding most frequent types of disruptions and their impacts. The paper thereby may contribute to the identification of vulnerabilities in supply chains and to the development of methods to counteract such disruptions.

Nevertheless, there are also limitations to the approach of this paper. First of all, part of information may get lost in classification frameworks. This is a general constraint to any classification framework, since the decision-maker has to take an absolute judgement (Zopounidis & Doumpos 2002). Then, the features selected may turn out to be not appropriate for the investigation of supply chain disruptions. The quality of information provided might not allow the differentiation between the different flows or different dimensions.

Therefore, the empirical testing of the classification framework is important, and should be the next step in order to validate the classification framework. Another opportunity for further research is the extension or adaption of the framework to other purposes. For example, the identification of the location of disruption might be very interesting to find out, which sections of the supply chain are especially vulnerable. Finally, the research in supply chain disruptions in general, as well as their management, but also their formal description should be further elaborated, both, in general, and in industry-specific contexts. Thereby, the understanding of factors contributing to disruptions could be enhanced and the occurrence of disruptions possibly reduced.

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RELATIONSHIP CONSTRUCTS IN THE AGILE ENVIRONMENT: A COMPARISON BETWEEN MNCs AND SMEs IN THE CONTEXT OF MALAYSIAN ELECTRICAL AND ELECTRONICS INDUSTRY

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ABSTRACT:

Today's competitive environment requires businesses to increasingly reliant on the relationships with their partners to stay ahead of competition. Several studies have been conducted to identify factors of buyer-supplier relationships and their impacts on organization performance. However, there is a limited literature which studied the factors of relationships in the context of agile supply chain. Using 252 firms within the electrical and electronics industry in Malaysia, this study provides insights into the constructs for developing mutual beneficial relationships for SMEs and MNCs in the agile business environment. The results indicate that in the case SME two constructs such as partner's characteristics capability and process capability were found to be related to supply chain agility performance, whereas, in the case of MNC constructs found to be related to agility performance are alliance management capability and process capability.

Keywords:
Buyer-supplier relationship, agile supply chain, and agility performance

1.0 INTRODUCTION

To compete in today's business environment, organizations have embraced the concept of supply chain strategy (Vonderembse et al. 2006; Childerhouse et al. 2002; Tan 2001;). Supply chain management views the entire business process as one system and emphasises is on the relationships between partners in the supply chain, integration of activities from the original supplier to end customer with the benefits of adding value, maximizing profitability, and achieving customer satisfaction (Stock & Boyer 2009; Hitt et al. 2008; Mentzer et al. 2001).
Managing relationships between members of the supply chain may vary based on the nature of the supply chain environment. Organizational relationships within the agile environment are expected to be more complex (Sarkis & Talluri 2001). This complexity is due to the greater need for rapid integration and coordination amongst members of agile supply chains. Thus, the partnership characteristic is categorized as fluid cluster where speed, flexibility and quality are critical (Cagliano et al. 2004; Christopher & Towill 2002). The aim of this study is to investigate the constructs of supply chain relationships for SMEs and MNCs in the context of Malaysian electrical and electronics industry.

The rest of the paper is organised as follows. Section 2.0 provides a review of literature on the constructs of buyer-supplier relationship in the context of agile supply chain. This is followed by the research methodology in section 3.0. Section 4 provides the analysis and results of the study. Finally, discussion on various implications and the conclusion are presented in Section 5.

2.0 LITERATURE REVIEW

Organizations are increasingly becoming reliant on the relationships with their partners and are demanding that they adhere to high standards. Strong relationships with suppliers are essential to stay ahead of competition (Parsons 2002). According to Hoyt and Huq (2000), if the relationship is too restrictive, flexibility will be difficult to achieve and, if it too lenient the risk of opportunism will be present. Partnerships enable different people and organizations to support each other by leveraging, combining, and capitalizing on their complementary strengths and capabilities (Barney et al. 2000).

Lately, organizations have realized that integrative relationships with supply chain members can provide benefits, such as reduced cost, reduced cycle time in order fulfilment, lower inventory levels, high visibility, and reduction in the time it requires to bring new products to market (Acquaah 2009; Andersen et al. 2009). While not all integrative relationships prove successful as the potential benefit is significant and thus has attracted many organizations interested in long-term involvement with their supply chain members.

2.1 Partner's characteristics capability

Success of both domestic and cross-border collaborations may be a function of partner characteristics (Hitt et al. 2000). Collaborative value creation through alliance requires the simultaneous pursuit of partners with similar characteristics on certain dimensions and different characteristic on other dimensions. Sarkar et al. (2001) mentioned that the partnering firms need to have different resource and capability profiles yet share similarities in their social institutions. These partner characteristics are important since they help in the formation of relationship capital or the behavioural aspects of an alliance that find expression in relational dynamics such as mutual trust, commitment, and information exchange (Cullen et al. 2000). Partner's compatibility, resources complementarities, goal congruence and corporate reputation are the measurement for partner's characteristics capability considered in this research.

2.2 Alliance management capability

Conflict is almost unavoidable in buyer-supplier relationship as a consequence of two firms trying to maximize their returns from the business relationship. Reducing conflict and promoting stability is one of the objectives of collaborative partnership (Hitt et al. 2008; Kozan et al. 2006). Effective management of buyer-supplier relationships is an important research domain (Monczka et al. 1994; Tan 2001) to avoid conflict. Long term collaboration may result from managing conflict efficiently by members in the supply chain. Thus, alliance management capability is necessary for managing relationship. This research identified and employed commitment, trust, cooperation and conflict management as measurements for alliance management capability.

2.3 Process capability

Process efficiency is the likely objective in buyer and seller relationships that entail close coordination between buyers and suppliers (Saeed et al. 2005). The need for adaptation and synchronization of process in these types of relationships is high. The need to integrate these processes also arises to maximize flow, focus on end customer and compete on a range of different competitive priorities. Nesting the capabilities of these processes creates power and synergy for the network. If different links in the supply chain are directed towards different competitive priorities, then the chain will not be able to serve the end-customer (Harrison & Van Hoek 2008). Information technology, innovation and flexibility proficiency are considered as variables for process capability in this research.

Following the literature review we propose a research framework which is shown in Figure 1. The framework consists of three supply chain relationships constructs such as partner's characteristics capability (PCC), alliance management capability (AMC) and process capability (PC) (discussed earlier), and supply chain agility performance (AP) as the dependent variable. The supply chain agility performance is defined by items such as new product development, product customization, manufacturing lead time, and responsive to changes in customer requirement.

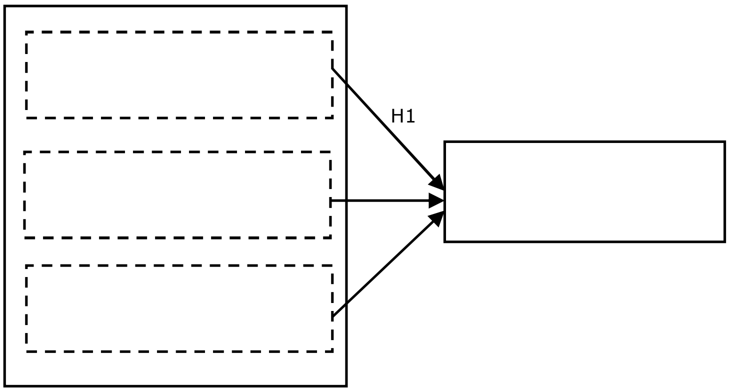

Figure 1: Conceptual framework of buyer-supplier relationships in an agile environment

We tested the following hypotheses which were derived from existing literature:

H1: Partners characteristics capability in an agile environment is positively related to the supply chain agility performance for both SME and MNC.

H2: Alliance management capability in an agile environment is positively related to the supply chain agility performance for both SME and MNC.

H3: Process capability in an agile environment is positively related to the supply chain agility performance for both SME and MNC.

3.0 METHODOLOGY

3.1 Respondents

Based on existing literature and the constructs described above, a survey instrument with 1–5 Likert scale (1=strongly disagree and 5=strongly agree) was designed and employed for this study. Before the primary study was implemented, the instrument was pretested and the comments and suggestions from these respondents were incorporated in the instrument which improved the readability and understandability of the instrument. The revised surveys were mailed to 600 firms (includes both MNC and SME) belonged to the electrical and electronics industry in Malaysia which were listed in the Federation of Malaysian Manufacturers (FMM) 2010 listed members. The survey was conducted in November 2009 and April 2010. A total of 252 usable responses were received, a response rate of 42%. Out of the 252 respondents, 133 (52.8%) are MNCs and 119 (47.2%) are SMEs. 34.1% of the companies have been operating for more than 10 years. Of the 252 responding companies, 22 (9.9%) have more than 1000 employees, 19 (7.5%) have between 500 to 1000 employees, 95 (37.7%) have between 151 to 500 employees, 46 (18.2%) have between 51 to 150 employees, and 67 (26.4%) have 50 and less employees.

4.0 ANALYSIS AND RESULTS:

As this research aims to examine the relationship between relationship constructs and agility performance, multiple regression were adopted to test the hypotheses. Hair et al. (2006) suggest that in order to analyse the relationship between a single dependent variable and several independent variables, multiple regression analysis should be used. As multi-item scales were used to measure each construct, responses were summed and averaged to represent constructs for regression analysis (Crosby et al. 1990). The reliability of each scale was determined using Cronbach’s Alpha. The results of the factor analysis indicated that Cronbach’s alpha (α) values for each construct varied between 0.902 to 0.920 (for SME) and 0.913 to 0.945 (for MNC) which are above the recommended value of 0.7 (Nunnally and Bernstein, 1994) (see Table 1).

Table 1: - Descriptive statistics of the scales and Cronbach's alphas

		SME			**MNCs**		
Contructs	Number of items	Mean	Std. Dev.	Cronbach's ɑ	Mean	Std. Dev.	Cronbach's ɑ
PCC	29	122.10	10.312	0.912	116.29	13.524	0.945
AMC	26	109.49	9.420	0.902	104.90	11.281	0.928
PC	21	86.08	9.376	0.920	83.93	10.006	0.913
AP	22	91.96	9.278	0.917	89.68	10.865	0.932

One of the key assumptions of correlation and regression analysis is that the independent variables should not have close to perfect linear relationships among themselves. Otherwise, it means there is some degree of redundancy among the constructs. This is so called multicollinearity. A correlation matrix was created for each set of constructs to assess potential effects of multicollinearity. Multicollinearity test is used to ensure that there is no strong correlation detected between the independent constructs before they are further tested for correlation and regression with supply chain relationships indicators.

The results explained for partner's characteristics capability, the strongest correlation is 0.705 between 'organization's values and norms' and 'organization's goals and objective'. Alliance management capability has shown the highest correlation coefficient of 0.579 between 'organization encourages employees to be culturally sensitive' and 'organization seldom has conflict with partners'. Meanwhile the highest correlation coefficients for process capability is 0.654 between 'partner has major influence on the design of new products' and 'our organization and partner actively seek innovative idea to satisfy market needs'. These correlations coefficient do not indicate that the correlation is severe (i.e., >0.90), which implies that although the constructs may be similar, they are still measuring different dimensions and should not cause severe problems in further analysis (Tabachnick & Fidell 2007). The correlation coefficients between the other variables for each construct are all relatively low to moderate.

Next, correlation analyses were created for MNC and SME separately to assess relationships between relationships constructs and agility performance. Strong correlations were found between each individual supply chain relationships construct. The results of the correlation analysis suggested that the relationships between all three constructs and supply chain agility performance in the case of both MNC and SME were positive and statistically significant ($p < 0.01$) (see Table 2 and Table 3). For SME, the strongest correlation was found between AMC and PCC (0.824) while for MNC, it was the correlation between PC and AMC (0.876). However, the results broadly support hypotheses H1, H2 and H3.

Table 2: SME: Correlation between relationship constructs and agility performance

	AP	**PCC**	**AMC**	**PC**
AP	1.00			
PCC	0.732*	1.00		
AMC	0.711*	0.824*	1.00	
PC	0.780*	0.783*	0.799*	1.00

**significant at p <0.01*

Table 3: MNC: Correlation between relationship constructs and agility performance

	AP	PCC	AMC	PC
AP	1.00			
PCC	0.614*	1.00		
AMC	0.784*	0.714*	1.00	
PC	0.839*	0.709*	0.876*	1.00

*significant at $p <0.01$

All the constructs depicted in Figure 1 have significant impact on the supply chain agility performance. Results of the multiple regression analysis in Table 4 display that the constructs account 80 percent of the variance in agility performance. The results were supported by adjusted R-square values of 0.805. In the case of SME only two constructs were found to be related to supply chain agility performance; partner's characteristics capability ($p < 0.05$) and process capability ($p < 0.01$). Alliance management capability in an agile environment was not found to be related to agility performance.

In the case of MNC, two constructs found to be related to agility performance are alliance management capability ($p < 0.05$) and process capability ($p < 0.01$). The results are shown in Table 5. The test of the relationships constructs indicated that these constructs account for 84.5 percent of the variance in agility performance. Partner's characteristics capability in agile environment was not found to be related to agility performance.

Table 4: SME: Standardized Multiple Regression

Dependent Variable	Agility Performance		
R^2	0.805		
Model	**Standardized Coefficients (Beta)**	**t**	**Sig**
PCC	0.264	2.522	0.013*
AMC	0.096	0.890	0.375
PC	0.497	5.035	0.000**

* Significant at $p<0.05$; **Significant at $p < 0.01$.

Table 5: MNC: Standardized Multiple Regression

Dependent Variable	Agility Performance		
R^2	0.845		
Model	**Standardized Coefficients (Beta)**	**t**	**Sig**
PCC	0.000	0.005	0.996
AMC	0.211	2.077	0.040*
PC	0.654	6.485	0.000**

* Significant at $p<0.05$; **Significant at $p < 0.01$.

5.0 DISCUSSION AND CONCLUSION:

The objective of this research was to investigate the nature of relationship between supply chain relationship constructs of partner's characteristics capability, alliance management capability and process capability and agility performance within Malaysian E&E industry. Drawing on the regression analysis, this research addresses significant constructs of supply chain relationships in agile environment.

The findings from this research show that all the three identified relationship constructs were strong indicators of supply chain agility performance. It is however been viewed differently by the MNCs and SMEs in Malaysian electrical and electronics industry. All the three relationships constructs were highly correlated to each other but the multiple regression analysis proven only process capability was significant to supply chain agility performance for both MNC and SME.

Process capability is an important determinant in agile environment. This is supported by Raschke (2010) who studied the drivers of process capability where information technology was seen as one of the platform for agility in which subsequent value is derived. As agility is vital to the innovation and competitive performance of firms in contemporary business environments, firms are increasingly relying on information technologies, including process, knowledge, and communication technologies, to enhance their agility. Agility means to apply the concepts of flexibility throughout different parts of the organisation, and not to a specific part such as manufacturing or production processes(Conboy & Fitzgerald 2004). Van Hoek et al.(2001) in their study mentioned a central characteristic of supply chain agility is the flexibility of a firm in responding to unexpected changes in the market and demand conditions. It is also suggested that agility is flexibility with an "organisational orientation" (Christopher 2000), in that it is applied throughout the enterprise, in a business-wide context.

Building on the theoretical notion that a firm's alliance management capability can be a source of competitive advantage (Ireland et al. 2002). Our empirical findings support our theory on alliance management capability and its relation to agility performance. The results indicate that alliance management capability, in terms of its four dimensions, plays a significant role in explaining key outcomes of agility performance. As for MNC, alliance management capability fosters the expansion of joint activities between partners by facilitating cooperation to leverage the interdependence between buyer and suppliers, by enhancing commitment to identify and grow the potential for joint action, by developing trust between partners for long term cooperation, and by cultivating conflict management mechanism that alleviate concerns about risks or uncertainties associated with joint action. The positive relation between alliance management capability and agility performance highlights that this capability also enables MNC to realize and expand the supply chain agility performance from that alliance. SME however, has a different judgment on alliance management capability and the findings prove that alliance management capability has no relation to agility performance. The dimensions of the construct are considered not significant to the agility performance despite the positive view from the MNC.

Partner's characteristics capability in terms of its four dimensions; partner compatibility, goal congruence, corporate reputation and resources complementarities is seen as significant capability to affect agility performance. This is evident from the analysis findings on SME data where there is a significant positive relationship between partner's characteristics capability and agility performance. This indicates the importance of this construct to supply chain agility performance of an organization. Pansiri (2008) observes that like relationships between people, organization relationships begin with courtship, where organizations attracted to each other seek to discover their compatibility. This is ranked as one of the main ingredients for a successful alliance because the sophistication and expression of the strategy will not work if relationship is not workable (Hagen 2002). To avoid the pitfall of ambiguity or failure to accomplish the beneficial outcomes of strategic alliance, partners should make sure they have synchronous goals to begin with, complementary resources, compatible goal and established reputation of partners.

In general the significant positive relation between the three relationship constructs and agility performance demonstrate the importance of developing these constructs at the organizational level. It provides insights and ideas on the improvement of mutually beneficial relationship in agile environment between MNC and SME in Malaysian electrical and electronics industry. When a supply chain is "agile" and environmental uncertainties exist, collaboration will have a greater influence on supply chain performance. The study provides a framework to understand the critical constructs of relationships in the agile business environment and assist decision makers in aligning their capabilities appropriately.

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AN INTEGRATED APPROACH TO THE DESIGN AND EVALUATION OF LAST MILE LOGISTICS SOLUTIONS

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ABSTRACT

Many initiatives (e.g. managing urban congestion) fail to proceed to the implementation phase because benefits can not be evaluated easily. This research can provide valuable supporting evidence for transport planners and B2B/B2C solution providers to better understand alternative transport solutions within an urban environment (using a 'triple helix' perspective) and evaluate performance implications of alternative service offerings.

The purpose of this paper is to develop a methodology for the evaluation of Last Mile (LM) logistics solutions from the perspective of consumers, industry and institutional stakeholders. Previous studies have predominantly considered LM provision from an industrial supply chain perspective. This framework aims to capture the perspectives of multiple stakeholders operating within the urban environment to identify synergies where a collaborative approach to network design can lead to socio-environmental, efficiency and service benefits. The approach involves re-defining the role of institutional players that facilitate performance outcomes rather than a more traditional governance role. Similarly, industrial efficiency dimensions are focused around customer service outcomes. Finally, the research proposes a common set of measures that integrates the three stakeholder groups and is applicable to B2B and B2C models.

INTRODUCTION

Direct-to-consumer business delivery has risen exponentially during the last decade (Boyer *et al*, 2009). This rapid development has highlighted many challenges and problems within the logistics system and the subsequent need for optimisation. The multiple stakeholders involved in e-tailing, conventional retail, parcel delivery and transport systems within a particular geography is complex, with opportunities for data sharing and systems integration. At present, UK logistics providers report that 30% of small packages dispatched to customer homes fail to be delivered first time, resulting in poor customer service and avoidable logistics inefficiencies (Fernie and McKinnon, 2004). This, in turn, results in larger numbers of delivery runs, which exacerbates urban congestion, pollution and accident levels. From the perspective of the consumer, lack of visibility on deliveries is a significant source of dissatisfaction. At present a significant number of consumers are deterred from utilising the full potential of internet-based shopping solutions due to the issue of failed deliveries. For logistics providers, these non-value adding process steps have financial impact and result in knock-on scheduling delays. For the logistics industry as a whole, the lack of an integrated, collaborative network results in a high level of inefficiency. For the general public, there are significant negative environmental and societal impacts caused by increased numbers of vehicles, which are often unsuitable for urban infrastructure. Institutional stakeholders (e.g. local and regional government) also have a critical role to play in the design of the logistics systems, e.g. regulating, pricing and supporting freight transportation infrastructure. However, no generic approach or tool currently exists which captures all the main system characteristics, to evaluate Last Mile solutions suitable to the requirements of their urban area and, therefore, may hinder a comprehensive evaluation.

The methodology involved development of a Last Mile design and evaluation framework integrating supply network configuration concepts (Srai and Gregory, 2008) with Last Mile logistics literature (Esper *et al*, 2003; Boyer *et al*, 2005). The next section summarises key academic literature on models, methods and performance measures in supporting this methodology/evaluation tool development, capturing all the main system characteristics in order to provide a multi-stakeholder perspective on the last mile system.

LITERATURE REVIEW

Many different models and methods are presented within the literature in order to try to evaluate logistics solutions. Beamon (1998) summarised multi-stage models for supply chain design and analysis into four categories: "(1) deterministic analytical models, in which the variables are known and specified, (2) stochastic analytical models, where at least one of the variables is unknown, and is assumed to follow a particular probability distribution, (3) economic models, and (4) simulation models". However, all these approaches use key performance indicators to describe the performance and findings of the specific system. Therefore, there has been significant reporting of academic literature on performance measurement indicators, focused on finding the correct metrics for a representative determination of the efficiency and effectiveness of the supply chain (Gunasekaran *et al*, 2001; Lambert and Pohlen, 2001; Neely *et al*, 2005). The following section summarises existing literature related to the last mile logistics, and further highlights the fact that no comprehensive approach or framework exists to adequately represent the last mile system.

Performance metrics

Browne *et al* (2005) present a review of urban freight studies over the last 40 years in the UK, which covers goods collection, delivery and service vehicle activities. Local authorities are often forced to spend a significant amount of their budgets in the collection of quantitative data in order to analyse urban freight movements (Muñuzuri et al, 2009). In addition, they are also faced with data security concerns from transport companies, who are not willing to divulge information and knowledge (Morris *et al, 1998)*. Muñuzuri *et al* (2009) state that the "*the lack of valid information is a permanent burden upon freight transport modelling*". However, this lack of exact information can be covered with easier obtainable indicators, which represent goods movements or delivery vehicle trips (Hensher and Button, 2000), in order to control the effects, which accompany increased freight transportation within the urban area. This underlines the importance of the use of the right indicators and the implementation of their associated measures to obtain a comprehensive image of logistics movements within the urban area.

Industry also stresses the importance of correct measure implementation. Neely *et al*, (2005) have proposed that a process cannot be managed if its performance cannot be measured. In addition, Caplice and Sheffi (1995) report that a good measurement system *"has to be more than a disparate assortment of individual metrics, it must be cohesive, comprehensive and complementary"*. Furthermore, they define four principles for measurement systems:

1. A measurement system should be comprehensive; capturing the performance from more than only one perspective; i.e. capturing all stakeholder perspectives
2. A measurement system should be causally oriented; capturing all drivers not only the end results; and not only the financial results
3. A measurement system should be vertically integrated by linking the overall corporate strategy to the particular types of decision making at each level in the organisation
4. A measurement system should be horizontally integrated; aligned along a process rather than with each function or department

In achieving a better understanding of the characteristics and nature of required indicators, an in-depth literature review on existing metrics within last mile logistics was conducted as part of this study (Wohlrab, 2012). This review also examined related research areas due to the limited literature on the specifics of last mile logistics (Gevaers *et al*, 2010). Hence, last mile logistics was considered as part of supply chain management (Delivery and Return), green supply chain management (Delivery and Return), urban freight transportation, including the emerging area of e-business, and analysed from each stakeholder perspective (Wohlrab, 2012).

RESEARCH GAP

The literature review synopsis presented in the previous section resulted in the identification of one main research gap: that a comprehensive and balanced indicator framework currently doesn´t exist, that captures all the main stakeholders and their main interests within the last mile logistics system. The following related sub-gaps, identified from the literature, have also been identified:

- The supply chain management perspective emphasises *Delivery* (Industrial Performance) and *Return* (Customer Satisfaction). Until recently there has been less attention paid to the sustainable agenda (e.g. carbon emission, congestion);
- Last mile logistics, from an industrial perspective, has not been comprehensively researched despite being recognised as a mayor inefficiency and avoidable cost, despite these issues appearing in special topics areas (e.g. e-business, e-grocery, online auction, last delivery part of the supply chain etc.);
- In the last mile context, the institutional interest is limited despite having significant potential impact on traffic movement, secure supply and business development. However, they are confronted with improving congestion, lowing carbon and supplying business;
- No construct currently exists which shows the relationship between the different measures and, therefore, between the interests of the different stakeholders;
- No comprehensive indicator framework currently exists, which links performance of the solution in the design stage with real performance in the post-implementation stage of the project.

CASE STUDY SELECTION

The pilot case study approach, used as part of this research and presented in this paper, involved the operation of a *Consumer Choice Portal and Package Consolidation Centre (PPCC)* e.g. delivery of packages to the home, supported by a packaging consolidation centre, located adjacent to a densely populated urban environment.

The consolidation centre concept empowers the consumer with respect to the delivery method in the 'last mile' of the package journey, and also enables supplies to be consolidated upstream and downstream of the centre. Failed deliveries significantly reduce the productivity of the logistics provider and increase congestion and pollution. Consumers are aware that deliveries to their home may fail repeatedly; however, no effective mechanisms exist to engage with the supply chain. Lack of integration means that many courier firms are engaged in multiple drops to the same urban area each day, with no value added to the consumer. The total UK postal services market was valued at £11bn in 2007/2008, including £4bn in courier and express delivery items, and £1.5bn in parcels. The UK delivery market currently exhibits a higher degree of fragmentation than those countries (e.g. Germany) who have adopted similar schemes.

The geographical area selected for the piloting of the PPCC was in the South-East of the UK, operating in the SS14 and SS15 postcodes, delivering to a potential customer base of approximately 50,000 households, reflecting a potential market size of ~250k packages. With 30% of deliveries missed first time, this translates to 600 parcels/day out of the 2,000 delivered daily in the specified geographical area.

The case study was also specifically chosen due to its ability to capture the perspectives of a series of key stakeholder groups, e.g. final customers, parcel delivery organisation and the local authority, within a collaborative supply network. In summary, the PPCC project involved:

- Development of a web-based portal that provides *consumer choice features* including *time* and *mode of delivery* (e.g. sustainable vehicle solutions) and *parcel traceability*
- *Local* urban consolidation centre providing *easy consumer access*, consolidation facilities for primary suppliers, efficient transfer to *last mile couriers* with *dynamic scheduling*, and *packaging recycling*

Stakeholder Identification

The interviewees and selection criteria are summarised as follows:

- The PPCC operating company represents the industrial perspective with respect to this study.
- *ECC* is the local authority responsible for the geographical area in which the PPCC operates. The mission of the ECC states a dedication 'to improving the lives of our residents' and an ambition 'to deliver the best quality of life in Britain' by 'providing high-quality, targeted services that deliver real value for money'. ECC is an active supporter of the PPCC pilot study and represents the 'institution' within the scope of this research.

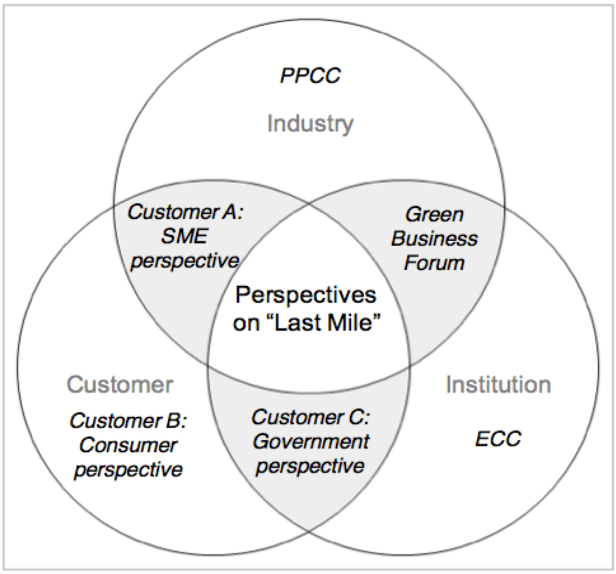

Figure 1. Case study interviewees and their relationship in terms of Customer, Industrial and Institution

- The *Green Business Forum* is a partnership between local businesses and the local authority within the geographical area of the pilot case study. The aims of the forum are to promote environmental awareness and best practice within the local business community with the aim of promoting e.g. improved efficiency, better environmental performance and subsequent cost savings. The *Green Business Forum* was chosen specifically to represent an industry-'institution' overlap within this research.
- Customer A had used the PPCC for some personal goods delivery but predominantly uses the 'pick-up' service in the context of his small-to-medium sized enterprise (SME) run from his home residence. Hence, customer A was chosen to represent the overlap of 'customer-industry' within this research.
- Customer B had used the PPCC exclusively for personal goods delivery and has used both the 'delivery' and 'pick-up' services of the PPCC. Hence, customer B was chosen to represent a typical customer-'consumer' within this research.
- Customer C had used the PPCC exclusively for personal goods delivery using the sustainable vehicle service due to a strong 'green' political affiliation. Hence,

customer C was chosen to represent a customer-‘institution’ overlap within this research.

METHODOLOGY

The evaluation framework was tested using in-depth case studies within a specific geographical urban area and involved B2B/B2C models within the same geographical area to exclude institutional bias (B2C case study presented in this paper). Process mapping of the decision making processes of institutional and industrial actors was undertaken to identify regulatory barriers/opportunities for the adoption of alternative LM delivery systems. Finally, pre-/post-implementation analysis of consumer/customer requirements and usage patterns was used to identify critical process/performance metrics for each of the stakeholders and the overall industrial system. Metric definition included efficiency, service and sustainability parameters at critical points within these two echelon supply chains.

A semi-structured interview method was used in this study, based on stakeholder interests identified in the academic literature. The aim was to prove the developed metrics and to identify the performance of the PPCC project. The data acquisition was collected using a four-tiered interview:

- Primarily, the interviewee had to define with his/her own words a general view on the PPCC portal.
- Secondly, the interviewee had to describe his/her perception of the identified metric dimensions in the context of the PPCC project naming criteria e.g. *cost, quality, time, flexibility and reliability (and STEEP)*. This enabled a direct determination of potential criteria spanning stakeholder interests.
- Thirdly, the interviewee was asked directly for evaluation criteria, which had not been mentioned within the second part of the interview.
- The last section of the interview process served to identify the most important measures for each interviewee and additional information, which had not been mentioned.

The tiered approach introduces the interviewee slowly to the topic and, therefore, allowed unbiased data acquisition and specific data assessment in the final stage.

RESULTS SUMMARY

Table I summarises the results of selected interviews. The left column contains criterion that could be identified and verified within the interviews. The right field links the criteria to the interviewees. The use of abbreviation for the definition of the relationship enables a quick and easy reading and understanding of the extensive information. The abbreviations stand for:

“+” The criterion is important to the interviewee and has a high performance.
“-“ The criterion is important, but low performing for the interviewee.
“o” The criterion is important, but cannot be evaluated by the interviewee.
“n” The interviewee has been asked directly to this criterion, but it has no importance for the interviewee.
“s” This criterion is important and will have a high performance, when the use of the portal gets scale.

Discussion/Conclusion

New approaches to LM supply chain design have been proposed which include an effective evaluation framework, process model development and outcome-based performance metrics at both industrial system level and for individual stakeholders. The role of institutional players in the governance of 'LM solutions' evaluation, design and implementation may be re-defined in order to support more outcome-oriented systems. In turn, LM solutions may be identified that enable the development of novel solutions in urban environments and focus more on a collaborative approach between institutional, industrial and end-users. This 'triple helix' concept requires;

- Understanding critical metrics of the stakeholders, representing common interests and where trade-offs are required to meet design criteria;
- Identification of interaction/integration points between the three stakeholder information chains, demonstrating critical interdependencies (e.g. see figure 2);
- Institutional/governance checkpoints mapping and alternative outcome-based approaches set out to facilitate novel delivery solutions.
- Critical role of institutional players in supply chain innovation suggests new policy approaches are required to facilitate/support the design and implementation of novel solutions as part of a more-partnered rather than regulatory control approach.

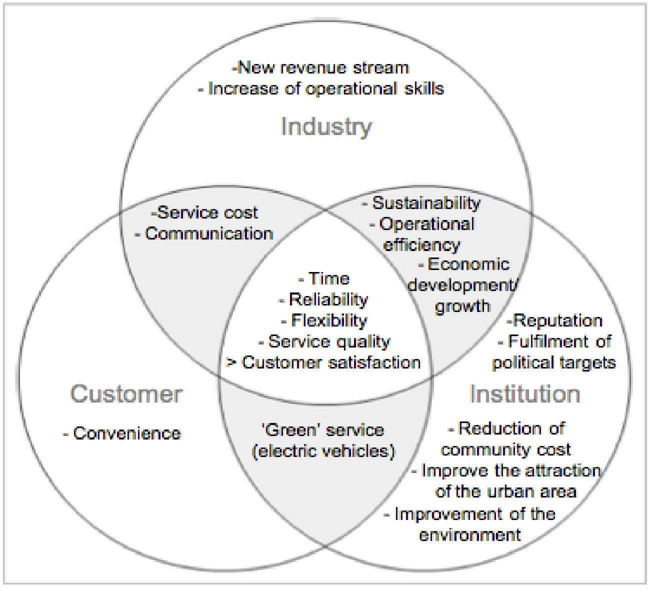

Figure 2. Identification of interaction/integration points between the three stakeholder information chains

In addition, it has a feature to enable differentiation between pre-/post- implementation criteria to enable the evaluation in both stages. The richness of assessed data lies in enabling a correlation of both stages and, therefore, the improvement of evaluation quality in the design stage. A limitation of the developed evaluation tool could be its applicability only within the European area, because the literature on institutional interests has been focused on European cities. Furthermore, the tool has been applied in only one urban area within the UK. However, the research on the current last mile logistics context illustrates that big cities around the world are challenged with the same or at least similar issues. Future case field research will look to prove the completeness of the evaluation criteria.

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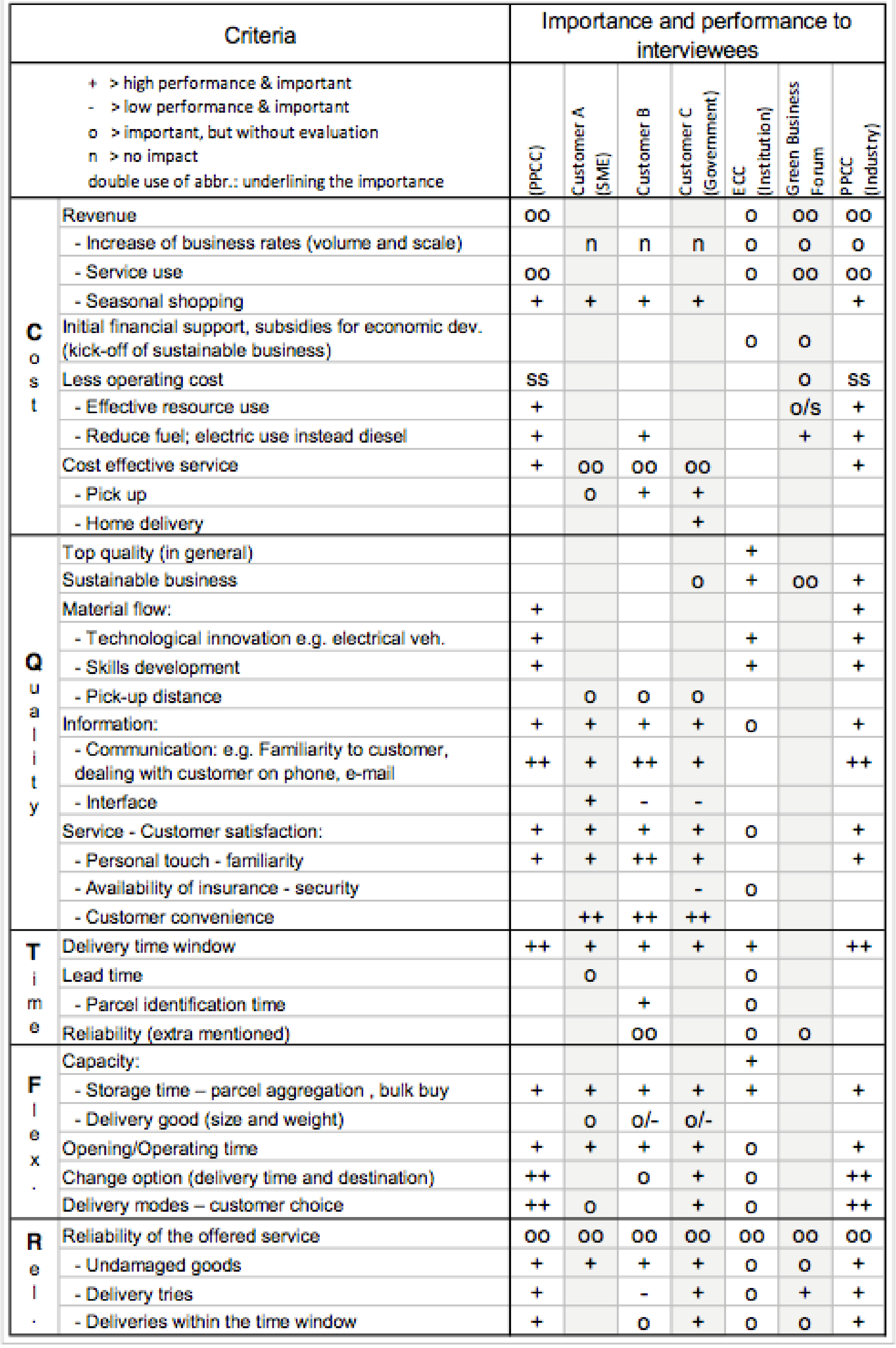

Criteria		Importance and performance to interviewees						
	+ > high performance & important - > low performance & important o > important, but without evaluation n > no impact double use of abbr.: underlining the importance	(PPCC)	Customer A (SME)	Customer B	Customer C (Government)	ECC (Institution)	Green Business Forum	PPCC (Industry)
Cost	Revenue	oo				o	oo	oo
	- Increase of business rates (volume and scale)		n	n	n	o	o	o
	- Service use	oo				o	oo	oo
	- Seasonal shopping	+	+	+	+			+
	Initial financial support, subsidies for economic dev. (kick-off of sustainable business)					o	o	
	Less operating cost	ss					o	ss
	- Effective resource use	+					o/s	+
	- Reduce fuel; electric use instead diesel	+		+			+	+
	Cost effective service	+	oo	oo	oo			+
	- Pick up		o	+	+			
	- Home delivery				+			
Quality	Top quality (in general)					+		
	Sustainable business				o	+	oo	+
	Material flow:	+						+
	- Technological innovation e.g. electrical veh.	+				+		+
	- Skills development	+				+		+
	- Pick-up distance		o	o	o			
	Information:	+	+	+	+	o		+
	- Communication: e.g. Familiarity to customer, dealing with customer on phone, e-mail	++	+	++	+			++
	- Interface		+	-	-			
	Service - Customer satisfaction:	+	+	+	+	o		+
	- Personal touch - familiarity	+	+	++	+			+
	- Availability of insurance - security				-	o		
	- Customer convenience		++	++	++			
Time	Delivery time window	++	+	+	+	+		++
	Lead time		o			o		
	- Parcel identification time			+		o		
	Reliability (extra mentioned)			oo		o	o	
Flex.	Capacity:					+		
	- Storage time – parcel aggregation , bulk buy	+	+	+	+	+		+
	- Delivery good (size and weight)		o	o/-	o/-			
	Opening/Operating time	+	+	+	+	o		+
	Change option (delivery time and destination)	++		o	+	o		++
	Delivery modes – customer choice	++	o		+	o		++
Rel.	Reliability of the offered service	oo	oo	oo	oo	oo	oo	oo
	- Undamaged goods	+	+	+	+	o	o	+
	- Delivery tries	+		-	+	o	+	+
	- Deliveries within the time window	+		o	+	o	o	+

Table I. *Results Summary from Interviews – Cost, Quality, Time, Flexibility, Reliability*

PROMOTING ADOPTION OF LOGISTICS AND SUPPLY CHAIN STRATEGY TO THAI SMES: TO ENHANCE COMPETITIVE ADVANTAGE FOR ASEAN MARKET

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ABSTRACT

After the economic crisis in 1997, Thai government continuously boosted Thailand's economic growth through many projects. One of the projects is how to improve capacity building and efficiency of Thai SMEs, especially logistics management. The aim of the paper is to examine issues and extend a knowledge body related to the status for adopting logistics strategies to Thai SMEs.

A total of 200 questionnaires were sent out and 106 usable completed questionnaires were received, generating a response rate of 53.0%. The hypothesis is statistically tested using SPSS version 10.0.5. The results indicated that there are strong relationships between SME entrepreneurs' logistics need and implementation and enhancing their competitive advantage. In addition, factors have strongly contributed and effected logistics operations and implementation. The implications reflect that building and adopting an effective logistics strategy offers opportunities to create sustainable competitive advantage. Research in area of logistics designing and implementation to each particular SME firms would be further conducted.

Keywords : Logistics, SME, strategy, supply chain, Thailand.

INTRODUCTION

After having faced an economic crisis in 1997, the Thai government established many projects with the purpose of continuously boosting Thailand's economic growth. One major project was the SME programme, which allowed local people to invent or produce a value-added product or service by using creative and innovative ideas of local cultures and customs. The programme was designed to upgrade the standard of living of the poor, mainly rural farmers which were a majority of Thai population. The government expected that the success of the project would boost sustainable economic growth.

After having launched the project, SME firms have become to well known and compete with others of international standard. However, there are problems and barriers associated with the SME firms' growth, especially, in the area of marketing, production, and logistics. With other areas, the government put full efforts to use marketing and production strategies for developing and promoting SME products in world market. However, the role of logistics has been still ignored or at least seen as cost-generated activities. Therefore, the aim of the study is to examine the current status of logistics' need and implementation for Thailand's SME firms. It also examines factors affecting the implementation, including using logistics strategies for building competitive advantage. Finally, the effectiveness and efficiency of SME firms' logistics implementation will be examined.

LITERATURE REVIEW

The literature from four leading logistics journals between 2000 and 2011 (International Journal of Logistics Management, International Journal of Physical Distribution & Logistics Management, Journal of Business Logistics, Logistics, and Transports and Transportation Review) were reviewed to address issues related to implementation of logistics strategies in SMEs. The relationship between logistics implementation and its organizational effectiveness, especially focusing on the SMEs was also examined.

Logistics refers to the art of managing the flow of physical material and information from source to user (1). It encompasses all of the information and material flows throughout an organization and interorganisations (2). It includes everything from movement of a product or from a service that needs to be rendered, through to management of incoming raw materials, production, storing of finished goods, its delivery to the customer and after sales service (3). The role of logistics function is a key determinant of business performance to ensure that there is smooth flow of material and information throughout a company's supply chains (4). Logistics has also become more prominent as a critical success factor in competitive advantage (5, 6) through reducing costs and improving service level or responsiveness to customers.

Problems arising in small firms include delayed and inaccurate information, incomplete services, slow and inefficient operation, and a high product damage rate (5). While the western small firms are developing and implementing quick response systems, efficient consumer response, cross docking and other areas of logistics management (3,4,5), these concept are not yet well recognized by Thailand's SME firms in making a strategic difference in competitiveness. The SMEs effectively lack strategic logistics formulation and implementation. The consequences are an inability to provide interlinked services, high operating costs and lack of flexibility in responding to changing demand.

Authors (4,5,6) identified the critical success factors in effective logistics management including not only good planning, close relationship with partners, effective warehouse and distribution management, and effective order processing, but logistics concept and mindset would be pervasive to all levels of an organisation.

The literature review led to conclusion that SMEs are increasingly recognizing the role and importance of logistics management as a strategic tool for enhancing competitive advantage. It revealed that effective logistics adoption would be carefully considered associated with factors affecting physical and information flows. Further, it found that studies on Thailand's OTOP products were few and very limited, especially in logistics management. Exploratory research found that SME firms have not given importance or priority to logistics management. Logistics activities (e.g. transport and warehousing) are overlooked as potential areas for building competitive advantage.

RESEARCH METHODOLOGY

With the limitation of research studies related to SMEs in Thailand, the researcher conducted exploratory interviews to generate broad views of SME operations. It collected data in *two* major sources. First, secondary sources through conducting *literature review* and *data analysis*. Secondly, primary data were collected by using *survey method*, *in-depth interviews* and *observation methods* for examining a relationship between variables and answering research questions.

The questionnaire was used for eliciting attitudes and perceptions of SME firms in Thailand. First, pre-testing was carried out to forty five respondents, which found

Cronbach's Alpha equaled 0.85. There were some minor changes in items of questionnaires. Three weeks later, the second pre-testing was conducted on the same group of respondents, with Cronbach's Alpha equaling 0.904. The result showed that the research instrument had a highly acceptable degree of reliability.

The key measures were based on assessing their perceptions related to roles and the importance of logistics, including implementation of logistics functions. Further, they also examined factors affecting implementation and effectiveness and efficiency after implementing logistics strategies in their operations. The questionnaires were randomly distributed to sampling targets by applying a five-point Likert-type scale. The 200 questionnaires were distributed in three major channels: *postal mail, face-to-face and electronic mail (e-mail)*. The total response rate generated was very good with 106 *respondents or 53 percent*. The span of time took four months. The data was processed with SPSS 11.0 Verifying dimensionality and reliability of each construct that included factor analysis, and item-to-total correlation and regression analysis were conducted.

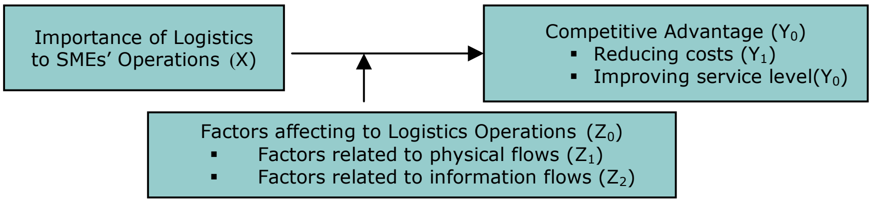

Figure 1 theoretical framework of the study

Based on the theoretical framework, variable **X** covered SME firms' implementation of logistics functions. Variable **Y_0** included adoption of logistics to build competitive advantage. After having conducted factor analysis, the variable was grouped in 2 parts: **Y_1 and Y_2** which were building competitive advantage through cost reduction and improving service level to customers respectively. Variable **Z_0** included factors affecting logistics implementation and using logistics to build competitive advantage. The variable **(Z_0)** was divided in 2 parts: **Z_1** and **Z_2** were factors related to physical flows and information flows respectively.

The model was based on two hypotheses of small enterprise behavior to logistics implementation and using logistics strategies for building competitive advantage:

1. SME firms' perception of logistics need and implementation were positively associated with building the firms' competitive advantage.

2. There was a relationship between factors affecting logistics operations and effective logistics implementation. Identifying the factors would facilitate SME firms to develop carefully more integrated logistics strategies.

FINDING RESULTS

The results show that samplings are normal distribution, and it is significantly used as representative of the population. The results show that variable **Y_0**,which means adoption of logistics to build competitive advantage can be divided in two groups: **Y_1 and Y_2** which are building competitive advantage through cost reduction (e.g. operating costs, logistics costs), and improving service level to customers (e.g. responsiveness, flexibility) respectively. Variable $\mathbf{Z_0}$ includes factors affecting logistics implementation for building competitive advantage. The variable is also divided in two groups: $\mathbf{Z_1}$ and $\mathbf{Z_2}$, which are factors related to physical flows (e.g. effective warehouse, transport), and information flows (order processing, IT for logistics) respectively.

The study examines factors affecting SME firms' operations and business. The results show that most entrepreneurs identify the following factors: lack of raw materials (85%), lack of skilled labors (75%), problems related to product quality (74%), intense competition (67%), economic conditions (64%), fuel prices (64%), customer demand (61%), funds for investment (53%), and support from government sectors (47%).

It also identifies factors influencing logistics implementation, as the result reveals as follows: warehouse management system (91%), after sale services (86%), fuel prices (83%), information technology (IT) for logistics (83%), order processing (80%), material management (78%), transport system (75%), logistics knowledge and management (75%), physical distribution management (64%).

Variable		Sig.	P-Value
Independent	Dependent		
X	Y_1	0.000	0.726
	Y_2	0.000	0.620
Z_1	X	0.000	0.804
Z_2	X	0.000	0.840

Table 1 summary relationship between variables

After testing the hypotheses, the results show a significant relationship between tested variables in some degrees. It found that there is a moderate relationship between the adoption of logistics management **(X)** and building competitive advantage through reducing costs **(Y_1)** and improving service level **(Y_2)**. Further, it also found that there is strong relationships between these factors and effective logistics implementation. Importantly, the factors have influence in a higher degree on logistics operations and management, especially factors related to information flow. Physical flow **(Z_1)** has a relationship to a lesser degree with improving service levels to their customers.

DISCUSSION AND RESEARCH IMPLICATIONS

The results indicate significantly strong relationships between variables. The first hypothesis reflects that SME firms recognize the importance and need of logistics implementation for building and enhancing their competitive advantage. Although adoption of their logistics tends to reduce operating costs more than improve service levels, it also reflects that firms have an expectation of outcomes from logistics implementation to a high degree. Further, it found that resources have not been fully utilized. Many Losses of raw materials, for example, occurred in production and movement processes. Transporting finished goods to markets took several weeks, instead of a few days. The symptoms reflect that SME firms sufficiently lack essential skills and knowledge how to effectively implement the logistics strategies to utilize efficiently their resources to minimize costs and improve service levels to customers.

It also found that some factors using IT for logistics for example have a strong contribution and influence on logistics functions and operations. The question is why firms provide the factors related to information flow a priority. Mainly, the reason is that firms use the internet as importance channel for transaction and receiving orders from customers. However, the internet has been narrowly limited of using only the four and five star products'. Further, some factors related to physical flows influence logistics implementation. Poor warehouse and distribution management, for example, would influence to logistics implementation, in a negative way including their competitive advantage.

While the study covered a wide range of SME products, it only surveyed in a specific province. It uses an inductive method or inferential statistics. It studied a small group, but the results should tend to represent the whole population. Therefore, in a broad view, SME firms would recognize logistics' role and importance as a value-added tool for their operations, including considering as key driving for enhancing their competitive advantage. They would increasingly put more focus on adoption of logistics techniques and strategies with their operations, especially in weak logistics functions (e.g. inventory, distribution and transport management).

Further, SME firms would seek an optimized way for managing logistics functions to reduce costs, in particular non-value added costs. Also, to improve the service level, they would understand importance of customer service, including how to effectively and efficiently manage physical and information flow with higher service quality to enhance customer satisfaction. Controlling is one of the major activities which has been ignored. They would adopt a performance measurement system to monitor and control logistics functions effectively and efficiently. The research implications reflect that building and adopting effective logistics and supply chain strategy offers opportunities to create sustainable competitive advantage. The role of support and assistance from government sectors is still needed, including seeking a way to build sustainable networks among SME firms.

CONCLUSION AND RECOMMENDATIONS

The paper examined issues related to logistics in the case of Thailand's SME products. The literature was reviewed in area of small and medium enterprises (SME), products, logistics and supply chain. The review provided a foundation for clearly developing a conceptual framework and research objectives. The rigorous methodology was conducted to generate a reliable and valid measurement instrument. Questionnaires and in-depth interviews were a major tool for collecting data. The sampling was randomly chosen to ensure that it represented characteristics and attributes of the population. The obtained data was analyzed using SPSS.

In conclusion, SME firms have been limited in understanding the role and importance of logistics affecting their operations. However, it found that entrepreneurs have mostly low education, including low skills and knowledge related to logistics implementation. The importance of factors influencing logistics operations has been ignored. Further they lacked a creative system, process, and culture to support systematic adoption of logistics activities. In addition, they lacked efficient and effective integration of activities related to physical and information flows. Therefore, they urgently need to develop and improve understanding and knowledge of logistics to entrepreneurs. Including encouraging them for adopting new logistics techniques and management. Supports and assistances of government sectors still need with the aim is to building sustainable networks, including providing essential facilities and infrastructures.

FURTHER RESEARCH

The study examines issues of Thailand's SME industry related to logistics implementation and its effectiveness, and it provides broad views of SME products (foods, cloths and gifts), but needs for focusing on logistics implementation on specific products are necessary so that the results can be effectively applied to specific SME products.

Further, studies mostly use questionnaire survey to the respondents; it was found that it is difficult to make clearly understandable to SME firms, who have mostly low education, through all items of questionnaire. Future research would find an appropriate methodology to elicit their attitudes and opinions based on research objectives.

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SECTION 4 – RISK, UNCERTAINTY, COMPLEXITY AND VISIBILITY

ANALYSIS OF THE EFFECTS OF PROCESS VARIABILITY IN DRY CONCRETE PRODUCTION USING SIMULATION MODELS

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ABSTRACT:

This research seeks to analyse the impact of variability in manufacturing processing times on the performance of a conceptual dry concrete plant using simulation. The paper presents the main characteristics of the industry, development of a simulation model, and presentation of experimental results from the model leading to conclusions. Some interesting relationships are observed between the variance and some system performance measures. Conclusions are presented and some suggestions for further work to develop of the topic.

1. INTRODUCTION

Concrete is an important material element in construction of architectural structures, such as: bridges, dams, roads and buildings. Concrete is made by mixing three basic components: aggregates, cement and water.

One of the most important characteristics that the aggregates must have for providing a high quality concrete is a good-graded mix. This means that the spaces between grains should be occupied by smaller grains rather than by cement.

Concrete manufacturing has become an important and stable business due to its basic needs coverage. U.S. Geological Survey, Mineral Commodity Summaries (2007, p40) states that 99,800 thousand metric tons of cement was produced in the United States in 2006, with sales for use in concrete of $54 billion. Of this 74% went to ready-mixed concrete producers.

2. DRY CONCRETE MANUFACTURING PROCESS

The dry concrete manufacturing process is divided in 5 main stages: raw material receipt, selection and storage, aggregate drying, de-dusting, mixing and final product storage, packing and delivery.

The mixing process seeks to obtain a homogeneous dry concrete mix formed by the coarse aggregates, fine aggregates and cement. Daniel and Lobo (2005, pp.67) mention two stationary mixing process types that are done either using a rotating drum or rotating shafts. Regardless of the machine used, the mixing process starts with the arrival of the coarse aggregates which is then followed by the fine aggregates, both coming from the de-duster, and finally by the cement, which arrives from its silo storage. Finished in the mixer, what is now called dry concrete is sent to an end product silo.

From the concrete silo, the final product flows to the packing machine. An average of 50 kg of concrete are packed in special bags whose properties are similar to the cement bags. The concrete bags are then transported to the warehouse by conveyors and placed on pallets for further distribution.

A conceptual model for a dry concrete manufacturing plant was used as the basis for development of a simulation model.

3. SIMULATION MODEL

3.1 Model Construction and Verification

From the system definition, assumptions were considered in order to balance real system complexity with model utility. These assumptions included avoiding peak production levels, reliable suppliers, processing time values described by a single probability distribution, with the purpose of avoiding the influence of other factors on the performance measures rather than the one under consideration and also to facilitate the simulation of technical issues in concrete manufacturing. The selected system was programmed in ARENA 8.0.

Having built the simulation model, system verification was assisted by specialist engineers that initially helped in the development of the conceptual model.

3.2 Simulation Conditions

The dry concrete production process was modelled as a non-terminating system, assuming that that the plant works 24 hours a day for 7 days a week.

Every run was set to simulate a month of production plus the system warm-up period (interval of time in which the system reaches a steady state). A sufficient warm-up period was observed to be equal to 3,700 minutes, therefore every simulation run was around 33 days in total.

The number of replications was set as 10, following the procedures of Law (2007, pp. 77) and Kelton D, Sadowski R and Swets N. (2010, pp. 278). It was concluded from statistical analysis that 10 replications per model provided enough information about the data population.

3.3 Model Validation

Model verification was undertaken using the following 4 main tests proposed by Garavito (2007): continuity test, consistency test, absurd condition test and degeneration test. Further verification and validation tests described by Sargent (2009, pp. 166) - face validity, internal validity, multistage validation, operational graphics, traces, Turing tests and comparison to other models – were also used. All these subjective and objective verification and validation methods were satisfactorily applied to the current simulation model.

3.4 Sensitivity Analysis and Design of Experiments

Having developed and validated the initial simulation model, it was possible to design a range of experiments by adjusting processing time variability. Two different situations were proposed for making such changes: first, modifications to all the activities' processing times, second, modifications in the variability of critical stages' processing times.

Each experiment considers an increase of variability with respect to the original experiment. The σ values were increased as a function of the μ values, using the following formula:

$\sigma = x * \mu$; where "x" is variable and in percentage units [%].

"x" could take values such as 10%, 20%, 30%, etc.

Different performance variables that measure system productivity and system efficiency were identified and used to compare the various models. The measures used were: *Total Waiting Time in Dryer*, *Average Waiting Time in Dryer*, *Total Waiting Time in Deduster*, *Average Waiting Time in Deduster*, *Total Waiting Time in Mixer*, *Average Waiting Time in Mixer*, *Average Production Time* and *Batch Counter*.

3.4.1 Variability in all Processing Times Experiments

This stage involves simulation runs where the same level of variability is applied to all the processing, transport and delivery activities simultaneously. Figure 1 represents this approach for a concentual system comprising of 7 phases and could be related to the concrete manufacturing process, where for example, "c" would be the dryer, "d" the de-duster, "f" the mixer and "g" the packing machine etc.

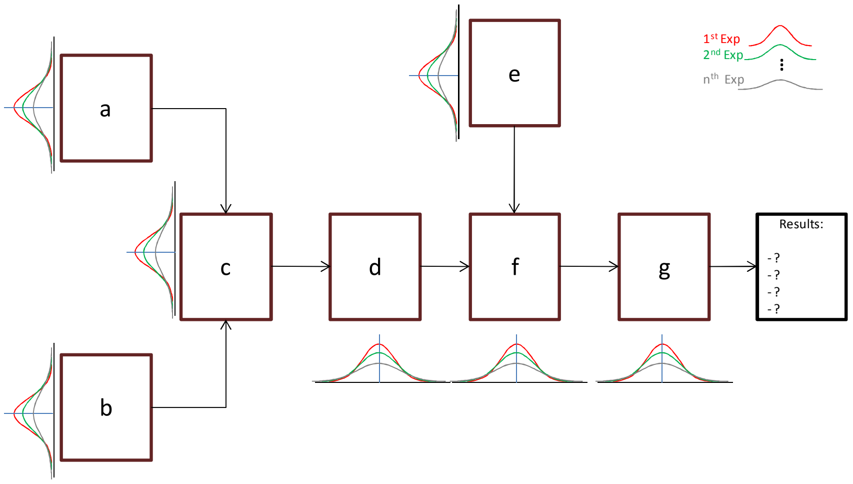


Figure 1. Variability on all Processing Times' Experiments

3.4.2 Variability in Critical Stages Experiments

In these experiments variability modifications were introduced more specifically in stages that were observed to be critical, these processes are: drying, de-dusting and mixing.

To analyse the critical stages, variability modifications were applied to a single process at a time. This means that while one stage's processing time is being varied all the remaining stages retain a constant variability, set as x = 5%. Figure 2 shows the approach used for this variability analysis phase. Figure 2a illustrates how the variability modifications were done initially to stage *c* while all the rest activities had constant variability, and then the analysis was transferred to stage *f* (figure 2b) and so on.

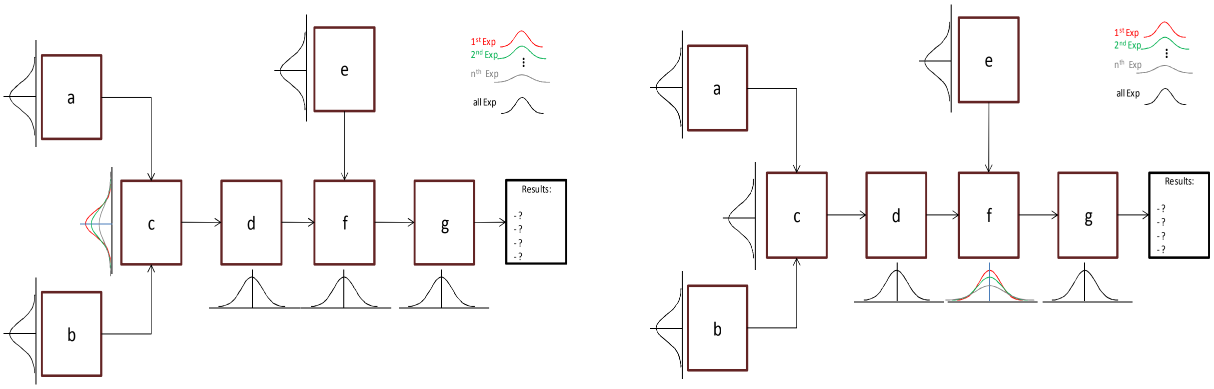


Figure 2a. Variability modifications for for stage c

Figure 2b. Variability modifications stage f

Figure 2. Variability on Critical Stages Experiments

Having designed the experimental methodology a total of 36 experiments were run considering the scenarios explained above. The experiment groups and subgroups are shown in figure 3.

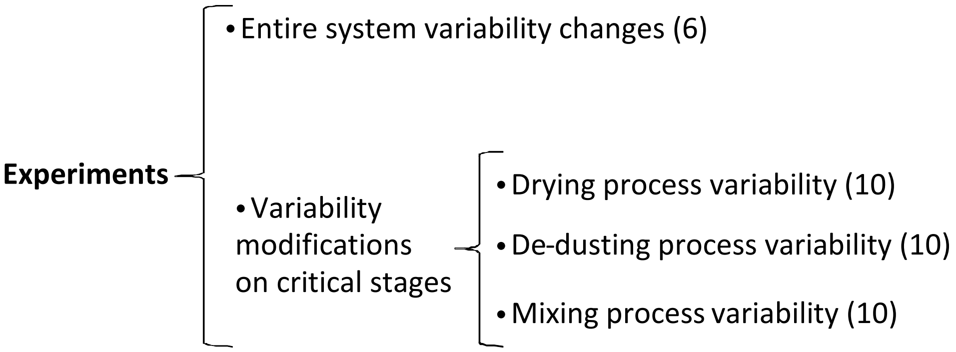


Figure 3. Simulation Experiment Scenarios

3.5 Results Gathering and Conclusions

3.5.1 Entire System Variability Experiments Results

The results of the first group of experiments for the first performance measure (throughput time) are shown in figure 4.

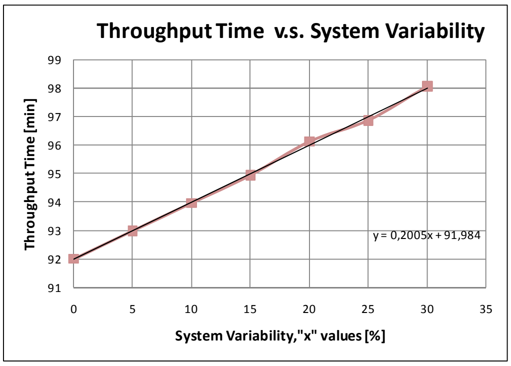


Figure 4. Influence of system variability on throughput time

From figure 4 it was concluded that the system variability and the throughput time follow an almost perfect linear relationship. This indicates that the performance of this system in terms of average production time is directly proportional to its activities' variability.

As can be seen in Figure 4, a trend line was drawn and the line equation was calculated. This equation allowed prediction of the production time with any given level of variability for a range of "x" values from 0 to 30%. It can be seen from the equation that for a unit increment on "x", an increase of 0.2005 [min] would be expected on the throughput time. In other words, for every 1% of the process time's mean on the standard deviation on all activities involved, a batch would take around 0.2 minutes longer to be produced.

In the same way, all the performance variables were plotted from the results of the simulation runs. Graphs were plotted for every scenario proposed and are presented in figures 5 to 8. A statistical analysis followed to support the development of conclusions.

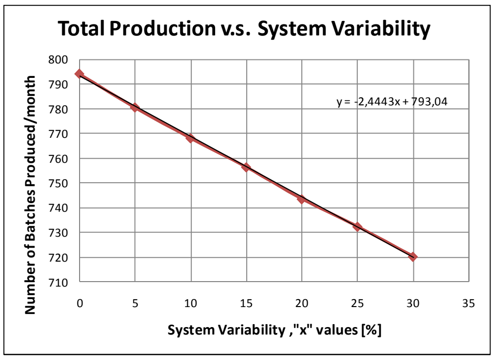


Figure 5. Influence of system variability on total production

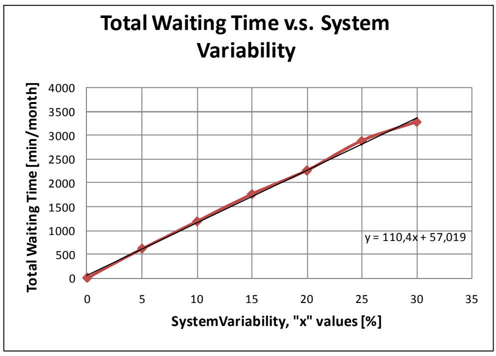


Figure 6. Influence of system variability on total waiting time

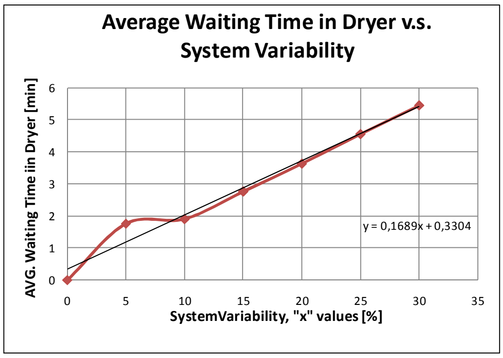


Figure 7. Influence of system variability on waiting time in dryer

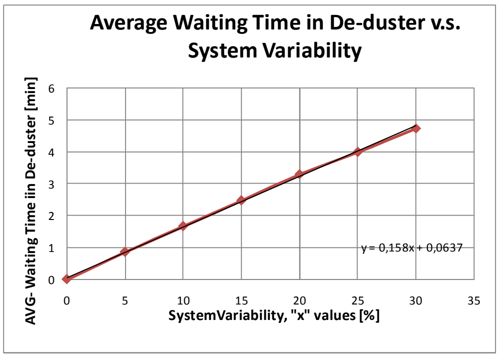
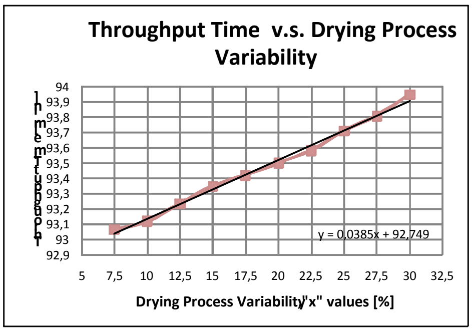
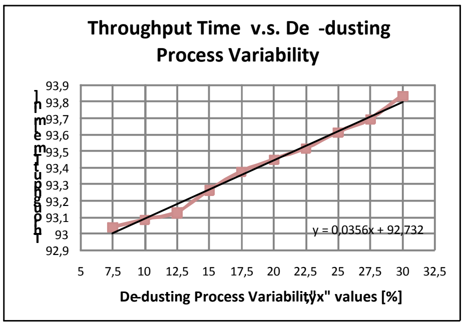


Figure 8. Influence of system variability on waiting time in de-duster

3.5.2 Critical Stages Variability Experiments Results





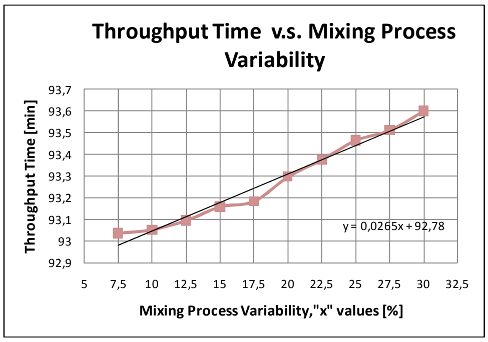


Figure 9. Influence of Critical Stages Variability on System Throughput Time

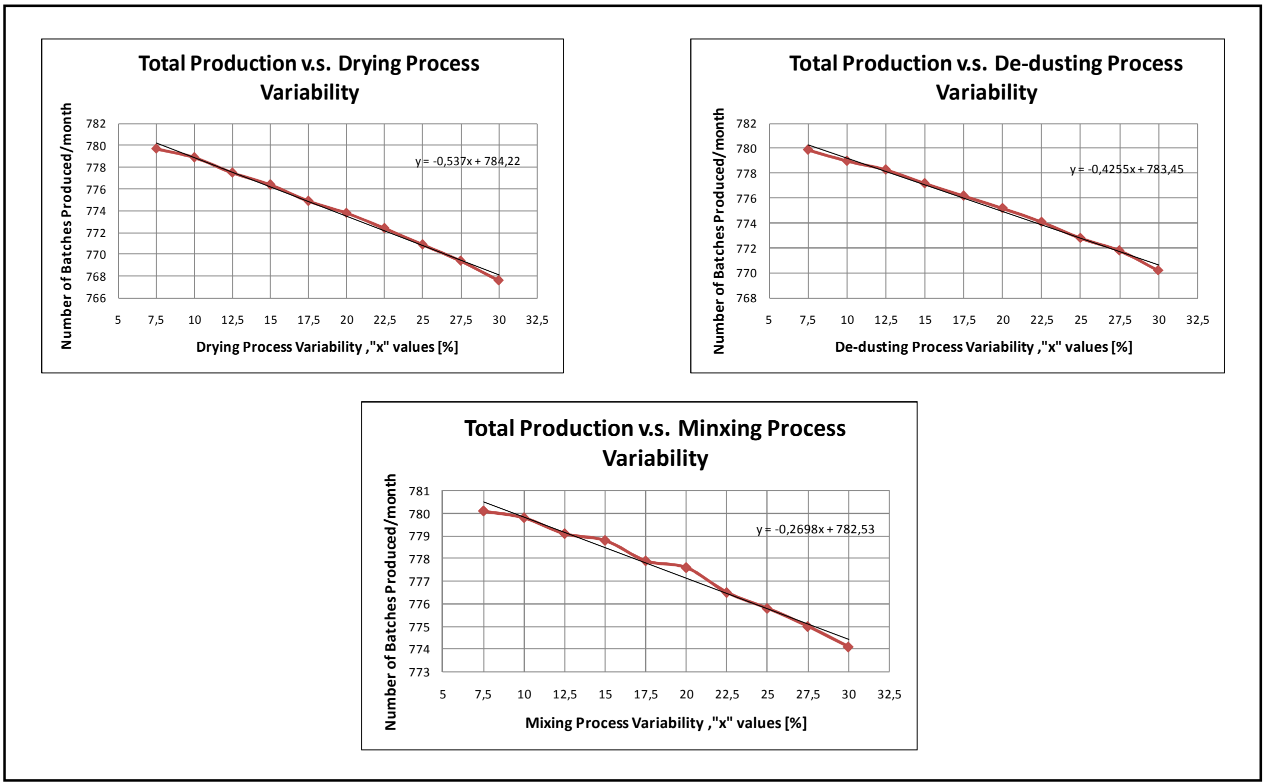


Figure 10. Influence of Critical Stages Variability on Total Production

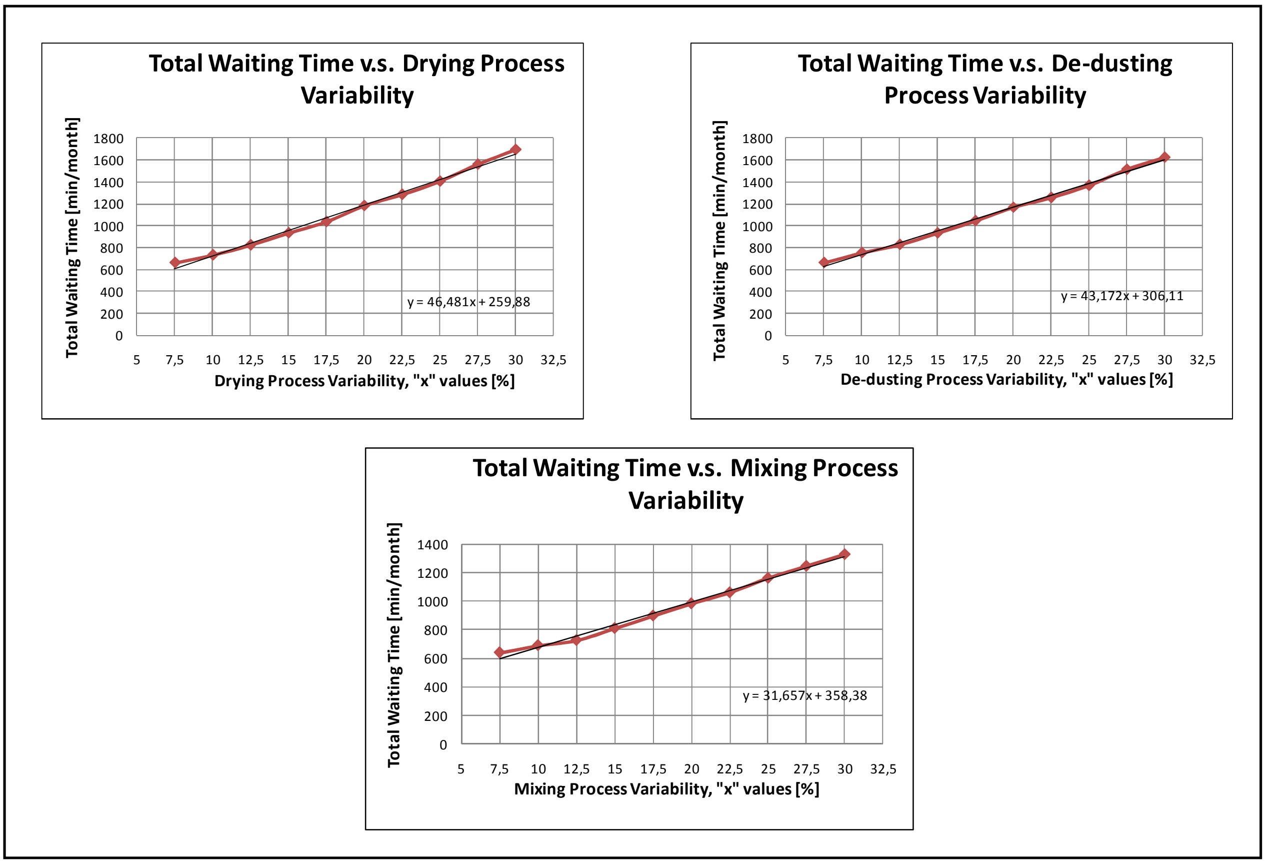


Figure 11. Influence of Critical Stages Variability on Total Waiting Time

Figures 9, 10 and 11 present the results of the experiments investigating the effects of variability in specific critical operations on the three performance measures. In each case a linear relationship between system variability and the relevant performance measure is evident.

4. LIMITATIONS

The lack of real sample data forced the authors to assume hypothetical processing times; difficulties were encountered on finding representative processing times for all the activities. This assumption was extended by the usage of a single probability distribution for random number generation. It is recognised that the collection of real samples would had helped the examination of different probability distributions that describe a real system with higher precision. Reference to a real system reference would also have facilitated the validation of the simulation model. Nevertheless, the constructed computational model was found to be very flexible: any change can be easily made in a short period of time and without affecting the behaviour of the simulated elements, so that any more realistic data, when available, could be inserted easily to the model in a future case.

5. CONCLUSIONS

This research examined the influence of processing time variability in the dry concrete manufacturing process by the construction and analysis of a simulation model based on such a system.

Despite an extended literature review of concrete manufacturing, simulation models and variability analysis, not a single publication that takes all the three areas into account was found. As a consequence, the current research is innovative, and its results could be implemented either for academic or practical industrial purposes.

Furthermore, the developed model includes a balance of simplicity and utility. Important results were obtained which indicate the effects of increasing variability on different variables that measure the system performance in efficiency and productivity terms.

The conceptual model was considered to be an important stage in the achievement of the research objectives; it helped to define in detail the inputs, elements interactions and outputs of the system. It also defined the boundaries of the activities to simulate, the complexity of the simulation model, and the selection of the simulation unit, and was of great importance to the computational model verification and validation phase.

The application of statistical principles was important at many phases of the research. For instance, a statistical analysis helped to validate the number of replications of 10 as sufficient for acquiring results with low error percentage.

Further statistical analysis showed that processing time variability affects the performance variables as shown in the figures.

The initial simulation model was an important preliminary to the other 36 models, serving as a results comparison reference, having zero variability and zero delays. For each of the other scenarios it was then possible to identify how far away the variability takes the system from the ideal scenario.

The “x” value allowed representation of all the processing activities and at the same time to relate the standard deviation to the individual mean processing times. The variation of this value was shown to be directly proportional to the selected performance measures. The plots of these relationships were found to be adequately described by a linear trend line. It helped to know by how much every performance value gets affected by a single unit increase in the standard deviation on the processing time.

It was clearly demonstrated, as anticipated, that processing time variability has a negative effect on system performance. It was also observed that variability has a greater effect in some activities of the system than others. However, the outputs consistently showed a negative response with the existence of variability at any stage.

A number of areas for further research have been identified, which would extend the insights from this study. One straightforward extension would be the consideration of lower and higher standard deviations, to explore whether the linear relationships discovered here apply over a wider range of degrees of variability.

A further extension of the work would be to explore the effects of process breakdowns and their variability on performance of the system.

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ON UNCERTAINTY IN SUPPLY CHAIN RISK MANAGEMENT

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INTRODUCTION

Supply chain complexity, specialisation and disintegration are emerging as one of the major challenges in supply chain risk management. These developments have made the supply chains vulnerable to disturbances from both inside and outside the system. Indeed, many recent events have shown how vulnerable long and complex supply chains are. This has attracted the attention of many academics in the field of logistics and supply management, where the risk-related issues are increasingly taken into account (Wagner and Nethan, 2010; Minahan, 2005; Sanchez-Rodrigues et al. 2008, Sanchez-Rodrigues et al. 2010). In this context, individual companies' livelihood depends on their ability to identify and mitigate the uncertainties and risks countering them. However, although awareness of the vulnerability and of risk management is increasing among academics and practitioners, many related concepts are still in their infancy. There are thus insufficient conceptual frameworks and empirical findings to provide a clear picture of the phenomenon of supply chain risk management (Jüttner, 2005; Manuj and Mentzer, 2008). Accordingly, both academic research and practitioner reports stress its importance and the need to develop different approaches (e.g., Blos et al., 2009; Manuj and Mentzer, 2008; Shaer and Goedhart, 2009).

According to Blome and Schoenherr, (2011), the current financial crisis has emphasized the role of supply chain risk management in many companies. Indeed, Jüttner (2005) found that 44 per cent of organisations expected their vulnerabilities to increase within the next five years. More recently, the need for supply chain risk management is evidenced in the results of Snell's (2010) study showing that 90 per cent of the respondent companies feared supply risks, whereas only 60 per cent felt confident or knowledgeable enough about such issues.

Supply chain risk management has understood risk as a situation entailing exposure to two essential components: exposure to an event and the uncertainty of possible outcomes (Holton, 2004). Thus, risks are considered based on the likelihood of occurrences and what kind of damage they will bring if they are realized (e.g. Mitchell, 1995). The different types of risks are extensively covered in the literature (see e.g., Rao and Goldsby, 2009), but the analysis of the risk concept has been very limited. A common way to manage the concept of risk is to use terms such as vulnerability, uncertainty and risk (Sorensen, 2005). In that case, the concept of risk is understood as an occurrence, in which the probability distribution is known. However, we suggest that in reality, the cases when probability distributions actually cannot be defined are much more common than those where probability distributions are known. Thus, in order to improve the understanding of how risks could better be managed under such conditions, in this study *we put forward a conceptual framework focused on the role of uncertainty in supply chain risk management*.

Supporting our argument, some authors have criticised the fact that the literature on supply chain risk management does not always clearly distinguish between risk and uncertainty, which makes the definitions quite vague (e.g. Tang and Nurmaya Musa, 2010). Indeed, in earlier studies it has been found that the concept of risk is less understood and developed in the area of supply chain risk management than in other disciplines (e.g. Khan and Burnes, 2007). As these terms are among the most essential in supply chain risk management, the clarity between them is of the essence. Therefore this article attempts to develop the understanding of these concepts by illustrating the levels of uncertainty in supply chain risk management. In doing this, the nature of uncertainty is defined in a way that offers a more comprehensive and valuable way to consider how the concept of uncertainty should be approached also in future supply chain risk management studies.

SUPPLY CHAIN RISK MANAGEMENT AND RELATED CONCEPTS

The supply chain consists of a series of activities and organizations through which material and information move on their way to the final customer. *Supply chain vulnerability* in that context is described by Jüttner (2005) as an exposure to a 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 risks in the chain. Again, 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 to jeopardize the supply chain's ability to effectively serve the end customer market. *Supply chain risk management* is a function that aims to identify the potential sources of risk and implement appropriate actions to avoid or contain supply chain vulnerability (Narasimhan and Talluri, 2009).

Supply chain risk is seen as a threat that something might happen to disrupt normal activities which stop things happening as planned (Waters, 2007). Most of the literature defines risk as purely negative and sees it leading to an undesired result or consequences (Harland et al., 2003; Manuj and Mentzer, 2008). A standard formula for a quantitative definition of supply chain risk is (Mitchell, 1995):

$$\text{Risk} = P(\text{Loss}) * I(\text{Loss}),$$

where risk is defined as the probability (P) of loss and its significance (I).

Hetland (2003) and Diekmann et al. (1988) view risks as an implication of an uncertain phenomenon. The difference, however, is explained by Waters (2007): risk occurs because there is uncertainty about the future. This uncertainty means that unexpected events may occur. Uncertainty means that we can list the events that might happen in the future, but have no idea about what will actually happen with their relative likelihoods. Both deal with the lack of knowledge about the future and consider events that may or may not happen; they, however, do not comment whether the events are harmful or beneficial.

The distinction launched by Knight (1921) can be regarded as the best known and most used typology of uncertainty for risk management where certainty, risk and uncertainty are distinguished. When defining risk, Knight coined the terms (quantitative) "measurable" uncertainty and (non-quantitative) "unmeasurable" uncertainty when only partial knowledge of outcomes such as beliefs and opinions of outcomes is available. Furthermore, Trkman and McCormack (2009) classify uncertainty into two categories, endogenous and exogenous, whether they derive from within or outside the supply chain. The distinction between exogenous and endogenous uncertainty alone is, however, too vague in order to make sense of how uncertainty really affects supply chain risk management decisions. Thus, we propose that uncertainty, especially in supply chain risk management context, could be examined through the lenses of substantive and procedural uncertainty, as explained in the following.

Parallel to Simon's rationality concept, Dosi and Egidi (1991, pp. 145-146) introduced substantive and procedural uncertainty. The substantive uncertainty derives from the "incompleteness of the information set" and it is related to a "lack of information about environmental events" and "all the information which would be necessary to make decisions with certain outcomes". Procedural uncertainty comes "from the inability of the agents to recognize and interpret the relevant information, even when available." It concerns the competence gap in problem-solving" and "limitations on the computational and cognitive capabilities of the agents to pursue unambiguously their objectives, given the available information". Uncertainty in a supply chain can be classified as illustrated in Figure 1.

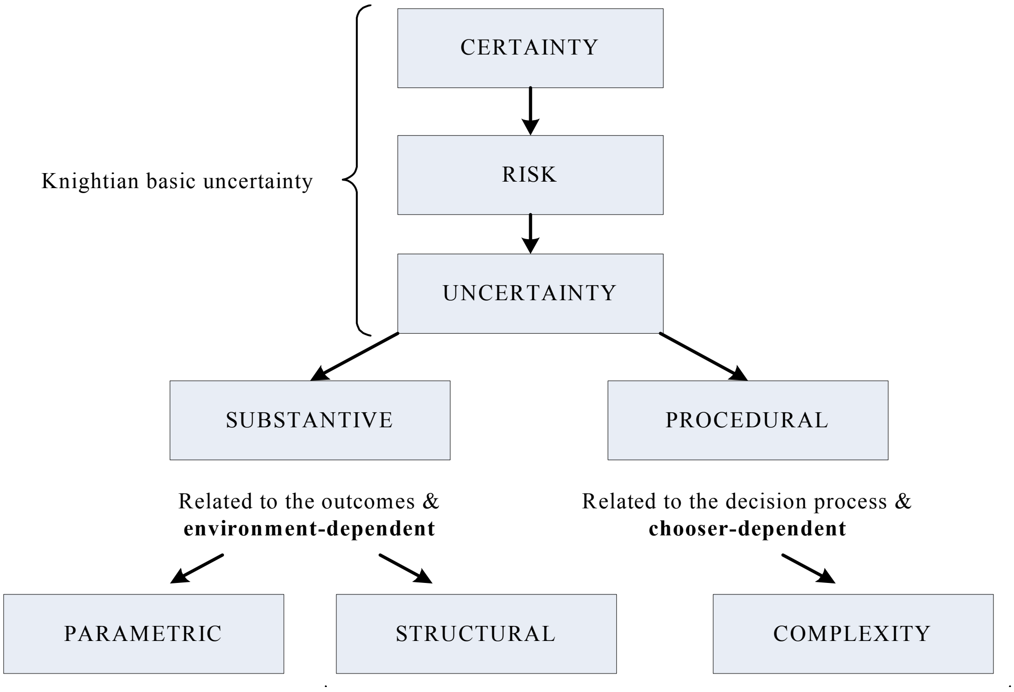

Figure 1. Certainty, risk, and uncertainty

The components of uncertainty levels include:

(i) The knowledge level the decision-maker holds related to the problem under each type of uncertainty.

(ii) The decision-maker's knowledge of the possible actions they can be engaged in.

(iii) The decision-maker's knowledge of the possible states of the world.

(iv) The decision-maker's knowledge of the consequences resulting from the interactions of the actions and states of the world.

(v) The decision-maker's subjective or objective knowledge of the probabilities of the occurrence of possible states of the world.

This classification distinguishes uncertainty as parametric and structural (i.e., environment-dependent uncertainty) and procedural (i.e., decision-maker dependent uncertainty) offering, in our view, a valuable perspective to uncertainty related to supply chain risk management decision-making (Langlois, 1984; Dosi and Egidi, 1991; Kyläheiko, 1995; Kyläheiko et al., 2002). Under each of these uncertainty categories the decision-maker has a different amount of knowledge about the state of the world and its events and, therefore, also different kinds of resources to cope with uncertainty. Uncertainty can also be radical when all pieces of knowledge are imperfect and there is no knowledge about the structure or probabilities of future events (Loasby, 1976; Kyläheiko, 1995).

CONCEPT OF (UN)CERTAINTY IN THE SUPPLY CHAIN CONTEXT

Supply chain risk management perceives to holistically mitigate the uncertainty driven risks opposed to the supply chain. The current supply chain risk literature commonly views all threats disrupting the normal activities (risks) as a product of the impact and the probability of an event. In reality the measure of those might not be available. Thus, we suggest that the nature of uncertainties plays a crucial role here, and for supply chain risk management to fulfil its tasks in both theory and practice it is crucial to understand the concept of uncertainty in its wholeness.

As the environment typically cannot be fully controlled there are unknown elements to the decision-makers. Taking into account all the affecting factors from the environment is therefore impossible and the information for forming probabilities imperfect. Table 1 explains in more detail the range between (complete) certainty and radical uncertainty.

Table 1. On defining uncertainty in supply chains (adapted from Kyläheiko, 1995; Kyläheiko, 1998; Dosi and Egidi, 1991).

	Certainty	***Certainty on probabilities (Risk)***	***Parametric uncertainty***	***Structural uncertainty***	***Procedural uncertainty***	***Radical uncertainty***
The knowledge decision-maker holds related to the decision problem	Every piece of relevant knowledge is known.	The future states and the structure of the decision situation are known. Probability of each future event is objectively known.	The structure of future is known. The probability parameters are not certain.	Imperfect knowledge of the structure the future can take.	The limitations of decision-maker's cognitive abilities to pursue unambiguous-ly their objectives given the available information.	All pieces of knowledge are imperfect, sometimes even comes close to ignorance.
The knowledge of the occurrence probabilities of possible states of the world, possible actions and consequences	Complete knowledge.	Objective knowledge of probabilities.	Subjective degrees of beliefs as to the probabilities of events and the consequences of own actions.	Subjective beliefs.	Incomplete knowledge about events.	No knowledge at all.
Implications to Supply chain risk management	Complete certainty about the supply chain and related risks. (Hypothetical world)	Typically assumed implicit foundation for supply chain risk management.	Risk probabilities are difficult to quantify.	The structure of the supply chain and the related risks are difficult to formulate.	Severely restricted visibility to supply chain and related risks.	Complete uncertainty about the supply chain and related risks. (Hypothetical world)
Implications to supply chain risk analysis	Supply chain risk analysis is not needed.	Supply chain risk parameters (likelihood and impact) can be measured and assessed with certainty.	Supply chain risk parameters (likelihood and impact) cannot be objectively assessed.	Supply chain risk events and their causalities cannot be objectively assessed.	Supply chain risk events and their causalities are not fully known and assessable.	The supply chain risk events and parameters cannot be assessed at all.

CONCLUSION

Supply chains have become very long and complex with many parallel physical and information flows to ensure that products are delivered in the right quantities, to the right place in a cost-effective manner (Jüttner, 2005). Drivers including globalization and the development of communications and other technologies, e-business and more agile logistics have affected supply chains and are becoming more and more vulnerable to serious disturbances. In line with these developments, supply chain risk management and uncertainty related to this have gained an increasingly important role. However, the concept of uncertainty is less understood in the area of supply chain risk management than in many other disciplines, and the lack of it has been already identified in some existing publications (e.g. Tang and Nurmaya Musa, 2010; Sorensen 2005).

In order to improve the current understanding on this gap, our study proposes a conceptual framework and implications illustrating the various levels of uncertainty in supply chain context. The presented viewpoint categorises the level of the uncertainties, and enables constructing better risk management strategy with better understanding to the level of actually known information available and the nature of uncertainty related to it.

In this paper, we combine the theories of uncertainty to supply chain risk management. In the presented framework the levels of uncertainty are presented between certainty and complete (radical) uncertainty. In particular, in our model risk is part of uncertainty whereas the risk management literature more commonly sees uncertainty as a part of risk. The view presented here thus differs from the mainstream supply chain risk management literature in that regard.

The presented framework illustrates the different levels of risks and therefore helps better to understand the nature of it. The findings suggest that certain scientific theories can be used to identify and analyse the levels and nature of uncertainty faced by the supply chain. In particular, the theoretical uncertainty construction can be utilized in analysing supply chain uncertainties and risks.

In practical terms, analysing the nature of uncertainty can provide crucial information for the supply chain risk management and therefore enable more efficient and effective implementation of it. The presented view can offer new viewpoints, and can be considered in the risk mitigation process.

The illustrated framework presenting the uncertainty theories in supply chain context is a new one and therefore this paper is aimed to act as a catalyst to further research. The presented viewpoint thus provides new opportunities for the research in supply chain risk management. However, the framework is a conceptual one, and it needs to be empirical tested and validated by the academic community in further research endeavours.

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SUPPLY CHAIN RISK MANAGEMENT RESEARCH IN AN INDIAN CONTEXT

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ABSTRACT

This paper provides a critique of supply chain risk management literature within an Indian context. Supply chain risk management (SCRM) has become a popular research topic, in part owing to the increased instability of the global business environment. Other factors such as shorter product life cycles, technological innovations, natural disasters and changing government policies have brought this topic into focus. We evaluated the papers with regards to the types of risks, industry sector, region and methodology. We found that various industry sectors are facing different types of risks, with the most common being operational and strategic risks. Furthermore, although SCRM is a widely published research topic, there is a lack of articles and more specifically research activity within an Indian context. Hence we provide a future research agenda in SCRM from an Indian perspective. Based on our literature review on global supply chain risk, we have identified key performance indicators for supply chain success. We have compared these factors between India and other regions in the world to provide a broad guide as a basis for assessing the competitiveness of Indian supply chains. Furthermore, we propose a new research agenda for supply chain risk management in an Indian context.

INTRODUCTION

It is not an over-statement to say that large manufacturing organizations either succeed or fail depending on the effectiveness of their supply chains (*Ritchie and Brindley, 2007; Gupta and Nehra, 2002; Tang, 2006*). Moreover, one could argue that categorizing and managing the risks inherent within supply chains is a key activity. These categories include supply risk, operational risk, demand risk, security risk, macro risk, policy risk, competitive risk and resource risk (*Manuj and Mentzer, 2008*). *Tang (2006)* classified supply chain risks into operations and disruption risks. Operations risks are related to uncertainties in a supply chain, which include demand, supply, and cost uncertainties while disruption risks are those caused by major natural and man-made disasters such as floods, earthquakes, terrorism, and major economic crises. Although these risks cause substantial harm, anticipating or controlling them is very difficult (*Tang, 2006*). Organizations that outsource most of their activities are particularly vulnerable to supply chain risk. Many examples of this exist; an indicative recent example is the fire at a German chemical plant in March 2012 that has subsequently threatened car brake production worldwide, owing to the fact that this factory is the source of up to 50% of the entire world production of a particular chemical required for car braking systems (*BBC, 2012).*

Articles on supply chain management in India - dealing specifically with issues such as flexibility (*Khan and Pillania, 2008*), responsiveness to customers due to fluctuating demand (*Kapoor and Ellinger, 2004*) and use of IT (*Rahman, 2004*) were identified. However, those based on SCRM practices in an Indian setting are rare. As suppliers are often in geographically dispersed locations, an important aspect of supply chain strategy is managing supply risk. More specifically, the Indian business environment currently poses several major challenges in terms of supply chain efficiency. Examples such as the transport network and other infrastructure-related capabilities have been well documented but are not yet resolved (*Cygnus Business Consulting and Research, 2010; Credit Rating and Information Services of India 2009; KPMG, 2010).* In India there is currently low use of IT to plan supply chain, inventories, and distribution, which reduces the transparency and hinders the flow of information (*Jharkharia and Shankar, 2004; Sahay et al., 2003*). Generally speaking Indian supply chains have many tiers of distribution, which increases the chances of failures. For example, transportation of commercial goods is mainly carried out by small logistic operators who typically run only 2-3 vehicles each, rather than specialised 3PLs.

RESEARCH OBJECTIVES AND METHODOLOGY

The aim is to evaluate current SCRM literature and its applicability to India, with the corresponding objectives being:

- Conduct a state of the art review of SCRM literature in a global context
- Carry out a comparative analysis of studies and assess their applicability to India
- Identify an agenda for future research on SCRM in India

The research approach can be summarised as follows:

1. Logistics and supply chain management-related journal articles (and some key online articles/reports and book chapters) were selected along keyword lines to delimit the field. A keyword search using the terms 'supply chain risk management', 'India', 'inbound supply chain risk', 'risk mitigation', 'supplier's imposed risk' and 'risk management' was carried out.
2. The classification context applied to the literature review structure was; key issue, author and year along the lines of methodology, sector, region and type of risk.
3. The material was analysed and sorted according to the classification categories in step 2. The classification allows identification of relevant issues based on a specific region, which in turn helps to identify research themes from a regional perspective.

Articles were sorted based on their methodology/approach. We found that literature reviews, questionnaires and case studies were most popular, followed by a quantitative/statistical approach.

Sector: Articles were also classified according to sector, which revealed that most were manufacturing-sector based. One reason for this could be a comparative analysis of traditional manufacturing supply chain with the service sector supply chain. Human labour forms a significant part of the service supply chain and decisions are taken locally. Therefore unlike a manufacturing supply chain, where physical handling of a product leads to standardized and centralized procedures and controls, in services this is not entirely possible.

Region: Many articles look at non-regional research, particularly emphasizing the global business environment. Some were found based on supply chain management practices in an Indian context. However very few articles were found based on SCRM in Indian context.

Type of risk: All articles were classified based on type of risk. The broad category includes operational risk which effects operations such as supply, labour strikes, etc. Some papers have studied supply or inbound risk exclusively (*Blackhurst et al., 2008; Wu et al., 2006; Zsidisin et al., 2004*) hence we have mentioned supply risk in addition to operational risk. Strategic risk includes risks related to overall business strategy in relation to supply chain i.e. to what extent a company is aligning its business objectives with its supply chain objectives. A number of articles about supply chain management practices in India were found, but there is no discussion of supply risks per se.

LITERATURE REVIEW

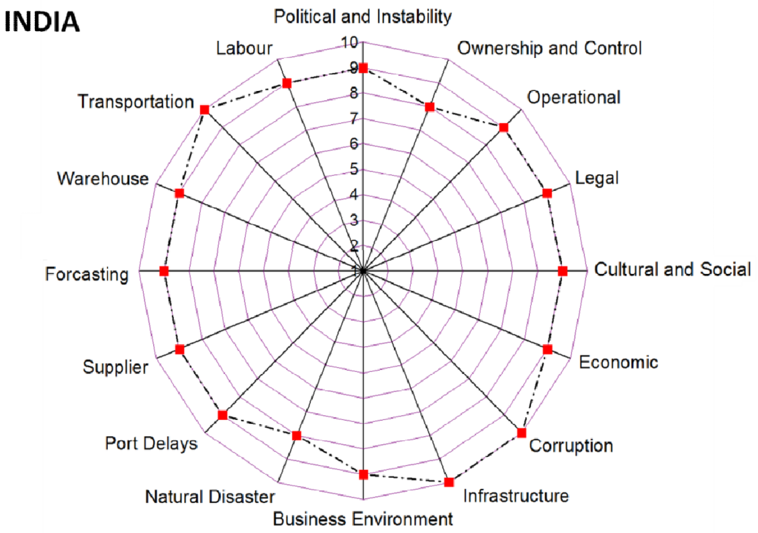
Supply chain risk has been explained in a variety of different ways. For example *Harland et al., (2003)* proposed a holistic view of risk assessment and management and concluded that as outsourcing and globalization increased, so too did the sources and types of risks. *Manuj and Mentzer, (2008)* drew from several disciplines - primarily logistics, supply chain management, operations management, strategy and international business management - to propose a comprehensive risk management and mitigation model for global supply chains. *Mitchell, (1995)* suggests that risk reducers include: using approved suppliers, multiple sourcing, choosing a market leader and frequent visits to supplier operations. *Sahay et al., (2006)* conducted research to assess the current state of supply management practices of Indian organizations. *Sahay and Mohan, (2003)* investigated supply chain practices in Indian industries and cover four dimensions (strategy, integration, inventory management and IT). They concluded that Indian companies should align supply chain strategy with business strategy to deliver best customer satisfaction. *Kapoor and Ellinger, (2004)* studied the Indian motorcycle manufacturer supply chain. They revealed that suppliers were having problems meeting demand and recommended a collaborative approach to identify and fixing the root cause of supply chain issues. *Jharkharia and Shankar, (2006)* studied Indian manufacturing and concluded that there are fundamental dissimilarities in the operations across sectors and that this might be the cause of the observed dissimilarity in their supply chain practices. *Altekar (2004)* explored supplier partnerships in Indian manufacturing and defined eight levels of programs and suggests implementation of trust, integration, and investment and alignment strategies. *Saad and Patel, (2006)* investigated supply chain performance measurement in the Indian automotive sector and found that the concept of supply chain performance is not fully embraced and highlight the difficulties associated with its implementation. *Rahman (2004)* researched the use of the internet in Indian SCM. He found that there is lack of internet use across all sections of the supply chain which hampers dissemination of information across supply chain personnel. *Khan and Pillania (2008)* studied strategic sourcing for supply chin agility and firm's performance. They classify manufacturing firms based on their level of supply chain agility.

The literature review reveals that SCRM is a growing issue. *Manuj and Mentzer, (2008) suggest that* several types of supply chain risks exist such as operational, security, strategic, security and demand risk (customer risk). Additionally it seems most of the techniques for risk identification steps are qualitative in nature (*Wu et al., 2006, Norrman and Jansson, 2004*). A common mitigation strategy for inbound supply risk is either multiple sourcing or efforts to increase and improve the supplier reliability base. Firms need to be careful while reducing their supply base. The reduction should be appropriate and rational (*Sarkar and Mohapatra, 2006*). Other risk mitigation strategies include avoidance, postponement, hedging, control, transferring/sharing risk, security, real option/decision analysis (*Juttner et al., 2003; Zsidisin, 2004; Christopher and Holweg, 2011; Wu et al., 2006; Blackhurst et al., 2008, Chopra and Sodhi, 2004).* In the full version of this paper, the results are summarised in tabular form, along three geographical lines i.e. Non-regional, Asia and Europe, and USA.

COMPARATIVE ANALYSIS OF SUPPLY CHAIN RISKS

In terms of country comparisons, supply chain risks can be divided into two broad categories; *exogenous* and *endogenous* risks. Exogenous risks include risks that are external to organization such as environmental risks, demand and supply side risks. Environmental risks can be further divided into categories such as natural disaster, political and instability risks, economic risk, legal risk, cultural and social risks, corruption, infrastructure, transportation etc. Although environmental risks are not directly related to the supply chain, they can significantly disrupt a company’s operation, which in turn affects supply chains. Demand and supply side related risks include supplier performance risks, forecasting risk, etc. *(Kersten et al., 2006a*). Endogenous risks are related to a company´s operations i.e. warehouse risks, transportation, operational risks, port delays, ownership and control risks, etc. **(***Christopher and Peck, 2004***)**.

The overall risk for any supply chain is an accumulation of all these risks, hence it is important to consider and discuss these risks. We have classified these risks as key performance indicators (KPIs) and studied the intensity of these risks in India, China, USA and Europe. For Europe we have included 13 countries (Germany, Sweden, Netherlands, Luxembourg, Switzerland, UK, Belgium, Norway, Ireland, Finland, Denmark, France and Austria). Based on indicative industrial reports, key research articles and consulting firms’ analyses (e.g. *KPMG 2010, World Bank 2011, Maplecroft 2011*) a score between 1 and 10 has been assigned to each region to indicate the relative risk. This in turn led to the construction of ‘radar’ diagrams as shown in Figure 1 (below).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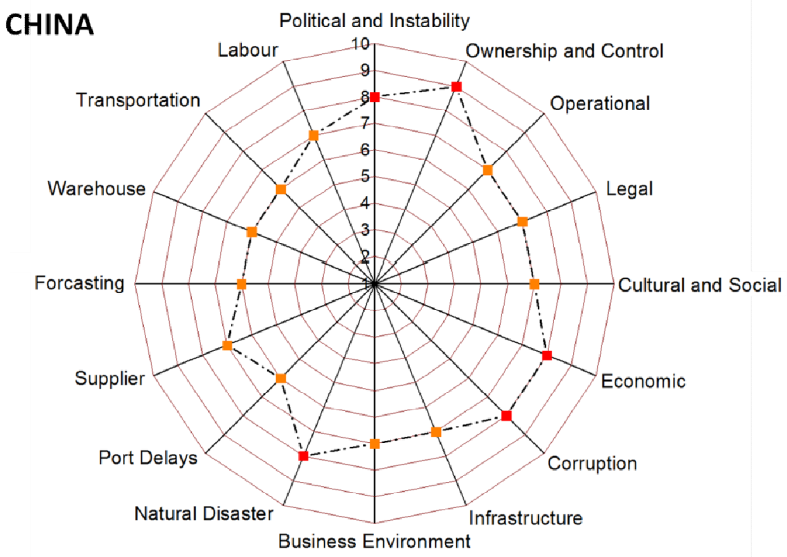
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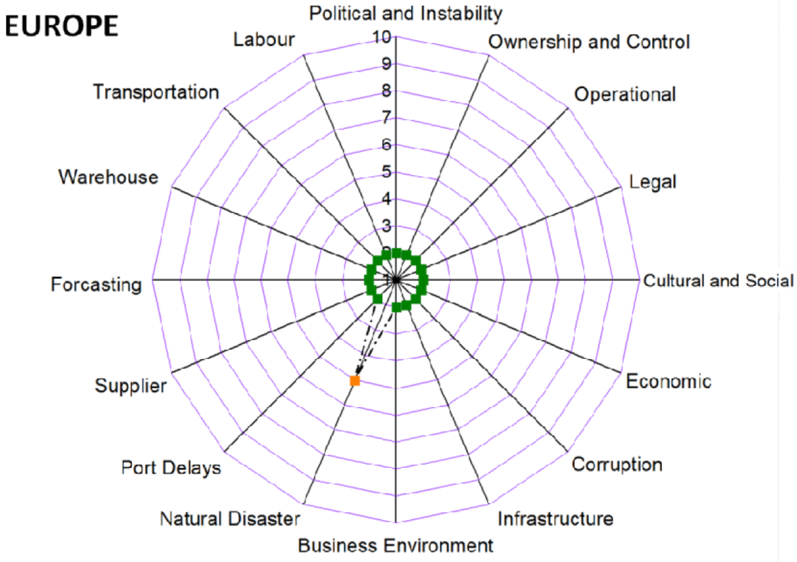
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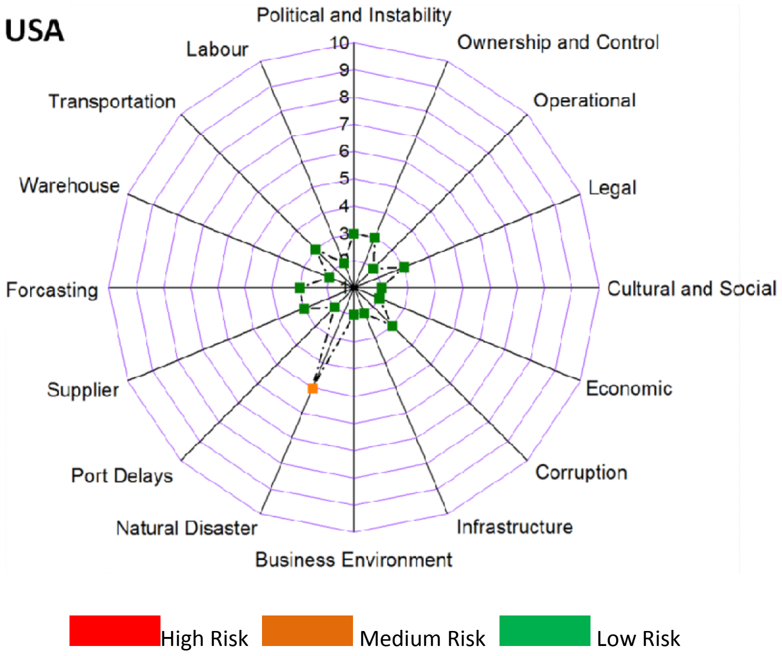

Figure 1. Intensity of supply chain related risks: India, China, Europe and USA

We have considered a score of 1 to 3 as low risk, 4 to 7 as medium risk and 8 to 10 as high risk In general we found that Europe and USA fall in the low risk category, owing to good infrastructure, and other factors (as shown). China has been ranked as medium to high risk, with India being ranked mostly as risk in most areas.

In general, progress in infrastructure has remained slow in India. Regulatory frameworks, as well as the aggregate investment in the road sector remains behind the requirements. For example the average truck speed in India is approximately 30-40 kmph, whereas in China it is 60-80 kmph. In India four-lane road coverage is currently approximately 7000 km, whereas it is 34000 km in China. Annual container handling capacity in India and China is 8.4 mn TEU and 60 mn TEUs respectively *(KPMG 2010).* Currently, the Indian government has adopted innovative measures to increase revenue in order to finance additional investment (and sought to attract more private sector investment), but still it will insufficient to meet growing transport demand. Indian labour laws are considered challenging, with vague guidelines for activities such as labour rights and protection, working hours, compensation, contracts, employment law, health and safety, freedom of Association and collective bargaining, discrimination, forced labour and of child labour. In terms of business environment risk, taxation policies are also important. In India indirect taxes are high which leads to higher manufactured product cost as compared to China. Custom collections as a percentage of total value of imports in India are 15% against 3% in China. Besides the multiplicity of rates and surcharges, excise duties and excise / sales tax rates varies from 25% to 30% against a simpler flat rate of 17% in China. Political instability and corruption are important factors affecting operations in several ways. In India corruption continues to be an issue. A weak legal framework and the low capacity of anti-corruption agencies have exacerbated the problem.

DISCUSSION AND CONCLUSIONS

As evidenced by the literature review, supply chain risks play a pivotal role in effective supply chain management and this is especially the case in a global context. Our focus rests on India, which, owing to its abundance of low cost labour, is becoming a global business hub. Any significant disruption in the supply chain adversely impacts the credibility and business potential of Indian industry. We have categorised and discussed various risks from exogenous to endogenous and rated them accordingly. We conclude that Indian companies are facing numerous supply chain-related risks. Many exogenous risks such as political, corruption, legal, cultural are beyond the control of any organization, meaning little can be done (especially in the short term) to mitigate these risks. However there is significant scope to develop strategies to mitigate endogenous and operational risks - such as increase privatization of transport sector, improve taxation policies to make it more even from state to state, promote increased use of 3PLs, implementation of latest IT tools across the supply chain, etc. Indian companies currently typically have low logistics performance due inefficiency in logistics services. However in the 2010 LPI, India did score highest among the low-income group countries. India's expenditure in logistics activities (approximately 13 % of GDP) is higher than that of developed countries *(World Bank 2011)*. A key reason is the relatively high level of inefficiency in the system with lower average trucking speeds, higher turnaround time at ports and high cost of administrative delays. Of particular note is that 3PL service provision is still at the nascent stage. Increased outsourcing of logistics services could lead to supply chain performance improvements.

By addressing the area of supply chain risks, the accompanying disruptions can be either anticipated or avoided. Therefore we propose a theory-driven empirical research approach *(Amundson, 1998)* to examine supply chain failures and recommended risk mitigation strategies based on the available literature. Although several papers have investigated supply risk mitigation strategies (e.g. *Zsidisin et al, 2004; Christopher and Peck, 2004; Harland, 2003; Christopher and Holweg, 2011),* there appears to be a lack of research in an Indian context. Furthermore there is little evidence to evaluate the degree of risk a company is exposed to by dealing with domestic Indian suppliers (many of whom are inexperienced in global business) and to formulate risk mitigation strategies to overcome these challenges. Modern supply chains need to be responsive and efficient. If a company's supply chain is responsive it means it is capable of meeting customers' needs in a timely fashion. Efficient supply chains enable firms to deliver service at the lowest possible cost, directly affecting company profitability. A supply chain can face many types of risk such as disruption of supply, quality issues, technology uncertainty, breakdowns, technology change, introduction of new product, IT security, governmental, business & economic, social and environmental, etc. A proactive approach to risk mitigation planning assists managers in coping with unexpected losses caused by unexpected events. Supply risks vary from industry to industry. Foreign companies doing business in India must consider India´s social economic, political and legal framework in order to access and successfully deal with future supply chain risk. As discussed, in India these supply chain-related risks are currently multifaceted. Additionally, in the Indian logistic sector deals are often done via informal channels. In many cases suppliers are motivated and well trained to deliver goods on time but their efficiency is hampered by a lack of adequate facilities to deliver goods. Take for example the fruit and vegetable business. The supplier may ship the required amount of product as specified but the main problems arise with distribution: In India there is still a lack of refrigerated trucks and significant amount of product continues to be transported by hand-pulled carts. Every year millions of dollars of product spoils because of this inefficient system. Hence it is extremely important to consider overall logistic infrastructure in addition to risk imposed by suppliers. It has been observed that SCRM practices in India are generally viewed as informal and reactive. The question remains as to why SCRM is not a high priority in Indian organizations. With an increasing level of activity by MNCs in India, Indian firms are beginning to realise the importance of SCRM as a way of helping them compete at a global level.

FUTURE RESEARCH AGENDA

In terms of future research, a thorough classification of Indian supply chain risks based on their intensity and level (strategic, tactical and operational) should now be carried out. The supply chain risk assessment could be based on their implications ('intensity') for doing damage (ranging from minor to radical and through to irrecoverable). For example all strategic changes are top level risk because a company's senior executive makes and implements a company's strategy based on which their company operates in the market. The intensity of supply risk can be defined as *minor* if there is a slight deviation in the company's strategy; *radical* if there is disruption at a strategic level (across the supply chain) and *irrecoverable* if there is a strategic 'disaster'. Top level supply risks are considered uncontrollable because a company implements strategic decisions with a long term perspective. Similarly, middle level risks are related to tactical changes and day to day risks are related to operations. Day to day supply risks are considered controllable because operations are implemented from a short term perspective. Middle level supply risks are somewhere in between. The research reported in this paper is limited to the available literature on SCRM and their mitigation strategies. A holistic conceptual model should be developed for supply chain risk assessment for Indian companies. The aim would be to discuss various supply risks, especially relevant to the Indian business environment and review the scope for future improvement. In terms of inbound risk it would be useful to focus on the types of suppliers used. For example a government supplier, monopoly suppliers, multiple and single sourcing suppliers, local and foreign suppliers, etc. In this way a more in depth picture of the differing requirements by type of suppliers would emerge, providing the foundations for greater transparency and improvement in SCRM.

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SECURING PROFITABILITY IN TURBULENT TIMES – INITIAL WORK ON A CONCEPT FOR REDUCED DEMAND VARIABILITY AND INCREASED SUPPLY CHAIN FLEXIBILITY IN THE CHEMICAL INDUSTRY

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INTRODUCTION

After the global economic downturn, many chemical companies are enjoying a return to profitability. However, at the same time the chemical industry is still facing a variety of challenges. Competitive pressure has intensified dramatically, customer requirements in terms of availability, flexibility and reliability have increased, lead times and logistics costs are rising. In response, a growing number of chemical companies are focusing on supply chain management. They have learnt that they need to continuously improve their supply chain performance to remain competitive. There is one development, however, that keeps threatening supply chain and financial performance alike: the high levels of volatility the industry is exposed to. Feedstock prices as well as demand volumes have seen severe instability during and after the world economic crisis. Opportunistic buyer behavior is complicating the situation in many chemical supply chains even more.

In this volatile environment, the chemical supply chain – once deliberately designed to achieve top performance under stable demand conditions – has come under pressure. Its supply chain focus on efficiency is increasingly posing a threat to firm profitability in times of high market volatility. The production system that has been built on economies of scale and closely interlinked production processes and stages, fails to fully cater for the conditions of the industry's "new normal". Sustainable success and profitability more and more depend on the ability to manage volatility in order to successfully meet customer demand. We will identify actionable strategies and approaches for the chemical industry to reduce demand variability and increase supply chain flexibility.

METHODOLOGY

Aim of this paper is to identify strategies for chemical companies to counteract demand volatility. Central basis of our investigation is the demand management process that has been mentioned as one of eight essential supply chain management processes by Croxton et al. (2001). Demand management is defined as: "the supply chain management process that balances the customers' requirements with the capabilities of the supply chain. […] The process is not limited to forecasting. It includes synchronizing supply and demand, increasing flexibility, and reducing variability" (Croxton et al., 2002, p. 51). While a lot of research has been centered on more accurate forecasting, little attention has been given to the other demand management aspects, especially in asset intensive industries. We will mainly look at strategies to synchronize supply and demand in turbulent times by increasing supply chain flexibility and reducing demand variability.

Following contingency theory, a fit between flexibility need (demand variability) and flexibility potential (capabilities of the supply chain) has to exist for optimal supply chain performance. Figure 1 shows this graphically. Due to increased uncertainty and demand variability, the efficient supply chain strategy most chemical manufacturers are applying has moved out of the lower left "fit area" (low demand variability, low flexibility) indicated in matrix (a) into a "non-fit area" (medium to high demand variability, low flexibility) indicated in matrix (b). Non-fit areas are characterized by suboptimal performance levels. To move back to a state of high performance, either demand variability has to be reduced or more flexibility needs to be incorporated into the supply chain. These two strategic options are indicated in matrix (c).

This paper represents the first part of a more comprehensive research project. In the next project phases the identified strategies will be assessed for their applicability in specific case study supply chains. Appropriate strategies will be prioritized according to the strategic fit with the business unit's general and supply chain strategies, the ease for implementation as well as the expected potential of an implementation. A short-list of applicable measures and strategies will then be proposed for implementation. An implementation concept will be developed and expected contributions will be shown.

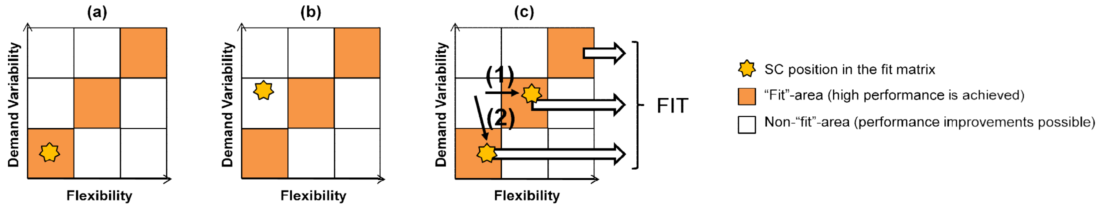


Figure 2: Achieving fit between flexibility potential and flexibility need

THE CHEMICAL SUPPLY CHAIN

The chemical industry is one of the world's key industries. Global chemical product sales in 2010 were worth 2,353 billion Euros (CEFIC 2011). The industry converts raw materials into more than 70,000 end products. These products can be grouped into basic chemicals, polymers, specialty and performance products, industrial gases, and agrochemicals (Hofmann/Budde, 2006).

Chemical companies have traditionally focused on manufacturing productivity. However, profitability in the chemical industry has come under pressure from both, falling prices and rising costs (Cappello et al., 2006). Challenges are posed from a variety of sources: from global competition and an increasingly global customer base, increased customer requirements, from volatile feedstock prices, rising logistics costs and increasingly complex operations (Mawet/Frisby, 2009). In this environment, supply chain management has been recognized as an important driver of competitive advantage. With all this increased importance in the industry, research in chemical supply chain management has also received increased attention. While some aspects of supply chain management in the chemical industry have been intensively studied, mainly the areas of operations management and production logistics (e.g. Loos 1997) as well as supply chain planning (e.g. Kannegiesser 2008), demand management is a topic with very little coverage in the academic literature.

According to Fisher (1997) there are two generic forms of supply chain strategies, namely the efficient and the customer responsive supply chain strategy. The efficient supply chain is catering for functional goods that are characterized by stable, predictable demand, long product life-cycles, low product variety, and rather low margins. Primary purpose of the efficient supply chain strategy is to supply predictable demand at the lowest possible cost. Innovative products are characterized by unpredictable demand, short life-cycles, high product variety, and high margins. Supply chains for innovative products therefore focus on responsiveness, rather than on costs.

The chemical industry with its large-scale facilities, complex and interlinked production processes and stages is a typical example of the former. Producing huge volumes at few large chemical plants helps exploiting economies of scale and minimizing resource consumption. All of this makes perfect sense as long as demand is predictable, but poses significant challenges in times of economic turbulence. There are attempts of chemical companies to increase the flexibility of their manufacturing networks, but changing production processes and chemical plants that are built to last for decades is a very long-term approach. We will be focusing on aspects of demand management that are implementable in the short- and medium-term.

A NEW ERA OF VOLATILITY

The above described stable system of the chemical supply chain is faced with increasing volatility. The industry has managed to master prior economic turbulences quite well. However, there is a difference to previous crises this time. The "supply chain volatility index" by Christopher/Holweg (2011) shows that the levels of volatility are far higher than in prior crises. It is at the same time not just volatility in the price of oil, but volatility in many key business parameters (e.g. exchange rates, interest rates, raw material prices, transportation costs, and stock markets) that is driving this general turbulence and it is expected that we are not just facing a temporary shock but are entering a new "era of volatility".

This general market observation holds true for the chemical industry as well. Most chemical companies have seen demand return to pre-recession levels by 2011. Volatility and uncertainty, however, remain high. A recent study identified the industry as generally relatively weak in the area of supply chain agility. The industry's mean score in this agility index was in the poor-to-moderate range (Fenton, 2009). This poses a significant threat to the industry as volatile supply costs and volatile sales turnover, if not managed properly, translate into profit volatility with all its negative valuation effects (Kannegiesser, 2008). In the current era of volatility, successful companies will be those that have the tools and skills to respond to the challenges ahead. We have identified demand management as an important capability in responding to these challenges. The next session will give a short overview on existing research in this field.

DEMAND MANAGEMENT OVERVIEW

Demand management is more and more recognized for its importance in efficiently and effectively managing supply chains. In the wider demand management area, a considerable amount of literature exists in both, the academic and practitioner fields. It ranges from the early work on demand amplification by Forrester (1958) to more recent initiatives, like efficient consumer response (e.g. Corsten/Kumar, 2005) and continuous planning, forecasting, and replenishment (e.g. Seifert, 2004). However, most of this literature focuses almost entirely on the retailer-manufacturer link in supply chains. Research on demand management in the upstream part of supply chains, remains in its infancy. But especially there companies face a significant challenge: fragmentation and a commodity culture regularly leave these companies at the end of a long bullwhip. Thus, these primary producers are increasingly confronted with the challenge of balancing uncertainty in supply with growing uncertainty in demand (Taylor/Fearne, 2006).

DEMAND MANAGEMENT STRATEGIES

Often variability is seen as the enemy of planning. However, variability is inherent in nearly any business environment. To minimize the negative impact of variability, two things can be done: reduce variability itself or increase the flexibility to react to it. As Croxton et al. (2002, p. 62) state: "A key component of demand management is an ongoing effort aimed at doing both of it." Increased flexibility makes the firm responsive to internal and external events. Reduced demand variability helps reducing costs through consistent planning. Variability should first be reduced. Building flexibility into a system often involves considerable investments and operational costs; therefore only in a second step the unavoidable variability should be managed by flexibility. With increased demand volatility in nearly all segments of the chemical industry, synchronizing supply and demand has become a challenge.

Sharing information is a good starting point for improved demand management. There is, however, more to achieving excellence in this field. We will start our analysis with some measures that tend to improve information sharing. With increased levels of environmental uncertainty and the current rollercoaster demand patterns driven by the volatile world economy, additional measures are needed. We will look into the use of demand shaping techniques and supply chain flexibility.

Reduction of demand variability by information sharing

The bullwhip effect, as an important concept concerning demand variability has been studied intensively and strategies aiming at the reduction of the bullwhip effect have been formed (e.g. Lee et al., 1997). However, as Killingsworth (2011, p. 6) states: "The dynamics of supply chains and large supply networks are still not well understood and major inefficiencies are the costly result. As supply chains have become more global and increasingly complex, supply chain dynamics and the associated risks and costs plague companies around the world." Our own investigations have also shown that in many chemical supply chains the bullwhip effect is still posing a challenge. It therefore seems appropriate to start our analysis with approaches aimed at the reduction of variability through improved information sharing:

- **Vendor managed inventory (VMI)**: Exchanging information on inventory levels and sales is well suited to reduce demand variability. The VMI concept centers on the sharing of these types of information. Instead of ordering, the customer shares demand information with the supplier who is responsible for replenishment and to maintain predefined service levels (Angulo et al., 2004). Demand variability due to randomness is considerably reduced, since the demand that the customer faces is directly passed on to the supplier. Since replenishment is usually based on stable prices, any price-driven variability is also tackled by this concept (Poiger, 2010).

- **Collaborative planning, forecasting and replenishment (CPFR)**: CPFR goes further than VMI in sharing information among supply chain partners. It involves all members of a supply chain in jointly developing demand forecasts, production and purchasing plans, as well as inventory replenishments (Sari, 2008). While its implementation requires more intensive organizational resources than VMI, CPFR is expected to additionally reduce demand variability.

- **Supply contracts**: If central planning is not possible or not desired, supply chain coordination can occur by using of supply contracts. Reducing demand variability is possible by entering quantity flexible contracts. A variety of different types of these contracts exist (e.g. Tsay, 1999). In their general form they work as follows: Sales forecasts are provided by the customer. Supplier and customer commit themselves to provide / purchase the predefined amount +/- a predefined tolerance amount at a particular time in the future. Regarding demand variability it can be assumed that the customer places better forecasts with the manufacturer, leading to decreased forecast errors (Poiger, 2010).

- **Price discounts**: Under the rolling horizon plan, a special form of the quantity flexible contract, the supplier provides price discounts to the buyer for future time period orders. As time progresses, further orders are allowed, but an additional cost has to be paid for the increased units (Lian/Deshmukh, 2009). Under such an agreement, order behavior can be influenced by the pricing component and orders may be shifted towards earlier commitment, thus decreasing forecast errors and reducing demand variability.

Reduction of demand variability through demand shaping

Information sharing is not the only way to deal with demand variability. In situations in which information sharing across supply chains is not feasible, influencing demand poses an opportunity to reduce variability and to better align supply and demand. The influencing of demand to match it with planned supply is generally known under the term demand shaping. At the strategic level, the emphasis is to match customers' demand patterns to long-term capacity constraints. At the tactical level, it centers on influencing customer demand towards available supply by the use of pricing, promotions and product bundling (Dey/Singh, 2007).

Especially the adjustment of prices appears to be a powerful steering mechanism for chemical companies in times of volatile demand. The beauty of this measure is that unlike many other strategies to align supply and demand, prices can be changed rapidly, and customer response thus influenced quickly (Zhang, 2007). Pricing approaches to match supply and demand usually fall under the concept of revenue management. It is concerned with optimal sales and demand decisions to achieve increased revenues (Tallury/Ryzin, 2005). For our purpose, especially revenue management's focus on estimating demand and using price control to manage demand is an interesting research area. Pricing mechanisms can be based on the analysis of demand patterns to ensure that available capacities can be used in the most profitable way (Kannegiesser, 2008). This can be done through the following two forms, dynamic pricing and auctioning:

- **Dynamic pricing**: Firms and individuals have always used price adjustments to market their products at a price as high as possible and yet acceptable for the buyer. Nevertheless, we are looking at the topic with a focus on actively responding to supply and demand pressures in real time. Dynamically adjusting prices can be a valid answer to this pressure (Sahay, 2007). Over the last years, advanced methods and software systems for dynamic pricing have been developed (Tallury/Ryzin, 2005). Therefore, this method seems to be able to strongly shape demand and aid in reducing demand variability.

- **Auctions**: Auctioning is another way to adjust prices dynamically. Here, however, the steering mechanism is given into the customer's hand. Generally, auctioning is a good way to reveal a customer's willingness to pay. Since the steering mechanism is given to an outside actor, its ability to actively shape demand is not given immediately. It could, however, lead to positive demand shaping outcomes in case of overcapacities. Dynamic auctioning where customers can bid on remaining capacity might be used (Tallury/Ryzin, 2005).

Demand shaping has not been incorporated on a broad basis yet. This is mainly due to immature pricing processes and the limited influence individual companies have in global supply chains (Dey/Singh, 2007). Additionally, in the chemical industry pricing has not been perceived as manageable, it has been mainly done reactively (Rüdiger et al., 2007). Nevertheless, first chemical companies have discovered the benefits of revenue management and its future relevance is assumed to be high (Kolisch/Zatta, 2009).

Supply chain flexibility

In a volatile environment we can assume that not all demand variability can be eliminated. To cater for the remaining variability, more flexibility can be incorporated into supply chains. Chemical companies that have previously aimed at order winning through low cost and standardized production, now increasingly face the need for supply chain flexibility (SCF). In this paper we define supply chain flexibility as a firm's "ability to respond to change without increasing operational and supply chain costs and with little or no delay in response time" (Simchi-Levi, 2010, p. 134).

Supply chain flexibility is more and more seen as a strategic capability. Accordingly, the topic has received increased attention from practice and academia. It has emerged from manufacturing flexibility which has been a hot topic especially in the 1980s and 1990s. From the beginning of this millennium on, the intra-firm view on flexibility has been extended to supply chain flexibility. A wide body of literature has been created since then. For an extensive literature review on the topic we refer to Stevenson/Spring (2007). What is often missing in the existing literature is guidance for the industry on how to incorporate SCF into their supply chains as well as empirical evidence on how SCF improves overall performance.

Forecasting and holding inventory might be the first logical reactions to increased demand uncertainty. But actually, they are limiting supply chain flexibility. Using standard forecasting approaches to predict short-term needs can easily lead to significant forecast errors. Inventory-based approaches very often are no option as they tie up too much capital and can even increase risk through obsolete inventory (Garber/Sarkar, 2007). We will focus on how supply chain flexibility can be used to respond to demand variability in the chemical industry. While flexibility of the entire supply chain is a result of the flexibility in all supply chain processes, our initial restriction was to exclude production processes and facilities and to center our attention on customer-facing activities. Aspects of supply chain flexibility focusing on manufacturing and supply processes will therefore be excluded from our analysis. The remaining SCF dimensions are grouped into the following strategies to increase flexibility: synchronizing the supply chain with market demand, improving capacity allocation and streamlining processes.

Synchronizing the supply chain with market demand

- **Pull-based replenishment**: Reactive inventory and replenishment techniques improve SCF by synchronizing production processes with real market demand. Buffer inventories at different stock points are replenished based on demand. Shipments and production are stopped once preset inventory levels are reached. By doing so, the right products are produced based on actual demand. Both, production and logistics are freed up from managing products that are not demanded and therefore are able to respond faster to real changes in demand (Garber/Sarkar, 2007). Tichon/Fumero (2010) describe the use of the following pull planning techniques to replenish inventory at a chemical firm: Kanban is responsive and used to replenish materials in multiples of a fixed quantity. This approach provides self-management and flexibility. Where variability is too high for Kanban, re-order points are used. This technique is also responsive, but just uses one re-order quantity. For very low-volume products with high demand variability, campaign management can be used. For special products make-to-forecast and make-to-order are used. While these techniques are not incorporating information sharing with the customer, the next concepts do.

- **Information sharing**: Sharing real-time information between firms can improve flexibility by giving firms superior visibility and time to respond to change. Many companies have invested in expensive ERP systems to streamline internal processes, but fail to extend these systems to their supply chain partners where approximately 80 percent of the information needed to orchestrate the supply chain lies. Tighter collaboration, the use of VMI and CPFR as well as the application of state-of-the-art technologies, such as cloud information platforms, allow visibility into real-time sales-order and inventory data (Garber/ Sarkar, 2007; GT Nexus, 2011). In order to commit to information sharing, trust and collaboration needs to be improved.

- **Collaboration and strong buyer-supplier relationship**: Close relationships increase the willingness to share information and cope with change and thus provide one dimension of flexibility (Stevenson/Spring, 2007). Centralized decision making as for example through VMI has benefits, as described above, but from a supply chain dynamics perspective, nothing fundamental is changed. Still two decisions are made individually from each other at the supplier: replenishment decisions and production decisions. The next step is to fully synchronize demand with the supplier's own production and inventory control process to increase SCF and reduce lead time. However, even with sophisticated CPFR systems, few companies have been able to exploit these advantages. Large suppliers find difficulties to benefit from this tight collaboration. In the case of centralized manufacturing, collaboration benefits often are diluted. Synchronizing demand from many local sources with global production easily results in friction losses and information mismatch. Geographical distortion is another limiting factor. The more nodes there are between supplier plants and customer sites, the higher the effort to synchronize the individual supply and demand patterns and managing inventory pipelines with long lead times is a challenge for joint inventory control. The ability to fully synchronize supply chains also depends on the characteristics of product demand. In case of seasonal or weather-dependent demand, synchronization might be also very difficult to realize (Holweg et al., 2005).

The above detailed concepts behind supply chain synchronization are simple and powerful, but they are not broadly implemented in the industry (Holweg et al., 2005). Information sharing can be a challenge as supply chain partners often have differing interests in the short term. Full synchronization is difficult to implement for supply chains with long lead times and volatile demand. The next strategic approaches will aim at increasing flexibility by reducing the response time to changed demand, either through flexible allocation of capacity and / or responsive processes.

Reducing cycle time through flexible capacity allocation

- **Customer segmentation**: Supply chain segmentation describes how a given market can be divided into different customer groups that share similar needs (Harrison/van Hoek, 2008). Its goal is to find the appropriate supply chain processes and policies to meet each customer segment's needs while maximizing customer service and profitability (Thomas, 2012). Using customer segmentation can reduce the impact of demand variability on the supply chain and increase its responsiveness at the same time. Resources are freed up from standard demand in peak times and allocated to those customer segments that require (and pay for) increased flexibility.

- Outsourcing: Outsourcing reduces the own need for flexibility. In times of excess demand, the contract manufacturer's capacity can be used or the production of goods with high demand variability can be completely outsourced. Using contract manufacturers can also help reducing cycle time by moving production closer to customer plants (Garber/Sarkar, 2007). Contract manufacturing is specifically important in the pharmaceutical chemicals and agrochemicals segment where it represents major parts of the manufacturing capacity (Lambert, 2008). Logistics service providers are another lever for increased supply chain flexibility. Negotiating flexible contracts regarding transportation and warehousing capacities can significantly speed up distribution processes (Reichhart/Holweg, 2007).

- Capacity swaps: Swapping capacities between competitors is another strategy to potentially improve demand response. Two firms producing the same commodities in geographically distant locations can swap their capacities. Under such an agreement , e.g. firm A with a European plant uses firm B's US plant to cover its own US demand. With shorter lead-times, response to demand changes can be improved. Swapping production capacity is most common in the electricity, oil and gas industries and is also applied by chemical firms (Kosansky/Schaefer, 2010).

- **Shared resources**: The idea behind shared resources is similar to capacity swaps, but more internally focused. The benefits of risk pooling can be applied by aggregating and re-distributing resources from an under-loaded to an over-loaded site to cope with demand fluctuations across the group (Stevenson/Spring, 2009).

- Network design audit: To ensure that the supply chain network is set up to move goods as quickly and flexibly as demanded, supply chains should be periodically redesigned. Based on strategic objectives and major developments in the business environment, decisions on plant and warehouse locations, transportation modes and distribution channels need to be made. (Garber/Sarkar, 2007).
- **Standardization**: Being able to reconfigure the supply chain is a vital aspect of flexibility. Barriers to reconfiguration exist through extensive approval processes, tacit knowledge of production processes, misaligned IT and traditionally stable and long-term supply chain relationships. Standardizing approval processes across the industry, standardized knowledge management processes, and using web-enabled EDI systems can help to reduce some barriers of supply chain reconfiguration (Stevenson/Spring, 2009).

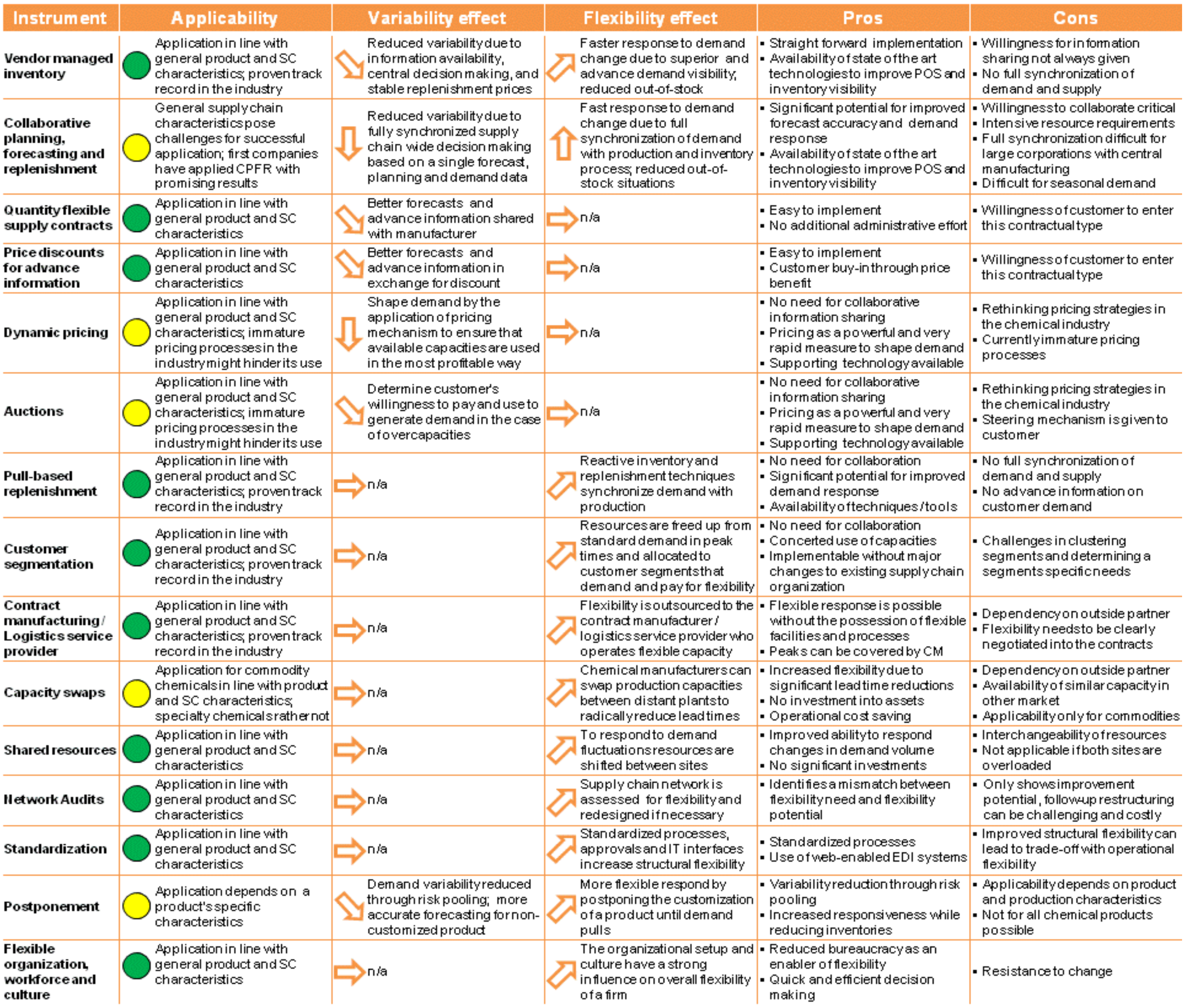
Reducing cycle time through streamlined processes and organization:

- Product design: Product architecture determines to a large extent where the decoupling point can be placed and thus how responsiveness can be achieved (Reichhart/Holweg, 2007). While involvement of customers in the product design phase as well as the use of modular design are important levers for flexibility in discrete industries, no immediate translation of these concepts to the chemical industry are seen. The ability to apply product postponement in the chemical industry depends very much on the specific characteristics of the product and production processes. Rietze (2004) gives an example of a PVB (polyvinyl butyral) supply chain that applies product postponement to answer to volatile local demands.

- Organization and culture: The amount of flexibility that a specific node in the supply chain can achieve also depends on the flexibility of its workforce and organizational structure, business practices and culture. Deep organizational hierarchies can hinder flexibility (Duclos et al., 2003) and layers of bureaucracy slow down communication between departments. What is needed is a culture and organizational setup where the organization, operational procedures, performance measures, and even office layouts are designed to enhance quick and efficient decision making and transaction processing is simplified (Ferdows et al., 2004).

DEMAND MANAGEMENT STRATEGIES FOR THE CHEMICAL INDUSTRY

We have identified a number of demand management strategies based on literature reviews and interviews with industry experts. These strategies have been assessed for their applicability in the chemical supply chain. Figure 2, shows a summary of the estimation of their effects on variability reduction and flexibility increase, as well as their potential benefits and challenges as demand management instruments.



Instrument	Applicability	Variability effect	Flexibility effect	Pros	Cons
Vendor managed inventory	🟢 Application in line with general product and SC characteristics; proven track record in the industry	⇘ Reduced variability due to information availability, central decision making, and stable replenishment prices	⇗ Faster response to demand change due to superior and advance demand visibility; reduced out-of-stock	▪ Straight forward implementation ▪ Availability of state of the art technologies to improve POS and inventory visibility	▪ Willingness for information sharing not always given ▪ No full synchronization of demand and supply
Collaborative planning, forecasting and replenishment	🟡 General supply chain characteristics pose challenges for successful application; first companies have applied CPFR with promising results	⇩ Reduced variability due to fully synchronized supply chain wide decision making based on a single forecast, planning and demand data	⇧ Fast response to demand change due to full synchronization of demand with production and inventory process; reduced out-of-stock situations	▪ Significant potential for improved forecast accuracy and demand response ▪ Availability of state of the art technologies to improve POS and inventory visibility	▪ Willingness to collaborate critical ▪ Intensive resource requirements ▪ Full synchronization difficult for large corporations with central manufacturing ▪ Difficult for seasonal demand
Quantity flexible supply contracts	🟢 Application in line with general product and SC characteristics	⇘ Better forecasts and advance information shared with manufacturer	⇨ n/a	▪ Easy to implement ▪ No additional administrative effort	▪ Willingness of customer to enter this contractual type
Price discounts for advance information	🟢 Application in line with general product and SC characteristics	⇘ Better forecasts and advance information in exchange for discount	⇨ n/a	▪ Easy to implement ▪ Customer buy-in through price benefit	▪ Willingness of customer to enter this contractual type
Dynamic pricing	🟡 Application in line with general product and SC characteristics; immature pricing processes in the industry might hinder its use	⇩ Shape demand by the application of pricing mechanism to ensure that available capacities are used in the most profitable way	⇨ n/a	▪ No need for collaborative information sharing ▪ Pricing as a powerful and very rapid measure to shape demand ▪ Supporting technology available	▪ Rethinking pricing strategies in the chemical industry ▪ Currently immature pricing processes
Auctions	🟡 Application in line with general product and SC characteristics; immature pricing processes in the industry might hinder its use	⇘ Determine customer's willingness to pay and use to generate demand in the case of overcapacities	⇨ n/a	▪ No need for collaborative information sharing ▪ Pricing as a powerful and very rapid measure to shape demand ▪ Supporting technology available	▪ Rethinking pricing strategies in the chemical industry ▪ Steering mechanism is given to customer
Pull-based replenishment	🟢 Application in line with general product and SC characteristics; proven track record in the industry	⇨ n/a	⇗ Reactive inventory and replenishment techniques synchronize demand with production	▪ No need for collaboration ▪ Significant potential for improved demand response ▪ Availability of techniques / tools	▪ No full synchronization of demand and supply ▪ No advance information on customer demand
Customer segmentation	🟢 Application in line with general product and SC characteristics; proven track record in the industry	⇨ n/a	⇗ Resources are freed up from standard demand in peak times and allocated to customer segments that demand and pay for flexibility	▪ No need for collaboration ▪ Concerted use of capacities ▪ Implementable without major changes to existing supply chain organization	▪ Challenges in clustering segments and determining a segments specific needs
Contract manufacturing / Logistics service provider	🟢 Application in line with general product and SC characteristics; proven track record in the industry	⇨ n/a	⇗ Flexibility is outsourced to the contract manufacturer / logistics service provider who operates flexible capacity	▪ Flexible response is possible without the possession of flexible facilities and processes ▪ Peaks can be covered by CM	▪ Dependency on outside partner ▪ Flexibility needs to be clearly negotiated into the contracts
Capacity swaps	🟡 Application for commodity chemicals in line with product and SC characteristics; specialty chemicals rather not	⇨ n/a	⇗ Chemical manufacturers can swap production capacities between distant plants to radically reduce lead times	▪ Increased flexibility due to significant lead time reductions ▪ No investment into assets ▪ Operational cost saving	▪ Dependency on outside partner ▪ Availability of similar capacity in other market ▪ Applicability only for commodities
Shared resources	🟢 Application in line with general product and SC characteristics	⇨ n/a	⇗ To respond to demand fluctuations resources are shifted between sites	▪ Improved ability to respond changes in demand volume ▪ No significant investments	▪ Interchangeability of resources ▪ Not applicable if both sites are overloaded
Network Audits	🟢 Application in line with general product and SC characteristics	⇨ n/a	⇗ Supply chain network is assessed for flexibility and redesigned if necessary	▪ Identifies a mismatch between flexibility need and flexibility potential	▪ Only shows improvement potential , follow-up restructuring can be challenging and costly
Standardization	🟢 Application in line with general product and SC characteristics	⇨ n/a	⇗ Standardized processes, approvals and IT interfaces increase structural flexibility	▪ Standardized processes ▪ Use of web-enabled EDI systems	▪ Improved structural flexibility can lead to trade-off with operational flexibility
Postponement	🟡 Application depends on a product's specific characteristics	⇘ Demand variability reduced through risk pooling; more accurate forecasting for non-customized product	⇗ More flexible respond by postponing the customization of a product until demand pulls	▪ Variability reduction through risk pooling ▪ Increased responsiveness while reducing inventories	▪ Applicability depends on product and production characteristics ▪ Not for all chemical products possible
Flexible organization, workforce and culture	🟢 Application in line with general product and SC characteristics	⇨ n/a	⇗ The organizational setup and culture have a strong influence on overall flexibility of a firm	▪ Reduced bureaucracy as an enabler of flexibility ▪ Quick and efficient decision making	▪ Resistance to change

Figure 3: Initial analysis of the applicability of demand management measures

CONCLUSION

It has been shown how demand management can be improved by reducing demand variability and increasing supply chain flexibility. Reducing variability is generally possible by the two levers information sharing and pricing. Flexibility can be increased by reducing cycle times and by synchronizing the supply chain with market demand. Measures aiming at improved visibility through collaborative information sharing are expected to have strong effects on improved demand management, both through variability reduction and increased flexibility. Increased collaboration is, however, not always feasible in the chemical industry with commodity characteristics and opportunistic buyer behavior in many of its segments. It has been shown that a number of additional instruments are available. Demand shaping seems to have a high potential for success, once more sophisticated pricing processes are implemented. Additionally, many instruments that can be implemented without extensive customer collaboration seem promising to both reducing variability and increasing flexibility.

Further research in this area is needed. In a next step, the identified instruments will be tested for their applicability and contribution in a number of in-depth case studies.

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AIRCRAFT PRODUCTION RAMP-UPS – A SUPPLY CHAIN RISK MANAGEMENT STUDY

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1 INTRODUCTION

Today Aviation news frequently report on delayed or even failed aircraft ramp-ups, even for the market leader Airbus and Boeing. The successful ramp-up of commercial aircraft is threatened by a variety of risks which cause reductions in targeted production rate (see Figure 1). Exploding costs are the result.

The growing competition and a shorter innovation cycle lead to a rising number of ramp-ups. Besides the complexity of the aircraft itself future ramp-ups face further challenges. The here examined aircraft manufacturer and the Boeing 787 program (Sodhi and Tang, 2012) follow an outsourcing strategy of manufacturing and development capabilities. Hence, supply chain partners are heavily challenged in ramp-up, too.

Manufacturing of airplanes is characterized by low-volume and highly customizable products. Thus, they belong to small series production whereas automobiles are manufactured typically in big series production aircraft. We focus on the challenges which are set by small series production in ramp-up. The occurring risks are by no means comparable to automotive ramp-up scenarios. Consequently, a different view on risk management is required.

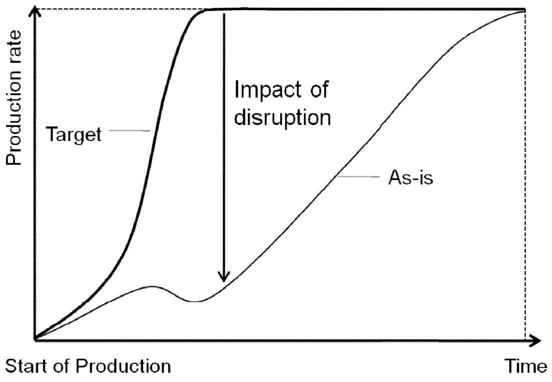

Figure 4: Reduction of production rate caused by risks (original idea see Haas and Romberger, 2005)

The aim of this study is to demonstrate the need for new mitigation strategies and identify strategies to mitigate ramp-up risks in the sector of commercial aircraft. Therefore we use a conceptual framework which is applied on an aircraft programme in ramp-up.

The paper is organised as follows: The general approach of the proposed framework is described in section 2. In section 3 we discuss the application of the framework on an aircraft ramp-up case study illustrating practicability and key features. Finally, we state results in section 4 and draw a conclusion.

Literature on ramp-up so far has focused mainly on the automotive industry (compare Straube and Fitzek, 2004; Risse, 2003; Fitzek, 2006). A holistic supply chain analysis for aircraft in ramp-up does not exist. An interesting analysis offer Sodhi and Tang (2012) analyzing exclusively development risks in the supply chain of the Boeing 787. Their approach is related to our supply chain context but they follow an automotive perspective. Lu et al. (2007) discuss the customization in large assembly manufacturing with supply-chain perspective which can be applied on ramp-up of commercial aircraft.

2 RISK MANAGEMENT APPROACH

Risk can be seen in several ways. For us risk is negative deviation from normal and is therefore a possibility of danger, loss, or any other undesired consequence (Harland et al., 2003). A disruption to the supply of services or goods leads to a failure to satisfy customer requirements and usually to longer lead times (Zsidisin and Ritchie, 2008).

Long lead times have negative effects on a firm’s performance. In our case a disruption leads to a delayed shipment of the finished aircraft.

Mitigation means to lessen the impact and the occurrence of disruptions. Sodhi and Tang (2009) provide a simple supply chain risk management approach showing the effect of disruption preparedness and the benefits of quick response. In this paper a structured approach is followed for supply chain risk management. Supply chain risk management can be applied to analyse risk during ramp-up since part or all of a supply chain are examined during this phase including its members and flows (product and information).

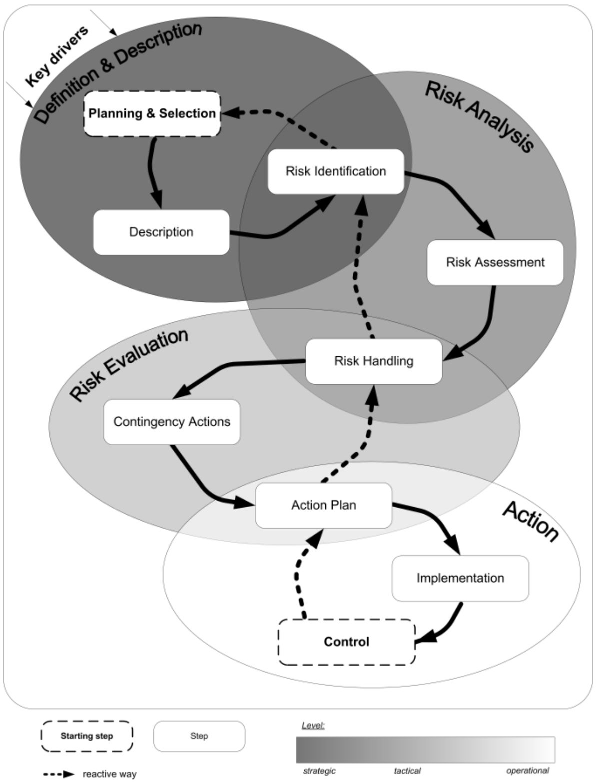

Figure 5: Applied framework for risk management (Weishaeupl, 2011)

The main tasks of supply chain risk management are usually split into at least three stages: risk identification, risk assessment and risk mitigation. In literature there are many different approaches which can be clustered into two different groups. One group uses feedback loops; the other does not. Weishaeupl and Jammernegg (2010) highlight that the framework is beneficial to increase the responsiveness of supply chains being disturbed by disruptive events.

The applied framework (see Figure 2) of Weishaeupl (2011) is motivated by the Deming (plan-do-check-act). The execution of the framework can be done in a proactive way, to be prepared for risks, as well as a reactive way, to handle unforeseen risks. This raises the attractiveness to apply it on the ramp-up of commercial aircraft. Furthermore, it is bolstered with a kit of supply chain risk management analysis methods like process, quality, risk and strategic management.

The framework consists of four overlapping cycles: Definition & Description, Risk Analysis, Risk Evaluation and Action. They are linked with management levels and time horizons, i.e. strategic level/long-term, tactical level/medium term and operational level/short-term. These overlaps provide the user with the ability to go back if something has to be adapted to new environmental situations. During ramp-up unforeseen disruptions occur frequently (Lanza, 2004). The cyclic framework supports fast reactions to lessen the negative impact of disruptions as the risk management process does not have to start from the beginning. The approach includes two main starting points. One is situated in the topmost cycle for proactive supply chain risk management, and the other in the bottom cycle for reactive supply chain risk management.

3 PHASES OF RISK MANAGEMENT AT THE EXAMPLE OF AN AIRCRAFT RAMP-UP

The analyzed good is an aircraft within the ramp-up. The scope of the analysis is limited within the boundaries of the organization. The aircraft manufacturer works in an international environment and has multiple suppliers and customers. These facts lead to a complex supply chain structure.

In general, ramp-up marks the phase of transition between product development and the maximum capacity utilization. To concretize this broad definition we define the term as the period between the release of pilot production and the achievement of stable production in terms of cost, quality, time and output targets. (Fitzek, 2006)

3.1 Definition & Description and Risk Analysis cycle

The aim of the first two steps (Definition & Description and Risk Analysis) is to define the scope of analysis by selecting the examined goods and processes as well as to describe them. Furthermore, the key performance indicators are applied to evaluate the risks and assign which risks are acceptable or intolerable.

The identification of risks is in our case achieved by using expert knowledge (brainstorming and questionnaires), fishbone diagrams and on-hand information search, i.e. literature research and past experience. The risks are classified by following the criterion "point of origin" used by Christopher and Peck (2004). The groups were adapted to our setting. The three risk categories are called internal risks, network risks and environmental risks. Risks arising in the organisation and can be influenced are internal risks. Environmental risks have origins outside the organisation and cannot be controlled. Figure 3 gives an overview of these three risk categories and their corresponding subcategories. Since internal and network risks can be influenced by the organisation, further analysis will focus on them. In total 91 risks are identified. Internal risks comprise around 60% and contain seven subcategories.

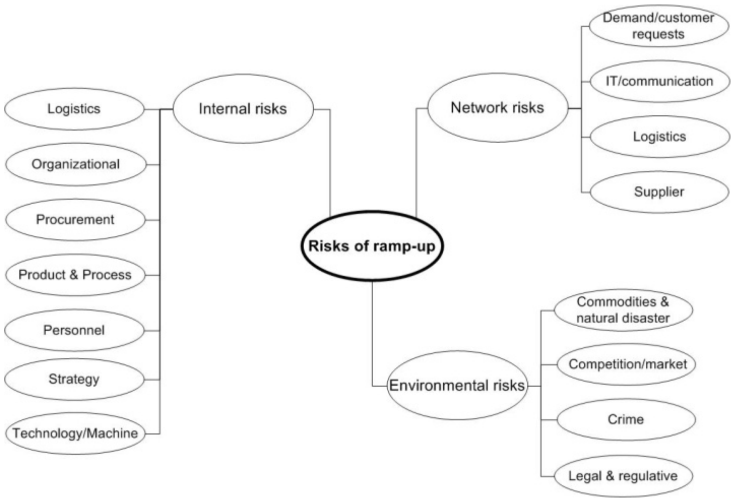

Figure 6: Risk catalogue

Risk Assessment evaluates the identified risks with respect to several characteristics in a quantitative or qualitative way. For assessing the risks two techniques are used, bi-criteria analysis (see Haimes et al., 2002) and failure mode effect analysis (FMEA) by asking experts of the organisation. The bi-criteria analysis gives an initial view of the examined characteristics. FMEA is used to assess the risks in a more systematic way. Risks can be classified into A-, B-, C- and D-risks, with A-risks being the most severe and D-risks being minor.

Then Risk Handling ranks the identified and assessed risks by the risk priority number motivated by the FMEA and compared with the findings of the bi-criteria analysis**.** Table 1 presents the top risks assessed by risk priority number, being the product of the factors occurrence, impact and detection. Among the top five risks are four internal risks and one network risk. The highest risk, insufficient production tests, belongs to the subcategory "product & process". The top four ranked risks lead to late modification at components which are developed and/or produced by suppliers.

Ranking	**Risk**	**Category**
1	Insufficient production tests	Internal
2	Extraordinary customisation requests	Network
3	Insufficient supplier integration	Internal
4	Insufficient maturity management	Internal
5	Insufficient change management	Internal

Table 2: Identified top risks ranked by risk priority number

The next two cycles of the framework analyse how the assessed risks are mitigated in the challenging environment of small series production. After explaining the upcoming steps of the cycle an introduction to characteristics of this industry will be given.

3.2 Risk Evaluation Cycle

The Risk Evaluation incorporates the further handling of the assessed and ranked risks. General mitigation strategies and tactics, which can arise from and affect all management levels, are formulated and finalized in an Action Plan utilizing the execution and/or costs perspective. This cycle builds an interface between design and implementation of risk mitigation strategies. Employee collaboration of planning and controlling is critical since both perspectives and considerations are taken into account.

Strategy	Tactic	Strategy	Tactic
Robustness	Avoidance	Flexibility	Multiple transport routes
	Demand management		Multiple sourcing
	Strategic stock		Multi-modal/carrier transport
	Multi-carrier transport		Contracts (Supplier)
	Postponement		Cross trained workers
Redundancy	Back-up capacity	Visibility	Collaboration
	Safety stock		Information Sharing
	Multi-modal / carrier transport		Tracking and Tracing
	Multiple sites		
	Multiple sourcing		

Table 3: General mitigation strategies and tactics (Weishaeupl, 2011)

The aim of the step Contingency Planning is the identification of mitigation strategies to lower the probability of risks or alternative actions after the occurrence of the negative event. In

Table **3** general mitigation strategies are displayed. Flexibility and redundancy are used likewise. Flexibility is the capability to adapt successfully to expected and unexpected disruptions, whereas robustness refers to the ability to endure such changes without adapting (Husdal, 2009).

In order to select the means of mitigation appropriately a further explanation of aircraft production and small series production is given. The automotive industry typifies big series runs with very high production rates, whereas aerospace or ships are examples of small series runs with low production rates but higher customization (Gienke and Kaempf, 2007; Lu et al., 2007).

Ramp-up preparation also differs with automotive using pre-series, zero-series and try-outs. All these tests contribute to a steep ramp-up after start of production with a high product quality (Risse, 2003). Product modification can be implemented in an early stage and all manufacturing processes can be optimized together with all supply chain partners. Due to the value and size of an aircraft complete production tests are not carried out. Digital and physical mock-ups are beneficial, but do not offer the advantages of physical testing. The cable problem in the airbus A380 sets a good example (Metzner and Wintzenburg, 2006). It shows that not all flaws are discovered in simulation regardless of number of successful cases, and results in massive rework due to late modifications identified in the phase of ramp-up.

Late modifications and belated development releases are among the top ranked ramp-up risks in automotive production, too. The costs for product change are 18% of the product development cost (Straube, F and Fitzek, D, 2004). Early results of our analysis proof that this figure is higher in aviation. The difference to aviation is that in automotive the demand for product modification is limited to the testing phase and the early ramp-up.

Optimal opportunities for product configuration of large integrated products like aircraft exist only in product design stages as Lu et al. (2007) states. Thus, another crucial challenge is extraordinary customer requests, especially for cabin equipment of airplanes. These solutions are not pre-configured and lead to late modifications. Even after achieving maximum capacity utilization in the serial phase, the degree of change for products and processes in aviation is higher than in automotive.

The above mentioned differences between big and small series production and the risk analysis prove that the supply chain requirements in ramp-up of an aircraft are different to the automotive industry. Hence, the comparison carried out by Sodhi and Tang (2012) between the supply chain of the Boeing 787 and Toyota is not in general appropriate.

First of all the tactic of avoidance is discussed. The reduction of complexity of product and processes is a possible approach even though limited in the field of aviation. Many issues of the customization requests can be eased by an enhanced configuration management. But still customer of a premium object will have customization requests extending the range of any catalogue or modularization concept. Since the demand for customization and modification is permanent, mitigation must be achieved by the enhancement of robustness in a proactive manner. Especially the ability to modify dynamically and respond quickly needs to be achieved by a supplier providing a component exposed to that risks (Lu et al., 2008). -

As Sodhi and Tang (2012) state a possible risk mitigation strategy is the selection of suppliers on technical capability and supply chain expertise. According to our analysis additional capabilities like change management need to be considered additionally. But unlike in big series production the capacities for change management (design changes due to errors and customization) need to be available beyond the time of production tests and early stages of ramp-up. Component characteristics like complexity, specification variability, and level of customization or standardization influence modifications. Thus, the performance of the supplier must match the characteristics of a component in order to produce economically.

Additionally, service level agreements (SLA) on the response time of the supplier on late modifications have to be clarified and evaluated. As mentioned in Sodhi and Tang (2012) 2nd and 3rd tier suppliers have to fulfill the SLAs as well since they significantly influence production rate during ramp-up. Therefore special incentives need to be created for the supplier. In an international supply chain with remote production facilities between supplier and the integrator it is crucial to guarantee quick response time for product changes and the final implementation in the physical product. In order to overcome geographical distances between production sites Rapid Manufacturing offers big advantages if critical items are missing. A tradeoff between higher production costs and cost of delays has to be considered. The RM process is useful in low volume production series and can produce parts from difficult to process materials such as titanium and ceramics (Santos, 2005) This method unifies several advantages. Parts can be made from different materials in the same machine. Certain methods can produce parts with chemistry, microstructure and mechanical properties that meet aerospace requirements (Arcella & Froes, 2000).

Portable units are possible so the machine can be moved in instances for risk mitigation (Taminger and Hafley, 2007). A disadvantage is that many of the machines are not capable of producing very large parts which can limit applications.

All the above mentioned risks in small series production result in a slow ascending learning curve for employees resulting in lower production rate than expected in the ramp-up as the Boeing 787 and the Airbus A380 prove (Figgen, 2009). Training of employees across the supply chain in case studies on ramp-up scenarios will be beneficial. Demand for flexibility concerning multi-sourcing or multi-modal/carrier transport was not identified in our study and eventually not considered here.

In the last step of the cycle the Action Plan identified mitigation strategies are evaluated with respect to their realizability. Therefore two perspectives are added to the contingency actions, execution and costs. For future analysis a framework for a predictive simulation is set up to evaluate the above mitigation measurements exposed to the analyzed risks proactive. The allocation of required ramp-up resources, e.g. for change processes and late modifications can be determined that way.

3.3 Action Cycle

The Action cycle deals with the implementation and control of the selected Action Plan and monitors arising disruptions. The positioning on the operational level indicates the executing, short-term, characteristic of the cycle. Besides, this feature highlights the reactive, event-related, style of the cycle. If an undesired event like a disruption occurs and cannot be handled appropriately the cycle may start and may go "up" to the Risk Evaluation cycle or further. The possible starting step Control indicates this characteristic.

4 RESULTS

The partial overlap of the cycles is proven to be successful in adapting the risk management in a quickly changing environmental like the ramp-up. This is of particular importance in the ramp-up of highly complex and customizable products like aircraft. Ramp-ups are not a common in the aircraft industry yet. So far products and processes achieve maturity late and customization is an ongoing challenge. Therefore the occurrence of risk needs to be reconsidered regularly which is supported by this framework.

Additionally, we show that ramp-up risks in aviation are not comparable to the automotive industry. Thus, the need for new mitigation strategies was proofed. Very promising concepts like rapid manufacturing and the selection of suppliers with ramp-up capabilities need to be evaluated. Therefore, the next step is to build up a simulation framework which simulates the identified ramp-up risks depending on the indicators impact and probability. The analyzed mitigation strategies will be evaluated by a cost and execution perspective which is provided by framework of Weishaeupl (2011). Successful evaluated mitigation strategies will be implemented finally in the Action plan.

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EVALUATING INVESTMENT RISK IN SUPPLY CHAINS: A MARITIME TRANSPORT PERSPECTIVE

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ABSTRACT

Global supply chains are large scale systems comprised of many suppliers and customers, production facilities and transport modes. Competition in the global marketplace puts pressure on supply chains to reduce both costs and risks. A significant aspect of risk management in supply chains is managing the financial risk of investment. In this context, this paper aims to examine the financial risk parameters for the maritime transport component of supply chains, In doing so the study explores the varying importance of a number of factors connected with the performance of bank loans for the purchase of new build and second-hand vessels. In this context, this paper aims to evaluate the performance drivers of shipping loans. Using a binary logit model it examines the criteria for assessing the security of shipping loans issued by banks. Thirty shipping loans made during the period 2005-2009 were analysed and the results suggest that the loan spread, the fleet leverage and the shipowner's experience are the best estimates for evaluating the performance of shipping loans.

1. INTRODUCTION

An important aspect for the efficiency of global supply chains is the availability of finance and the effective management of the financial risk of investment on behalf of the supply chain players. Maritime transport is vital for the existence of truly global supply chains as it carries approximately 90% of international trade (IMO, 2009). The long-term consequences of significant failure in financing would have significant effects on the supply chain. Shipping finance is a high-risk area due to the extremely volatile pricing swings in both freight rates and asset values and the lack of financial transparency in shipping companies. Bad investment decisions have detrimental consequences for both the financer and the ship owner, who can suffer significant losses, as well as for the shipping industry and more widely for the efficient function of supply chains, which may, for example, suffer from disruptions in their transport leg or run the risk of bearing additional costs being transferred to them as a result of such disruptions. The recent shipping crisis which began at the end of 2008 had a serious impact on both shipping players and the banking community. Bank lending became a scarce resource, the process of lending became more lengthy and more rigorous, and borrowers had to become more meticulous in their application for loans within a lenders market. Ultimately this process increases costs in the supply chain with inevitable consequences for both business and the consumer.

There has been little work undertaken on the implications of financial risk on the supply chain. The first stage in this process is to understand the factors which could have a bearing on this issue. Thus, this paper examines the role of certain determinants of shipping bank loans performance seeking to address the issue of credit risk and the probability of default of bank loans in the shipping industry. Thirty shipping loans made during the period 2005-2009 are examined. The period under examination includes peak and bust market conditions. Our results suggest that the loan spread, the fleet leverage and the shipowner's experience are the best estimates for evaluating the performance of shipping loans.

2. INVESTMENT RISK CRITERIA IN MARITIME TRANSPORT

Traditionally, ship owners would finance, to a smaller or greater degree, new investments from healthy cash-flows with the participation of a lending institution providing the remaining portion of necessary capital. Credit enhancement mechanisms are in place for banks looking to safeguard the security of the loan, typically a mortgage on the vessel. Capital intensiveness, high volatility in freight rates and prices, cyclicality, seasonality, strong business cycles and exposure to direct fluctuations of regional and global economies (Kavussanos and Visvikis, 2006a; Xu et al., 2011) create a risk-laden investment environment for banks. Shipping companies are faced with substantial operational business risks which result from great swings in freight rates, voyage and operating costs, all of which determine a venture's cash flow and have a profound effect on the company's operating profitability and loan repayment capability. Banks often have to deal with inadequate information on their clients' true assets and balance sheets, which blurs the picture of borrower's credibility, complicates the loan granting evaluation process and increases the uncertainty of loan repayment (Alizadeh and Nomikos, 2011, p.106). In the 2000s the experience of both the peak and the trough of a shipping cycle exacerbated the impact of the factors discussed above and have put more pressure on shipping finance and the parties involved. Heavy investment in new-build vessels at historically high levels in the booming period in the mid-2000s was followed by a sudden and great bust in 2008, which contracted severely the ship owners' income, had a detrimental impact on the liquidity of the sector and halted financing and investment. Currently such pressures are still on as the global recovery is uneven, slower compared to the recoveries that followed previous recent recessions, and challenged by the fragile conditions prevailing in most advanced economies (UNCTAD, 2010; 2011).

The underlying effect of all the above is for lending institutions to divert away from unnecessary risk and to exercise more rigorous discretion in respect of borrowers. This leads to the shrinkage of the number of banks involved in ship finance debt; a shrinkage of banks' shipping portfolios being judged as too risky, and; the use of rigorous formal rating schemes in the risk evaluation of shipping bank loans. Successful risk evaluation mechanism for shipping bank loans is essential. The appropriate tool encompassing the right criteria is crucial for banks making lending decisions, and it is also useful for ship owners wishing to enhance their borrower's profile and creditworthiness especially in an increasingly competitive financing context. This papers, therefore, focuses on certain criteria of credit risk analysis and examines their impact on the performance of shipping loans.

The potential for default by counterparties will give rise to a high level of credit risk for banks (Kavussanos and Visivikis, 2006a; b). When financial institutions make loans they are required to comply with regulations regarding their capital levels and credit policies. These regulations are known as the Basel II capital accord and provide banks with two options to assess capital reserves against default risk. Banks are required to use either an external credit rating system or their own internal credit evaluation in order to quantify the credit risk of the contemplated loan (Gupton G *et al*, 1997; Kavussanos MG, Tsouknidis DA, 2011). As Kavussanos and Tsouknidis (2011) highlight generally larger banks using internal credit evaluation tend to provide cheaper loans compared to smaller banks providing loans assessed against external criteria. The internal rating approach includes more diverse risk weights than external credit assessments and produces greater risk sensitivity. Thus banks are able to produce greater risk sensitivity calculations for individual loans. However, the credit rating system, in itself, only provides an ordinal ranking of the default likelihood across risk categories. Thus, a quantitative assessment will also have to be made of both the probability of default and the potential loss should a default occur.

Loan evaluation should not only analyse the client's financial capabilities, it should span a much greater range of issues. Grammenos (1977, 1979) introduced the five 'C's of credit in ship bank finance, later expanded to six 'C's (Grammenos, 2002). This credit analysis approach has been adopted by large financial institutions as an effective way of analysing credit risk. The six elements of credit risk are: **Character**: the expertise and credibility of the shipowner regarding, for example, investment, finance, chartering, risk management and creditors; **Company:** the ownership structure and chartering strategy of the company as well as its operating position and financial standing in the market; **Capacity:** the ability of the customer to comply with the terms of the loan under negotiation; **Capital:** the available capital of the company sufficient to meet its operating needs. Shipping companies require high levels of capital to place new-buildings and purchase second hand vessels. A higher level of capital investment by the shipowner will indicate both confidence in their own business, and the company's financial strength; **Collateral:** The composition of the company's fleet is important and diversified larger fleets will offer higher income security; and **Conditions:** the bank must understand the market in which the shipping company is operating including the international financial, political and economic environments. In addition the shipping company's earning capacity, financial status and position in the relevant shipping market are important considerations. The six Cs detailed thus provide factual evidence of the level of credit risk likely to be faced (Grammenos, 1977; 1979; 2002).

A wider literature on default risk for corporate credit loans has recognised the importance of a number of factors such as information asymmetry (Liao et al, 2009) and firm's financial structure (Bonfim, 2009). Dimitras et al (2002, p.237) argue 'most of the critical parameters in the credit granting decision in shipping industry are not quantitative measures but qualitative characteristics of the loan application under evaluation'. In the light of recent developments and trends, however, a greater emphasis is placed on the need for formality, uniformity and rigorousness. Suggestions include the introduction of an industry-wide model to cater for the variation in accounting systems, for example and measure creditworthiness among shipping interests has been put forward (Gray, 2000), or; internal benchmarking schemes being tied more to variables such as cash flows and less on the underlying asset (Measures and Rosa, 2004, p.102). The recent shipping crisis has had a serious impact on both shipping and the banking community. In the past, banks ideally looked for modern tonnage with low leverage, a good owner with a strong balance sheet plus a long time-charter to a quality charterer (Wilson, 2009). Yet, today, not only is lending scarce, but the process of lending can now take much longer because bankers have become more risk averse. In the past big family names were used as collateral (Anon, 2009), but banks are now much more selective and conservative (McGroarty, 2009). Corporate governance, transparency, and proper accounts are high on the wish lists of advisers and financiers (Anon, 2005).A study undertaken by Jimenez and Saurina (2004) which considered the default risk attributable to more than three million loans entered into by Spanish lending institutions, found that collateralised loans have a higher probability of default but that a closer bank-borrower relationship 'increases the willingness to take more risk'. In the study the focus was on whether the loan had defaulted or not and allowed for the direct testing of the relationship between explanatory variables and credit risk. Kavussanos and Tsouknidis (2011) have found that that the leverage ratio, the current ratio and the internal bank rating are able to explain around 18% of the observed defaults in shipping bank loans.

3. DATA DESCRIPTION

The dataset comprised 30 shipping loans from a shipping bank's portfolio over the period 2005-2009, of which 18 shipping loans were fully paid and 12 had problems in their repayment. The dependent variable reflects the repayment status of the shipping loan, 1 denotes the shipping loan with full repayment, and 0 denotes the shipping loans with repayment problems. We use ten independent variables divided into four categories of: Loan Nature, Borrower's Finances, Vessel Nature and Borrower's Reliability (Table 1).

4. EMPIRICAL RESULTS

This paper aims to evaluate the performance drivers of shipping loans. The dependent variable measures the performance of the shipping loan: 1 for the fully repaid shipping loans and 0 for the defective ones. The dependent variable is then regressed again the independent variable in four categories: Loan Nature, Borrower's Finances, Vessel Nature and Borrower's Reliability (Tables 1 - 4). Lastly, we choose the statistically significant variables in each category to run an overall regression (Table 5).

Table 1. Categories and variables for Loans

Category	Independent Variable
Loan nature	Spread of the loan
	Tenor of the loan
	Minimum value clause
	Balloon/Loan ratio
Vessel nature	Tonnage deadweight
	Age of the vessel
Borrower's finances	Asset cover ratio
	Percentage of finance
	Fleet leverage
Borrower's reliability	Shipowner's experience

The Binary Logit Model based on the Loan Nature is shown in Table 2. We use Spread of the loan (SPPREAD), Tenor of the loan (TENOR), Minimum value clause (MVC) and Balloon/Loan ratio (BALLOON) to represent the loan nature. Only TENOR is proved to be statistically significant after the first regression, we then take out the least significant variable and run the regression again, it can be seen that SPREAD, TENOR and BALLOON are statistically significant.

Table 2. Binary Logit Model for predicting the performance of shipping loans based on the Loan Nature

Variable	Coefficient	Prob.	Coefficient	Prob.
SPREAD	0.870	0.135	1.066*	0.061
TENOR	0.158*	0.055	0.144*	0.075
MVC	0.030	0.430		
BALLOON	-0.074	0.151	-0.088*	0.075
C	-5.306	0.320	-1.277	0.411
McFadden R-squared	0.268		0.251	

Table 3 illustrates the results of the Binary Logit Model based on the Borrower's Finances. Asset cover ratio (ACR), Percentage of finance (FINANCE) and Fleet leverage (LEVERAGE) are used to represent the borrowers' finances. We adopt the same approach by taking out the least significant variables until all the variables are significant. Only one variable LEVERAGE contributes to the performance of shipping loans.

Table 3. Binary Logit Model for predicting the performance of shipping loans based on the Borrower's Finances

Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
ACR	-0.003	0.227	-0.003	0.224		
FINANCE	-0.004	0.851				

LEVERAGE	-0.044**	0.036	-0.044**	0.032	-0.039**	0.049
C	3.404	0.043	3.213	0.015	2.291	0.032
McFadden R-squared	0.151		0.150		0.110	

Tonnage deadweight (DWT) and Age of the vessel (AGE) represent the Vessel Nature of the shipping loan. As shown by Table 4, neither of them is statistically significant, which implies the vessel nature is not a critical driver of the performance of shipping loans.

Table 4. Binary Logit Model for predicting the performance of shipping loans based on the Vessel Nature

Variable	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
DWT	0.000	0.136	0.000	0.129
AGE	-0.014	0.650		
C	1.205	0.120	0.941	0.058
McFadden R-squared	0.087		0.081	

Lastly, we measure the Borrower's Reliability by the shipowner's experience (EXPERIENCE). Table 5 shows that EXPERIENCE is statistically significant to contribute to the performance of shipping loans.

Table 5. Binary Logit Model for predicting the performance of shipping loans based on the Borrower's Reliability

Variable	**Coefficient**	**Prob.**
EXPERIENCE	0.052*	0.083
C	-1.628	0.140
McFadden R-squared	0.082	

Based on the statistically significant variables in each category, five variables were chosen to run the overall regression (Table 6). SPREAD, TENOR and BALLOON represent the loan nature, LEVERAGE represents the borrower's finances, and EXPERIENCE represents the borrower's reliability. The results presented in Table 6 suggest that the loan spread, the fleet leverage and the shipowner's experience are the best estimates for evaluating the performance of shipping loans.

Table 6. Binary Logit Model for predicting the performance of shipping loans taking into consideration all of the four categories

Variable	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
SPREAD	1.112*	0.093	1.069	0.113	1.113*	0.100
TENOR	0.093	0.294	0.080	0.370		
BALLOON	-0.045	0.433				
LEVERAGE	-0.034	0.188	-0.042*	0.073	-0.039*	0.095
EXPERIENCE	0.055	0.164	0.059	0.132	0.074**	0.040
C	-2.163	0.389	-2.581	0.287	-2.906	0.242
McFadden R-squared	0.354		0.338		0.316	

McFadden R-square is a pseudo R-square used to measure the goodness of fit. This value tends to be smaller than R-square and values of .2 to .4 are considered highly satisfactory. The McFadden R-squares are considered high in the overall models in Table 5. We chose to study shipping loans that were drawn over the period 2005 – 2009. This interval is thought to be sufficient because the level of freight rate, the order-book, the second hand prices and the scrap volume have noted high volatility due to the complexities of economic turbulence before and after the financial crisis.

5. CONCLUSIONS

The research highlights the significance of the availability of finance and the effective management of the financial risk of investment for the efficient function of supply chains. For that reason, it focuses on the maritime transport mode of global supply chains and examines the varying importance of a number of factors connected with the performance of bank loans for the purchase of new build and second-hand vessels. Our results suggest that the loan spread, the fleet leverage and the shipowner's experience are the best estimates for evaluating the performance of shipping loans.

This paper contributes to the development of theory in this field through the expansion of literature examining new variables which could be considered important when banks are assessing potential loans. Further, a specific contribution to the shipping literature on risk management is made with regard to credit risk analysis by highlighting shipping specific factors and their importance for risk measurement. The paper also makes a significant contribution to industry practice; the results are of interest to banks as they can identify the factors to assess the credibility of the shipping loans, minimize their credit risk, assist in the credit granting decision-making process, and thus help them make more reliable investment decisions. Borrowers / Shipowners can also benefit by identifying the factors of credit risk they need to focus to enhance their creditworthiness when competing for scarce financing facilities, especially during risk-laden market conditions.

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INTEGRATING KNOWLEDGE TO RESOLVE MANUFACTURING SUPPLY CHAIN RISKS: DEVELOPMENT OF SCRIS

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ABSTRACT

The complexity of supply chain networks and uncertainty of environment they operate in create an extremely challenging environment to identify risks in supply chain (SC) networks. Various tools and techniques are available but can only assist top management in identifying risks in limited manner. Although there are considerable numbers of publications, a decision support tool which could identify majority of critical SC risks and their interrelationships with other risks as well as flexible enough to assist several process strategies have not been developed. In this paper, the process of developing a unique tool called the Supply Chain Risk Identification System (SCRIS) to support top management in SC risk identification process by utilising a Knowledge Based System (KBS) approach is presented. Both the development as well as the validation stages of SCRIS will be summarised. It is applicable to different process strategies which are widely utilised by manufacturing organisations, namely Make to Stock (MTS), Make to Order (MTO) and Engineering to Order (ETO).

INTRODUCTION

Risk identification is the first and essential stage in Supply Chain Risk Management (Norrman and Lindroth,2004,Hallikas et al.,2004, Zoyza and Russell, 2003). It is a fundamental step as it provides information of potential SC risks for the next stages of SCRM process. Improper risk identification may misguide further SCRM stages (i.e. risk assessment, risk evaluation, risk mitigation). It is critical to identify most, if not all, of the potential risks by covering every potential risk and its causes at every point of the SC network which could originate from within the internal (focal) organisation, its relations with SC partners and/or with external SC environment. Risk identification is aimed at providing a comprehensive list of potential SC risks which leads to a better understanding of future SC potential threats and enables appropriate management of this condition (Hallikas et al., 2004, Waters, 2007).

Since risk identification is an essential but also a difficult and complex task, it cannot solely depend on top management 'instinct' and personal knowledge. A consistent structure is required to support risk identification processes and to ensure appropriate outcomes. Therefore, risk identification should follow a formal procedure which involves particular tools and techniques to support its processes. There are various tools and techniques available to support risk identification for gathering opinions, analysing past events/projects/experiences, examining operations or classifying risks in a certain manner. In spite of this, most of the existing tools and techniques are for general purpose use and are not specifically for identifying risk in SC networks (Waters, 2007, Shi, 2004).

There are vast amounts of research in Supply Chain Risk Management (SCRM) area covering risk identification, assessment, evaluation and mitigation stages. These papers propose a range of different approaches to managing and identifying SC risks; most do not adopt an informal method and focus instead on limited aspects such as the upstream side of SC networks, internal SC networks or particular industry types. In general, manufacturing organisations operate in different manufacturing environments which dictate their operations and engage with different risks. Therefore, there is a need for a risk identification approach that considers this issue, which is not covered in existing publications.

Moreover, while it is essential to recognise the mutual relations of SC risks when identifying risks, only some of the literature takes this issue into account. In addition, the output of risk identification should be to represent the entire range of SC risks attributes. Even so, it is understandable that the literature reviewed proposes various ways to classify SC risks as it has several attributes; still most of the literature only partially considers SC risks attributes.

In summary, a systematic and formal SC risk identification approach which is applicable to different manufacturing environments whilst also considering the entire SC network by recognising the mutual relations of SC risks, are currently not available.

Accordingly, in this paper, the process of developing a unique decision support tool called the Supply Chain Risk Identification System (SCRIS)for risk identification process is presented.

BACKGROUND

This section presents an overview of related literatures in two major topics, Supply Chain Risk Management (SCRM) and Knowledge Based System (KBS).

As the basis of the SCRM research area, understanding the definition of SCM is essential. Many studies have proposed various definitions of SCM in an effort to develop universal consensus. The most recent definition is proposed by Stock and Boyer (2009).

For the purpose of this research, SCM is defined as a coordination and integration of all SC activities from planning until disposing (product return) covering flow of material, service, financial, and information between suppliers, manufacturer, logistics provider, distribution centres, retailers, and customers which is aimed at satisfying end customers (e.g. time, quality, price) while keeping costs low.

The SC has becomes a highly complex and interdependent network due to rapid developments in today’s business environment, and this makes the network more susceptible to any disturbance. Accordingly, SCRM can be seen as an effort to reduce SC vulnerability in order to achieve the SC aim of recognising and managing all potential disruptions, not only within the SC network but also outside (SC external environment). Managing risk in SC is a complicated task; therefore a formal and structured approach is required. A broad range of SCRM approaches has been proposed, and these share similar basic steps with common risk management. The steps are: risk identification, risk assessment, risk evaluation and risk mitigation. These steps form a continuous flow to ensure that all potential SC risks (new and existing) are recognised and mitigated against properly.

Risk identification is the most important and fundamental step in SCRM. The appropriateness of risk assessment, evaluation and mitigation are determined by the accuracy of risk identification output or result. Although there are vast amounts of tools and techniques available to support risk management (including risk identification), identifying risks in a SC is not an easy task as this network operates in a complex environment involving large number of companies which rely on each other heavily. To date, there are numerous studies that propose various risk identification approaches. There are several important issues in SC risk identification. These are:

- Representation of SC network operations and its environment using appropriate tools/techniques

- Examination of all potential risks and their sources (root causes) including taking into account other SC risk attributes (e.g. location, time and owner)
- Establishment of SC scope, which covers the whole SC network (internal and external environment), to identify as many potential SC risks as possible.
- Recognition of interrelationship between SC risks, as they should be seen as interrelated events not an individual occurrence.

Most of the studies utilise certain visual tools (e.g. business process flow, risk map) for depicting SC activities. By using visual assistance, potential risks are recognised through a detailed examination at each point of SC activities. While, in some studies, their visual representation is also enhanced with resources information at each SC activities (Basu et al., 2008), SC activity objectives and risk sources view (Neiger et al., 2009). Gaudenzi and Borghesi (2006) and Gaonkar and Viswanadham (2007) also made use of visual support but for depicting SC risks interrelationships after identification of potential risks by recognising possible reasons of unachieved SC objectives.

While Harland et al.(2003) and Sinha et al. (2004) focused on identifying SC risks without further examining their possible causes, other studies such as Hauser (2003) and Norrman and Jansson (2004), looked at more extensive risk attributes such as risk cause (source), location and time. However, all of these studies did not consider the relationships among SC risks. There are several studies that cover extensive risk attributes as well as risk interrelationship. Li and Hong (2007) identified SC risks including their source and recognised most risk attributes (location, time, cause) even though it was not clearly illustrated in the paper. Then, Pavlou and Manthou (2008) structured SC risks (detrimental event) according to the SCOR model and the external environment, including risk source (event cause). They also covered location and time of SC risks. Neiger et al. (2009) also presented SC risks in a multidimensional manner by linking them to SC objectives and SC detail activities.

Regarding the SC operations, more research in recent years has encompassed the whole environment of the SC network (supply side, demand side and its external environment). Still, there are several studies such as Hallikas et al. (2002), Harland et al. (2003), Norrman and Jansson (2004), Wu et al. (2006), Gaonkar and Viswanadham (2007), Trkman and McCormack (2009) that are more focused on the supply side.

As can be seen from the above discussion, four important issues in SC risks identification have been accommodated in recent publications but at different levels. There are some studies that either emphasise identifying risk only at the supply side of the SC network, or do not consider risk interrelationships, or only take limited risk attributes into account. Some studies delivered on all of these four issues – such as Basu et al. (2008), Li and Hong (2007), and Neiger et al. (2009).

Furthermore, the SC risk identification approaches which are proposed in the literature are varied. Some of the approaches are specifically developed for certain SC conditions (e.g. supply side with first and second tier suppliers) or certain industry types (e.g. aerospace). This is similar to what happened with risk classification as an output from the risk identification process. Up to recently, different studies proposed different classifications and, most importantly, existing risk classification is still unable to represent comprehensive risk attributes. As yet, generic SC risk identification approaches and risk classification that is applicable to different manufacturing environments (i.e. inventory level/manufacturing system MTO, MTS and ETO) are not available.

As has been mentioned before, managing risks in SC is not an easy task due to the complexity and mutual dependency which is characteristic of the network. As one of SCRM steps, risk identification also encounters a similar problem. Risk identification in an organisation is aiming at providing a complete list of potential SC risks. Therefore, top management should have a broad view, not only of its organisation activities, but also of the whole SC network activities and its external environment. Moreover, interrelationships between these SC risks should also be recognised.

There are a number of tools and techniques to support the risk identification process (these range from generic tools to commercial risk management software). However, most of these tools are not specifically developed for identifying risks in the SC environment and more importantly they do not consider the interrelations between SC risks. Therefore, there is an urgent need for a specific tool that can support top management in providing a complete list of potential SC risks and acknowledging their relationships.

Knowledge based system (KBS) has been known for having the capability to assist problem solving by capturing and organising any knowledge from experts or past experiences and then reusing it in future projects. Moreover, this knowledge can be stored and organised so that individuals and teams can access it easily. Because of these benefits, KBS has been utilised in many areas. KBS has been applied widely in risk management (especially in construction/infrastructure project). In spite of this, a KBS application for supporting SCRM, especially for SC risks identification, has not been explored. In view of the fact that there is a need for a specific supporting tool for identifying SC risks. Lastly, there are a vast amount of studies available in the area of risk management, SCM and SCRM. Therefore, this invaluable knowledge can be gathered and utilised to develop a KBS based tool for supporting SC risk identification in an organisation. Briefly, KBS is a suitable approach to be utilised for developing a SC risks identification tool.

METHODOLOGY

Risk identification should be able to provide a comprehensive list of potential SC risks by considering and encompassing these three important issues:

- The whole SC network environment (internal and external)
- The complete SC risk attributes (risks sources, location, time and owner)
- The interrelationships of SC risks

Accordingly, the main features of SCRIS are:

1. *To provide its users with information about potential risks in SC network and environment based on causal relationships between SC risks and their sources.*
   Every SC risk is triggered by a particular risk source which has happened through certain conditions/characteristics of the internal SC network and the external SC environment. Using these causal relations as the rule of thumb, SCRIS identifies potential SC risks based on information about these SC network conditions/characteristics and the product that they deliver.

2. *To provide the capability to support decision makers on complex cases or projects.*
   Today’s SC is a vastly intertwined network and consists of numerous organisations (suppliers, manufacturers, logistics providers and customers). Identifying SC risks and mapping their interrelationships is very complex. SCRIS covers potential risks that may occur in both internal and external SC environments and the interrelationships of risks are established to be converted into causal relations for further use in the SCRIS knowledge domain.

3. *To provide a flexible structure.*
   SCRIS identifies the risks inherent in different process strategies. This research covers Make to Stock (MTS), Make to Order (MTO) and Engineer to Order (ETO) process strategies which are widely adapted by manufacturing organisations.

This section covers the SCRIS development framework, which is covered in five main stages.

1. Initial problem assessment: defining the task, scope, audience, sources of knowledge, and requirement resources.
2. SCRIS structure establishment: eliciting, organising and representing the knowledge for solving the problem.
3. SCRIS prototype development: building knowledge base, working memory, inference engine and user interface.
4. SCRIS prototype evaluation and refinement: testing prototypes in industry and development of a revised version of SCRIS for MTO.
5. SCRIS testing and finalisation: evaluation and validation of SCRIS in companies.

SCRIS provides list of SC risks which are designed to be categorised and displayed in a structured and informative form, detailing when risks may occur, at which locations, their root causes and ownership of the risks. In addition, combinations of interactions and the interrelationships between these risks are also analysed and displayed for the end-user (Figure 1).

To develop SCRIS, knowledge elicitation is conducted through gathering deterministic/documented type of knowledge. The extensive range of existing literature makes it possible to develop a knowledge based system. This knowledge is acquired through the growing body of literature covering case studies, fieldwork findings and expert opinions and experiences and it is not only limited to the SCM or SCRM area, but also includes the broader area of risk management and operations management. This knowledge may be in different forms since it is gathered from various references. Thus, this elicited knowledge is then sorted, organised and arranged to build causal structures. SCRIS structure can be seen as a pathway to identify the majority of SC risks according to unique and relevant characteristics of the SC internal and external network environment in relation to the process strategy that is utilised by manufacturing organisation (Figure 2). Hence, SCRIS output (recommendation) is different depending on the characteristics of the product, focal organisation, SC partners and SC external environment.

Knowledge representation and expert system shell selection

The production rule (rule-based) is utilised to represent the knowledge of risks in the supply chain as they have a cause–effect relationship. When the "if clause" is true, then some action is performed, so, for example, when risk factor X occurs then risk event A happens. In this research, forward chaining inference method is utilised. Thus, the rules are developed starting from the lowest level of knowledge structure (SC and product characteristics), then this is linked with risk factors and then risk events. SCRIS user provides information or confirms the "if" part during consultation with the system. expert systems shell is utilised since it has a rule based as knowledge representation approach, is easy to learn and is available with a relatively low cost. There are many expert system shells on the market with various prices and offering different capability. These include CLIPS, XpertRule, EXSYS, VPexpert, Nexpert, and many more. Several criteria were utilised to compare and select the appropriate expert system shell for developing SCRIS. Accordingly, CLIPS was chosen since it can fulfil most of those criteria compared to other expert system shells.

Development stages of SCRIS

SCRIS prototype is first developed aiming to ensure the feasibility of the system and the suitability of the development tool/expert system shell. It intends to cover three process strategies (MTO, MTS and ETO); however for prototype development purposes, the SCRIS prototype is built only for MTO organisation types. This prototype has the whole knowledge of the system and its user interface so it can identify SC risks, but only for

MTO organisations. The architecture of SCRIS-MTO prototype is similar to the full system of SCRIS. After constructing the generic hierarchical structure, the causal structure is built.The causal structure displays interrelationships between risk events, risk factors and risk sub-factors that are applicable for each risk owner, location and time. The interrelationships coverrisk events, risk factors and risk sub-factors.

SCRIS has a complex structure with a large number of interrelationships between risk sub-factors, risk factors and risk events across different hierarchical levels. Each risk sub-factor, risk factor and risk event should be represented in such a way that it can be accurately identified, modelled, analysed and documented.

Accordingly, SCRIS structure utilises a coding system to represent each level in a hierarchical structure and each risk in a causal structure. This coding system also aims to simplify translation from SCRIS structure into using rules as its knowledge representation. This code consists of a combination of Roman numerals, alphabetical letters and arithmetic numerals which follows these conventions.

- Level 0: Plan, Source, Make, Deliver and Return represent by Roman numerals I, II, III, IV and V consecutively.
- Level 1: Focal organisation, SC partners, and external SC environment is represented with arithmetic numeral 1, 2, 3 consecutively.
- Level 2: seven functions under focal organisation, three players of SC partners, and nine factors of SC external environment are each represented with arithmetic numeral 1, 2, 3, …n.
- Risk event is represented with arithmetic numeral 1, 2, 3, …n
- Risk factor is represented with arithmetic numeral 1, 2, 3, …n
- Risk sub-factor is represented with arithmetic numeral 1, 2, 3, …n

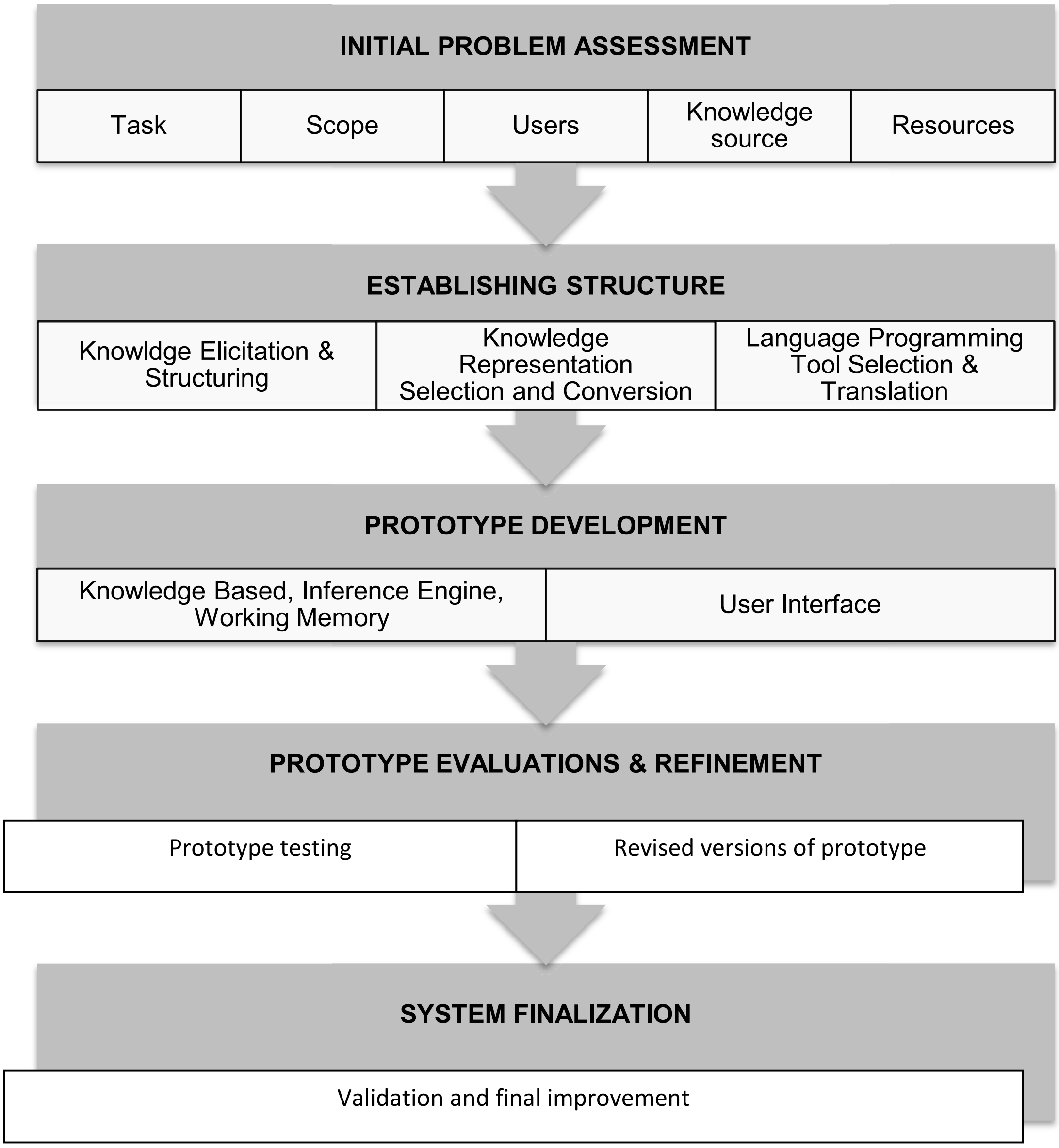

Figure 1 : Framework of SCRIS

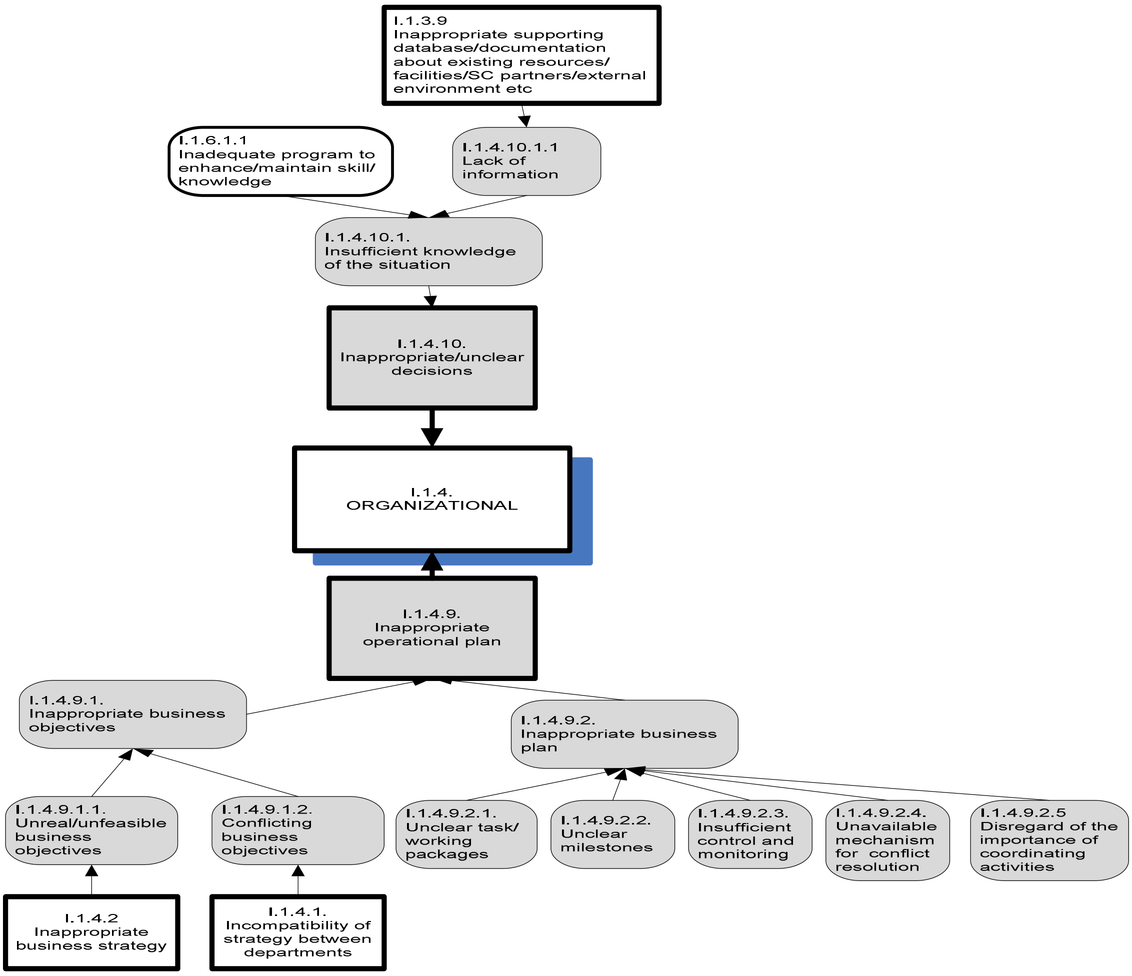

Figure 2: Examples of suggested risks incorporated into SCRIS

RESULTS

The feedback gathered from four manufacturing organisations on final version of SCRIS for MTO, MTS and ETO process strategies emphasised the inclusion of both additional potential SC risks, and further enhancement/additional features of SCRIS. Most of the additional potential SC risks are incorporated into the current version. Some of the suggestions on user friendliness of SCRIS include:

- Provide action/mitigation plan for the risks identified
- Provide similar risks other companies experienced in the lessons learnt
- Provide any standards, user guidelines, internet links
- Provide risk racking
- Develop link to Project management software used in the company

Users also suggested that SCRIS can also be utilised as a medium for communication and collaboration between manufacturing organisation and its SC partners in order to manage and mitigate SC risks.

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REACTIVE RISK MANAGEMENT USING A COMBINED MULTI-AGENT SIMULATION APPROACH

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ABSTRACT

Typically, intensified cooperation between companies is associated with increasing requirements concerning the adaptation and synchronization of supply chain processes. Besides the expected positive effects on competitive advantages (e.g. gained by reduced lead times and cost savings), this trend often is accompanied by additional risk potentials within supply chains. The purpose of our research is the development of a decision support framework, which allows reactions to unforeseen damaging events supporting agile process execution. We focus on reactive risk management as part of short-term decision making for so-called *sensitive logistics nodes*. Exemplarily, freight villages representing a specific type of sensitive logistics nodes, are used for the underlying studies. The aim is to reduce the extent of loss caused by such an event and to ensure the supply of necessary goods. Therefore, we present a combined approach based on a multi-agent system connected to a simulation environment.

Keywords:
Reactive risk management, multi-agent systems, simulation techniques, freight villages

INTRODUCTION

The growth of business combinations within supply chains, accompanied by increasing interdependencies between the supply chain partners and their processes, leads to a greater vulnerability of supply chains to incidents and damaging events (Sodhi et al. 2009, Christopher et al. 2004). The losses caused by such incidents and damaging events could be enormous, in particular, when important and sensitive logistics nodes are concerned.

In Germany's logistics infrastructure, freight villages perform important tasks as logistics hubs in the supply of goods. For the main part, they are a macro-logistics interface between rail and road (Koch et al. 2010). Within freight villages, different transport and logistics companies, as well as different traffic carriers, are united (Rall 2008, Kessler et al. 2009). If an incident or a damaging event arises, many supply chains are affected. To mitigate the risk of such events, proactive and/or reactive strategies could be pursued (Gadghe et al. 2011). In literature, the most discussed measures regarding supply chain risks are concerned with the prevention of risks, while the reactive handling of risks receives less attention (see for example Gadghe et al. 2011, Wagner et al. 2007, Ritchie et al. 2009). Our proposed approach concentrates on the reactive handling of risks in freight villages. Our main objective is the limitation of damage and maintaining the flow of goods after occurrence of a damaging event by use of a simulation-based multi-agent system.

In our paper we focus on the realization of a cross-supply chain reactive risk management strategy in freight villages to act and react rapidly after a disruption.

LITERATURE REVIEW

Besides the risks within a single business environment, supply chains are vulnerable to further risks, due to cross-company relationships. Exemplarily, cooperation risks within a supply chain as well as risk effects with a high impact on multiple supply chains and their members, can be mentioned (Steven et al. 2007, Goetze et al. 2007). The planned and structured handling of supply chain risks is a main objective of the supply chain risk management. Risk management comprises a collection of further several activities and objectives, like risk assessment, risk monitoring, risk identification as well as risk analysis (Ritchie et al. 2009). This paper mainly focuses on the handling of supply chain risks (see for example Ritchie et al. 2009, Götze et al. 2007, Wagner et al. 2007).

For the handling of risks, different strategies can be applied within supply chains. Besides the both basic strategies risk prevention and risk mitigation also risk sharing and risk acceptance can be pursued as well (Kersten et al. 2008). Risk prevention strategies focus on reducing the amount of business activities with a high risk potential (Goetze et al. 2007), whereas risk mitigation focus on diminishing the probability of occurrence, or at least reducing the impact of the damages. By passing risks to third parties, risk sharing is applied. Risk acceptance is applied by accepting risks and their consequences deliberately (Kersten et al. 2008).

Risk mitigation strategies can be more differentiated into proactive and reactive risk management strategies (Gadghe et al. 2011). A proactive risk management strategy comprises risk identification and measures in order to avoid the occurrence of identified risks. A reactive risk management strategy includes steps, which are performed in case of emergencies or damaging events (Dani 2009). Properties of such a reactive risk strategy are limitation, assessment and elimination of damage. This strategy's procedures focus on reducing and mitigating the extent of loss of a damaging event. Measures to achieve the aims of these strategies can be classified in measures related to the causes of risks and measures respective to the impact of risks (Wagner et al. 2007). Measures concerning the causes of risks should eliminate them or at least reduce their probability of occurrence. Measures related to the impacts of risks aim at the limitation of economic losses, caused by a damaging event (Hotwagner 2008).

Therefore, measures related to the causes of risks are applied in a proactive risk management strategy while in a reactive risk management strategy impact-oriented measures are used (Thun et al. 2011).

Proactive as well as reactive measures are applied before an incident or damaging event occurs. The distinction is that proactive measures are executed before a risk occurs to avoid them whilst reactive measures come into effect, after an incident or a damaging event occurs (Thun et al. 2011).

As mentioned above, our approach aims at a reactive risk management strategy. Measures in our reactive risk management are related to the impacts of risks. These measures are applied before a risk occurs and come into effect, when an incident or damaging event arises to reduce the extent of loss by allowing a rapid reaction to unforeseen incidents and damaging events.

METHODOLOGY

To support decision-making in case of damaging events, a combined approach based on simulation techniques and the concept of multi-agent technologies is developed.

Agent-based modeling is used, because it takes into account that complex non-linear problems require a direct investigation of decisions on the micro level, i.e. decisions of different individuals, their heterogeneity and their interaction (Wildebrand et al. 2011). Agent-based modeling is increasingly applied in the field of logistics (Meier 2008, Becker et al. 2007, Ickerott 2007, Alferes 2004).

Simulation experiments based on agent-based models, allow assumptions concerning the dynamics and the effects of interlinked actor specific decisions (micro level) regarding their influence on the system level (macro level) (Mosler 2002). The effects of damaging events like bottlenecks and redirection of flows of goods can be visualized and evaluated by use of reports, diagrams and specific methods within the simulation model.

Based on the simulation results and the resulting optimization of the emergency concept, an emergency handbook as well as an emergency training concept for actors in freight villages can be configured. In addition, a hybrid multi-agent software system (MAS) is integrated between the freight village actors, to support dynamic decision-making of human users through problem specific solutions proposed by the agents during emergency situations. The aim is to maintain the flow of goods by flexibly coordinated capacity planning and controlling of residual transport, transshipment and handling capacities in freight villages.

MULTI-AGENT-BASED MODELING

For agent-based modeling the first step is the identification of common involved actors and resources within the freight villages. In order to separate the various forms of these identified objects a classification of the relevant roles in active and passive objects is conducted. Active objects are the actual decision makers who are responsible for the co-ordination of the flow of goods as well as for goods handling within the supply chain processes in freight villages. We modeled the different kinds of forwarders (truck, railway and barge), logistics service providers, as well as other technical infrastructure operators (e.g. operator of combined transport terminals) as active objects. Passive objects on the other hand do not make decisions themselves - instead they change their state variables over time. So these passive objects provide input variables to the active objects. For example, if there is damage to the rail mode, its capacity is reduced for a certain amount and time. This information is needed by the railway forwarder who has to find a solution for fulfilling its orders, for instance through cooperation with a truck forwarder. In our agent-model passive objects are the seaport, inland port, airport, terminal of combined transport, road, rail, waterway and other special units like gas station, cool and frozen storages.

The central attributes of all passive objects are the maximum and the currently existing capacities in terms of the transportation and handling performance. These attributes serve as a basis for making statements regarding the capacity utilization of a specific resource as well as about the suitability of a specific logistics actor (active object) in terms of its own current possibility for taking over transport or handling capacities from other actors.

The mediator-agent is configured and implemented to act as the central communication unit between all active and passive objects. The mediator agent’s tasks consist of the transmission of capacity information and the control of the negotiation processes between the different actors. Based on an internal decision matrix the mediator decides on appropriate emergency procedures, which for example include a restructured transportation and handling process as a result. In order to enhance the efficiency of the negotiation process and to ensure the quality of the results, information like topographical data of the related actors and resources are considered. This efficient process design avoids unnecessary steps in the negotiation process, like sending inquiries to actors that either aren’t able to handle the requested capacity, since they are directly impaired themselves, or are inconveniently located, so that a redirection is not justifiable from an economic point of view.

For the negotiation of capacity shifts, the so-called Contract-Net protocol is used. In this context, all integrated actors are asked whether they can take over an additional amount of transport or handling capacity for a certain period of time. In this scenario, not only the free capacity of an actor is relevant, but also the actor’s specific attributes. This means, that the actor must be able to deal with special order, goods and logistics requirements e.g. handling of container, swap trailer, semi-trailers and/or freezer container. Further requirements are the ability to deal with dangerous goods based on special licenses, food or non-food, intermodal traffic and heavy cargo. According to their negotiation strategies, these asked actors return their answer back to the mediator. If an asked actor can’t deal with the special order, goods or logistics requirements, it quits the negotiation. Based on the predefined topographies and by prioritizing of related parameters, the mediator decides which actors are the most suitable for execution of additional transports and/or handling processes.

For the implementation of the multi-agent system the JADE-framework is used. This framework is characterized by good scalability and the integration of all necessary basic functions. Furthermore, JADE is well documented and its source code as well as the framework software is freely available.

To link the multi-agent system with the simulation environment, an XML-based interface is created. This allows the exchange of messages between the two systems in a well-defined and structured format. The transmission of data is realized by a direct connection (point-to-point).

SIMULATION MODEL

The purpose of the simulation model lies in the depiction of all relevant logistics processes within freight villages and the freight village network. The simulation model serves as a basis for visualizing the flow of goods, different transport carriers, different cargo transport units and involved actors. Furthermore the simulation model provides different reports, to evaluate the capacity utilization within the freight villages and their infrastructure. Diagrams visualize the currently existing capacities in terms of the transportation and handling performance. For this purpose the various structures of the freight villages with their specific capacities and different infrastructures are considered. In addition, different damaging events are simulated, in order to evaluate the behavior of the involved actors as well as to validate the solutions proposed by the multi-agent system. These areas of usage result in the following requirements:

- A hierarchical design of the simulation model
- Construction of the freight villages with basic elements
- Ability of parameterization
- Possibility to develop specific features
-

The hierarchical design of the simulation model is based on a process-driven reference model (Breuer et al. 2012) and leads to a high flexibility concerning the adaptability and the extensibility of the simulation model. The hierarchical design is shown in Figure 1. On the top level, the freight village network, consisting of the different traffic carriers (road, rail and waterway), is depicted. These carriers (passive object in the multi-agent system) provide the basis for visualizing the flow of goods within the freight village network and connect the freight villages among each other.

In order to avoid redundancies in the modelling process, a template freight village element is created and represented in a toolbox within the simulation software. This template contains all basic elements (i.e. a terminal of intermodal transport) and functions of a freight village. This template approach enables the user to rapidly implement further freight villages on the top level. For the construction of the freight villages, the actors (active objects in the multi-agent system) located in freight villages, are divided into clusters, based on functional aspects.

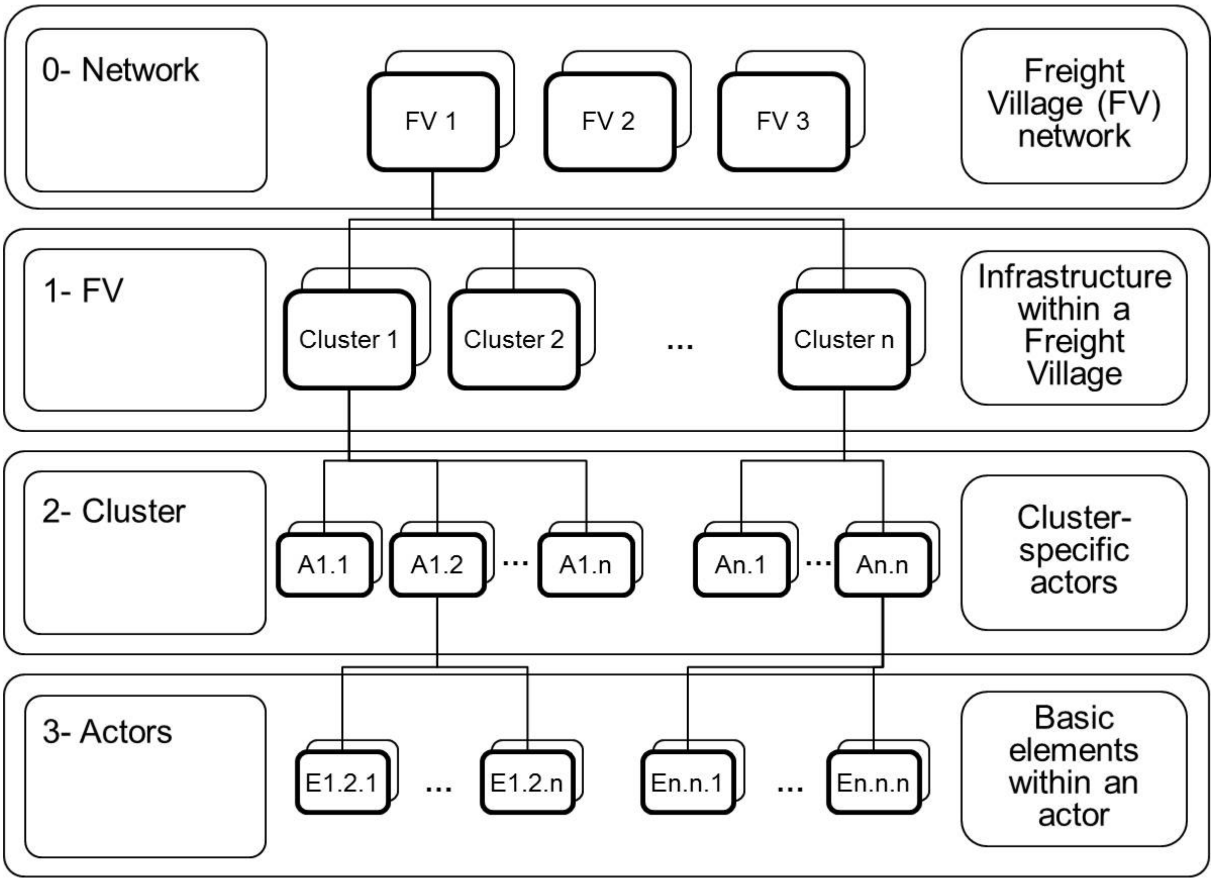

Figure 1: Hierarchical Design of the simulation model

According to the template approach of the freight villages, the identified clusters are implemented as template elements and added to the toolbox as well. Thus, these template elements can be easily used as basic elements to construct and configure the specific structure of a freight village, which represent the second level in the hierarchical design. In continuation to the top level, the clusters are also connected by the different transport carriers to visualize the flow of goods within a single freight village. The processes regarding the single actors in a cluster are shown on the next level.

The ability of parameterization is achieved through the use of the basic elements, which can be equipped with the actor’s specific attributes like daily distribution of traffic, maximum capacity, throughput speed or availability rate. The underlying data is ascertained from two German freight villages. For the visualization of the flow of goods in the simulation model, the processes of two selected freight villages are analyzed and captured in a reference model (see Breuer et al. 2012). Necessary data concerning for instance the daily distribution of traffic, freight village internal traffic flows and capacities of the logistic infrastructure, are collected by interviewing experts and future users.

The effects of damaging events concerning freight villages are to be analyzed by use of simulation techniques. Therefore, in a first step three selected damaging events are integrated in the simulation model. One damaging event refers to the failure of a traffic carrier within the freight village network; the others refer to disruptions in one of the traffic carriers within a single freight village. The damaging events are integrated in the model on the top level and can be triggered by user commands or a randomly generated event list. Possible changes of the capacities caused by damaging events are received from the multi-agent system over an interface. The decisions concerning the changes in the flow of goods and the associated redirections are made in the multi-agent system as well. The changes are communicated over the pre-defined XML-based interface and implemented in the simulation model. The results of the simulation experiments provide the basis for the emergency training concept for actors in freight villages.

For the implementation of the simulation model, an event-driven simulation tool is used. The software provides a variety of interfaces, in order to communicate with other software applications. To realize the message exchange between the simulation tool and the multi-agent system a socket interface is used. As mentioned above, the messages are based on XML.

CONCLUSION AND FURTHER RESEARCH

Agent-based modeling and simulation provides a suitable methodological research and development approach. The combined approach enables the conceptualization of dynamically adaptable organizational structures, problem-solving strategies as well as appropriate cooperation and coordination strategies for freight villages in case of emergencies caused by unforeseen incidents (Brenner 1998, Wildebrand et al. 2011).
The actors, resources as well as the related process data of freight villages are implemented as agents in the multi-agent system and accordingly as template elements in the simulation model.

The systems cooperate with each other and share their tasks, so that the specific advantages of each system are used. The multi-agent system performs the decision-making in occurrence of unforeseen incidents. For this purpose, the involved actors negotiate an appropriate solution. The mediator agent controls this negotiation process, makes the final decision and communicates it to the simulation environment. The simulation model depicts the dynamic aspects like logistics processes in freight villages and supports the decision-making process, by providing relevant information and simulation results. The information exchange is realized by an XML-based interface.

An emergency handbook, an emergency training concept as well as a hybrid multi-agent software system (MAS) are the results of the multi-agent-based simulation experiments.
In a next step, the simulation-based multi-agent system will be implemented in a test environment for demonstration, validation and evaluation purposes. After this, the system can be transferred into a productive environment, in order to support the decision-making process in freight villages in case of emergencies. To attain an effective and efficient tool for reactive risk management across different companies and different supply chains in freight villages, related companies will be involved in the future development and implementation processes.

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SUPPLY CHAINS IN TURBULENT TIMES - CHALLENGES AND STRATEGIES TO PERSIST IN A VOLATILE ENVIRONMENT

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Research Paper

INTRODUCTION

Disruptions in supply chains are not new, but tend to become more the rule than the exception, nowadays. Global supply chains characterize our present economy and link markets, suppliers, producers and customers. Therefore, fluctuations and disruptions impact on more than a single industry or region. Longer routes of transport and shorter lead times offer more opportunities for disruptions and a smaller margin for error if a disruption takes place (Kleindorfer and Saad 2005). Furthermore, the numerous involved stakeholders within a value or supply chain and the limited communication and exchange of information among the stakeholders forward and even amplify disruptions and volatilities, an effect which is referred to as bullwhip effect (Lee, Padmanabhan et al. 1997; Springer and Kim 2010). Consequently, researchers and practitioners have started to investigate different types of disruptions which affect the performance of supply chains in order develop strategies, which make supply chains more resilient (Blackhurst, Craighead et al. 2005; Oke and Gopalakrishnan 2009; Pettit, Fiksel et al. 2010). Even though the categorization of disruptions varies clearly within the literature, a general distinction can be made dividing disruptions into low-likelihood, high-impact and high-likelihood, low-impact events (Norrman and Jansson 2004; Makridakis, Hogarth et al. 2009; Oke and Gopalakrishnan 2009). Low-likelihood, high-impact disruptions are rare events (i.e. black swans (Taleb 2007) or wildcard events (Cornish 2003)) which are hard to predict, such as man-made attacks or natural disasters (Kleindorfer and Saad 2005). Many of these events (e.g. fire, earthquake and thefts) are well known, recurring and get accounted by companies, using risk management techniques and insurances. Problems in managing supply and demand instead belong to the second type of disruptions with a minor impact and higher likelihood (Yang, Burns et al. 2004). This paper is concerned with this second category of disruptions and investigates supply chain vulnerabilities due to volatile market environments.

Especially small and medium sized enterprises (SME), which have fewer resources than large companies, are struggling with the challenges of an increasingly volatile environment and are driven to their edge of existence. Against this background, this paper discusses current challenges faced by SME. Our research was conducted in Germany, but results may be generalized for SME in mature markets in general. At first, we analyze the changes in the market environment according to Porter's Five Forces (Porter 1980), identify upcoming trends (strategic issues), and discuss factors that contribute to potential supply chain disruptions (Pettit, Fiksel et al. 2010). Among others, appropriate strategies to respond to the challenges of volatile markets are derived and evaluated regarding their influence on corporate performance. Based on empirical research, we will finally provide recommendations to endure a crisis such as the recent financial crisis and improve crisis preparedness by creating more resilient and future robust supply chains.

LITERATURE REVIEW

Volatile markets impact the supply chain of a company on its supply and demand side. The resulting economic uncertainty with the two determining dimensions dynamics (e.g. in markets) and complexity (e.g. of value-added chains) (Duncan 1972) determines the environment that companies have to deal with in the post-crisis period. In contrast, the supply chain development of the last decades aimed to make supply chains leaner and more profitable, e.g. by decreasing of inventory. Therefore, the consequences of this development cause now a high vulnerability of companies (Natarajarathinam, Capar et al. 2009). The risks of each partner become risks of the entire supply chain (Harland, Brenchley et al. 2003). The lean supply chains have to cope with the characteristics of volatile markets, such as technology leaps, increased competition, more sophisticated consumers, growing product variety ad complexity, and a shortening of product life cycles. Furthermore, the amount of partners in supply chains has increased, leading to more interfaces. At the same time, global set-ups mean longer distances, more handling processes, longer demurrage, and more complex administrative processes (Jung and Nowitzky 2006). Thus, there is currently an increased attention on different kinds of mitigation strategies (Bowersox, Stank et al. 1999; Yang, Burns et al. 2004) in order to handle the challenges of a volatile market environment. Christopher and Holweg (2011) developed a supply chain volatility index in order to show, that more flexibility in supply chain designs will support managing turbulences and uncertainty. They claim that traditional accounting procedures to evaluate and mitigate risks are not sufficient to master this new era.

Several strategies exists which can help companies to make their supply chains more resilient (Sheffi 2005). Theoretically, companies could build a more resilient supply chain by creating redundancies and slack resources. However, holding extra inventory maintaining low capacity utilization, broadening the supplier base etc. would determine a backwards development and would significantly decrease supply chain efficiency. This means, we sacrifice short term cost reductions because we assume that in average a long-term investment in slack resources will pay-off (Christopher and Holweg 2011). Instead, an increased flexibility in companies' processes and structures as well as cultural changes could increase the supply chain efficiency but reduce the vulnerability of supply chains at the same time. Standardized processes, which are concurrent instead of sequential, postponement strategies and the alignment of procurement strategies with supplier relationships are just a few opportunities to increase a company's flexibility (Sheffi 2005). Especially Swink and Zsidisin (2006) provide some insights how to incorporate suppliers into risk management strategies and to prevent misalignment. Additionally, Lee (2004) refers to the competence of adaptability, which enables companies to adapt their supply chain design to a volatile and changing environment. Identifying potential risks can be realized by 'what if scenarios' (Chopra and Sodhi 2004; Crone 2006), supply chain risk auditing (Zsidisin, Melnyk et al. 2005), and supply chain mapping (Harland, Brenchley et al. 2003). Thus, managers can disclose bottlenecks and identify critical processes, for example maximum production capacities or minimum lead times, at second or third tier suppliers. Supply chain risk management also includes mitigation plans for adverse events which are an "exceptional and anomalous situation in comparison to every-day business" (Wagner and Bode 2006). Mitigation plans guide agile supply chain structures and blue prints how to manage adverse events. However, companies require a culture which encourages continuous communication among key employees within the supply chain. Furthermore, the distribution of power has been recommended in order to allow teams or individuals to take necessary actions as well as a continuous conditioning system to learn steadily from smaller operational interruptions (Sheffi 2005).

To make supply chains more resilient, their redesign or at least significant adaptations are frequently inevitable. Therefore it is crucial to identify and manage the sources of uncertainties in supply chains (van der Vorst and Beulens 2002). Investigations often focus on large-scale enterprises and disregard the situation and major challenges for SME. Therefore, our survey aimed to identify and analyze the described challenges in a crisis environment from a SME perspective.

METHODOLOGY

The sample was drawn from SME in Germany. It was based on the companies' turnover which was at least €290 millions. Therefore, the surveyed companies determine a set of upper-middle class SMEs with distinct supply chains. The selection of 25 SME was industry-independently and included among others companies from manufacturing, logistics, retail market, textile industry as well as from process industry. This assured a multi-facetted view on the topic of vulnerability to exogenous shocks, disruptions and other current supply chain challenges. Thus, the analysis of the results and the derivation of recommendations are cross-industry. We conducted semi-structured in-depth interviews with the companies' top decision makers of the management board or managers with sector responsibility. According to the industrial diversity of SME, the design of the semi-structured questionnaire allowed for comparability of answers without loosing the opportunity of individual responses. Besides general questions about company characteristics and performance indicators, the subject-related questions focused on perceived changes in the market environment, reactions on exogenous shocks and volatilities, the maturity level of the supply chain and the related measurement approach as well as on the impact of SCM strategies on the company performance. The dimensions of the maturity level assessment were developed in expert workshops and adapted after validity pretests. The analysis of the anonymized data consisted of paraphrasing, generalization, reduction, categorization and interpretation (Spiggle 1994). Furthermore, the research process was designed and followed along established qualitative research methods (Corbin and Strauss 1990).

RESULTS

With our research we contribute to the current debate on supply chain resilience and volatility management. We add particular insights from SME top decision makers who reflected on the financial crisis 2008/09 and its impact on their business. Our investigation is structured in three parts. First, we reveal the changing dynamics in the market environment of the interviewed SME and provide further insights on emerging challenges in their supply chain management. Secondly, we present strategic approaches to cope with the volatile market environment and discuss them according to their impact on sales growth, EBIT and capital employed. Finally, our interviews provide further insights on the status quo and the preparedness of SME regarding volatile markets.

Figure 1 illustrates the market forces according to Porter's Five Forces which are assessed regarding their estimated changes in the future market environment. The concentration on supply as well as sales market exposes firms to a highly competitive situation. Rare raw materials occur often in political unstable regions and are increasingly provided by oligopolies, which are in addition most often politically influenced. This raises difficulties especially for high-tech enterprises of resource-poor countries and drives them into highly dependent business relationships. Furthermore, the financial crisis brought strategically important suppliers in critical situations as well. The former aimed leanness in processes and structures for efficiency as pre-crisis paradigms cause now severe difficulties in the new market situation due to missing supply alternatives. Besides the challenges on the supply side, companies are facing an increasing number of global competitors. Especially companies from emerging countries from Asia and South America have managed the crisis well and are using their advantages to close up to market leaders from Europe and North America. Finally, the sales market features a concentration process as well and key customers of SME are struggling themselves with the consequences of the crisis.

The described developments lead to an increasing market volatility in which companies have to persist. Furthermore, the duration of economic cycles is expected to decrease, whereas as the number of exogenous shocks increases. The industry experts see the impacts from exogenous shocks much more severe than before, which is in particular a result of globalized operations and high integration of value chains. All these trends represent additional potential sources of turbulences in supply chains which companies and especially SME need to take into account when redesigning their supply chains in order to be more resilient to future disruptions.

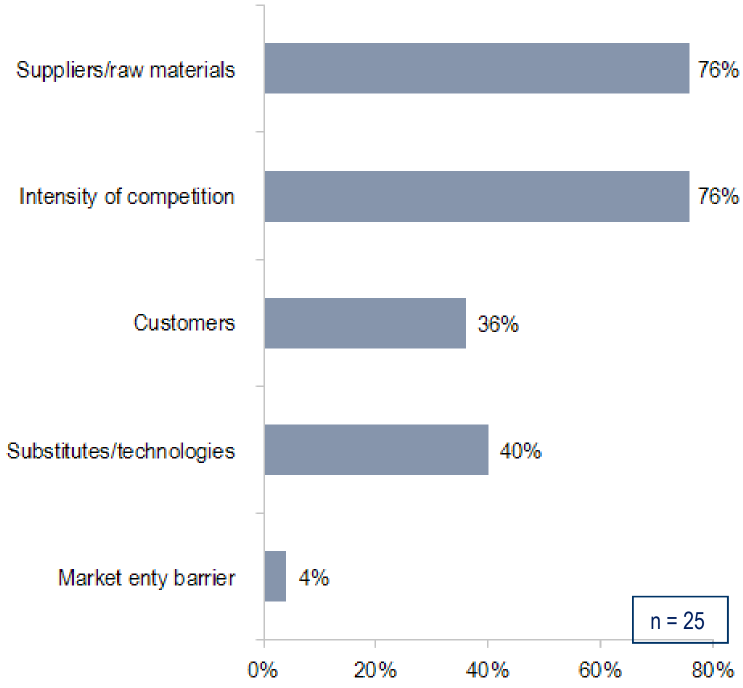


Figure 1. Competitive dimensions with the biggest changes

In order to cope with the challenges, SME are adapting their internal structures and product portfolios to the new requirements of a turbulent environment. Beside the optimization of process and cost structures, managers express a strong need to develop their risk management systems (cf. Figure 2). Especially financial risk management as well as optimized management of inventory and sales require a systematic improvement. Therefore, the extraction of financial key indicators and the generation of real-time reports are seen as an important starting point to provide a precise and real-time information basis for decision makers. In order to get a systematic and lasting improvement in supply chain management, it is important to make the contribution of actions measurable. Therefore, the financial indicators sales growth, EBIT and employed capital were used to indentify and discuss different strategies to persist in a volatile environment.

The surveyed decision makers were asked to indicate the most promising strategies with a positive impact on sales growth, EBIT and employed capital. 38 percent of the interviewees mentioned an optimization in the supplier selection and supplier relationship management as most relevant to increase the sales growth. Measures to the increase productivity and to optimize costs, such as outsourcing of secondary tasks, optimization of business processes and stringent cost management are also mentioned to have a positive impact on sales growth just as ensuring the availability of goods at the point of sale. The optimization of process and inventory costs was assessed by 72 percent of the decision makers as most relevant for increasing the EBIT. Furthermore, the implementation of a lead-buyer concept was considered important to ensure greater bargaining power, to reduce the amount of maverick buying and to promote knowledge-building. The use of global framework agreements, agreements on fixed prices and fixed exchange rates determine a package of measures for standardization, which also has a positive impact on the EBIT.

The SCM strategy with the greatest positive impact on the capital employed is from the perspective of the study participants, the optimization of inventory management. 63 percent of the respondents mentioned measures such as modern logistics concepts (e.g. Vendor Managed Inventory (VMI)) in combination with consignment stores, active portfolio management or a flexible staffing as helpful. The optimization of sales and procurement planning, which is increasingly based on scenario planning and supported by IT systems is seen as second most important lever regarding the capital employed. The enforcement of favorable payment terms to customers and suppliers is also evaluated to have an important impact on the capital employed. Supply chain financing offers here in particular interesting ideas to realize this goal without creating financial losses to the suppliers, which is – especially in the context of the earlier mentioned importance of supplier relationship management – of particular interest.

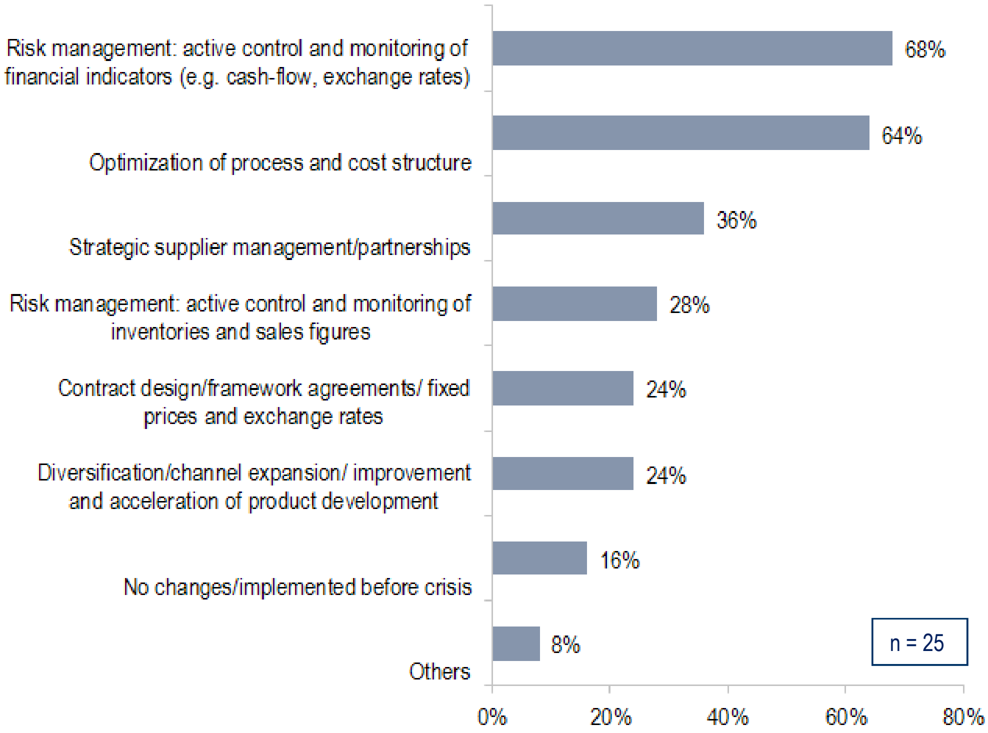
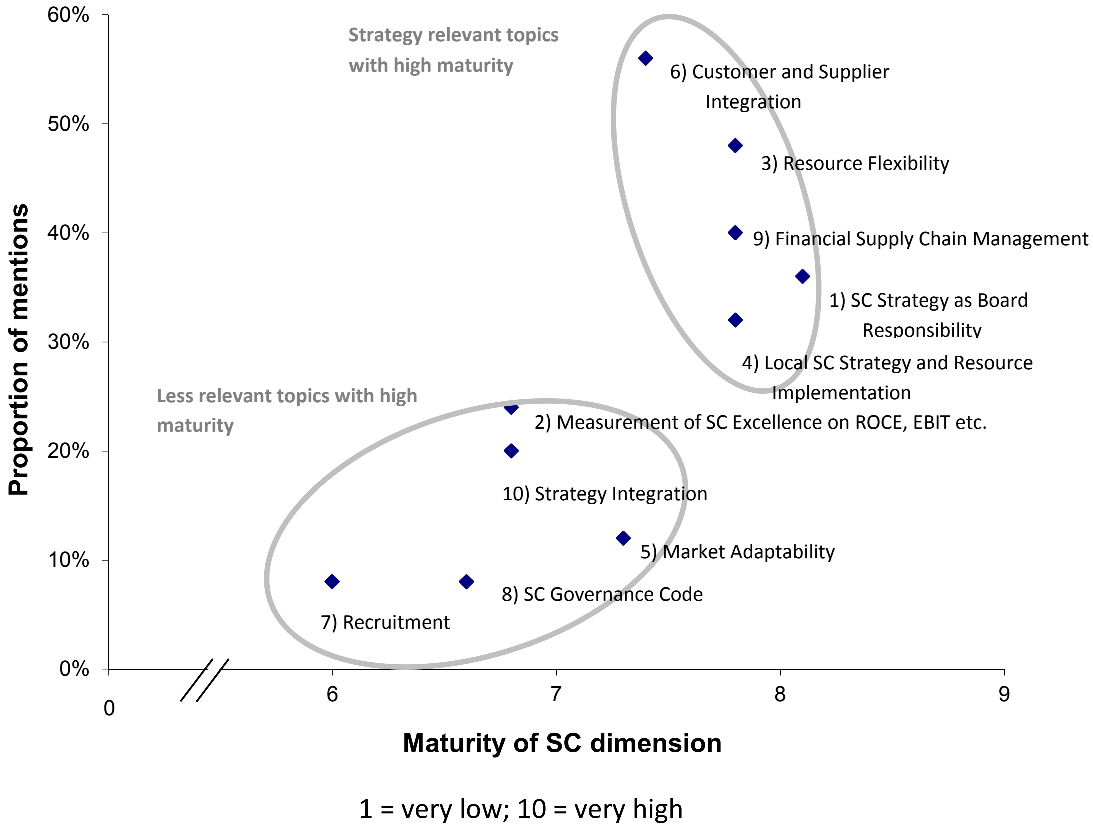


Figure 2. Strategies to minimize the impact of exogenous shocks

In evaluating different supply chain dimensions according to their level of maturity, most managers agree that the supply chain development has already become a corporate strategic issue. Especially the integration of customers and suppliers into the supply chain risk management process is seen as essential. An increased flexibility of resources has been determined as a key role to mitigate the effects of supply chain disruptions. Figure 3 combines the results of the maturity and relevance assessment of the different selected supply chain dimensions. As it can be seen, there are two groups of dimensions. Some of them are seen to play a major role in volatile environments and have already a high level of maturity within the surveyed sample. Other dimensions reflect a high maturity, but are less seen to be helpful in the context of a volatile market. It is striking that issues, which were important before the financial crisis and which might become critical in the next years, have low priority to our expert panel. Accordingly, the development of high-potentials and a more sustainable supply chain design seems to have moved out of focus. Rather, issues with a direct impact on the financial performance take centre stage.

Figure 3. Relevance and Maturity of Supply Chain Meansure in Volatile Markets



Supply chain dimensions

1) We view the development of the supply chain strategy as a senior management task (board of directors, management board)
2) We are able to quantify the impact of supply chain excellence on ROCE, EBIT and growth in sales.
3) We can make our resources flexible enough to respond to fluctuations in demand.
4) We are able to implement our supply chain resources and structures locally in global markets
5) We are able to adapt our supply chain structures to market requirements.
6) We successfully integrate customers and suppliers in supply chain optimization measures.
7) We systematically recruit and develop high potentials on the basis of our strategic objectives and with due regard for their future needs.
8) We have a supply chain governance code (encompassing sustainability, ethics and compliance) which is supported by management and the implementation of which is evaluated by internal and external auditors.
9) We proactively manage the financial aspects of our supply chain (taxes, working capital, supply chain finance etc.).
10) We successfully integrate our functional strategies in our overall supply chain strategy at company level.

CONCLUSION

The growing importance of supply chain management to a company’s overall performance can be seen in the way supply chain management is interacting more closely with other areas of the company and being given more management attention. Especially risk management is seen as important means to survive in a volatile environment and to adequately face exogenous shocks. The surveyed companies see supply chain management and the assessment of associated risks as a clear management responsibility, which may not be delegated. However, this importance is not sufficiently reflected in the organizational structures. Even if the majority of companies confirm a quite high maturity of the surveyed supply chain dimensions, they admit that more efforts are needed to adapt internal processes and structures to global trends. There is a growing interest in innovative planning techniques (scenario planning, road mapping etc.) as a complement to traditional approaches (forecasts, trend extrapolations) to prepare more effectively for a complex and volatile market environment. One important lesson we learned from the economic and financial crisis is that midsize companies are often worse hit by and less prepared for external shocks than large corporations. Future research could therefore investigate how to make SME more resilient to exogenous shocks and market volatilities.

By focusing on SME, we add new insights to current research that mainly concentrates on large companies. Our research aims to reveal the changes that supply chain management has to handle in increasingly volatile markets. It shows which general conditions are required in the next years and which areas are under pressure to act. In a long-term range, the creation of an efficient, flexible and strategically managed supply chain helps not only companies but also their smaller partners within the supply chain to survive turbulent times. However, global logistics is a fragmented business. Therefore, we presented best practices in coping with volatility and disruptions from an SME perspective and thereby complement existing research. We propose that future research should test our findings by increasing the sample size and conducting interviews with SME from other countries. Comparing the strategies from SME with the ones from large companies could also reveal valuable findings.

ACKNOWLEDGEMENTS

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SUPPLY CHAIN RISK AND RESILIENCE: THE PAST DECADE AND FUTURE DIRECTIONS

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ABSTRACT

The past decade has been an extremely important phase in which supply chains have rapidly developed to counter unprecedented uncertainties and risks. Terrorist attacks, closing of national borders, social unrests, and environmental disasters have brought business continuity planning, enterprise and operational risk management and resilience at the forefront of supply chain management. The past decade has also seen a proliferation of research and research publications in the field of supply chain risk management and resilience. The theory and concepts that have been developed over the past decade have provided further directions for academic research and have influenced industry. This paper presents an overview of the most important papers in this area which have created an impact in the last decade and considers future directions with reference to developments in the industrial sector with regards to supply chain risk management.

INTRODUCTION

Supply chain risk management is suggested to be in an emerging stage by researchers (Sodhi et.al, 2011). The topic has been researched deeply in the last decade however it still clearly has undefined boundaries in its scope of research. Literature reviews on SCRM have been carried out in past by Juttner et. al. (2003); Carter (2008), Gunasekaran and Kobu (2007), Tang (2006), Stevenson and Spring (2007). These literature reviews provide a good platform for beginners as well practitioners in making sense of the ongoing research and identifying the state-of-art within the field.

The following paper will briefly cover the background and current advances in SCRM for the last decade. The past decade has also seen a proliferation of research and research publications in the field of supply chain risk management and resilience. The theory and concepts that have been developed over the past decade have provided further directions for academic research and have influenced industry. This paper studies the most important papers on the basis of citation analysis and creates an overview of the important aspects of supply chain risks.

SUPPLY CHAIN RISK MANAGEMENT

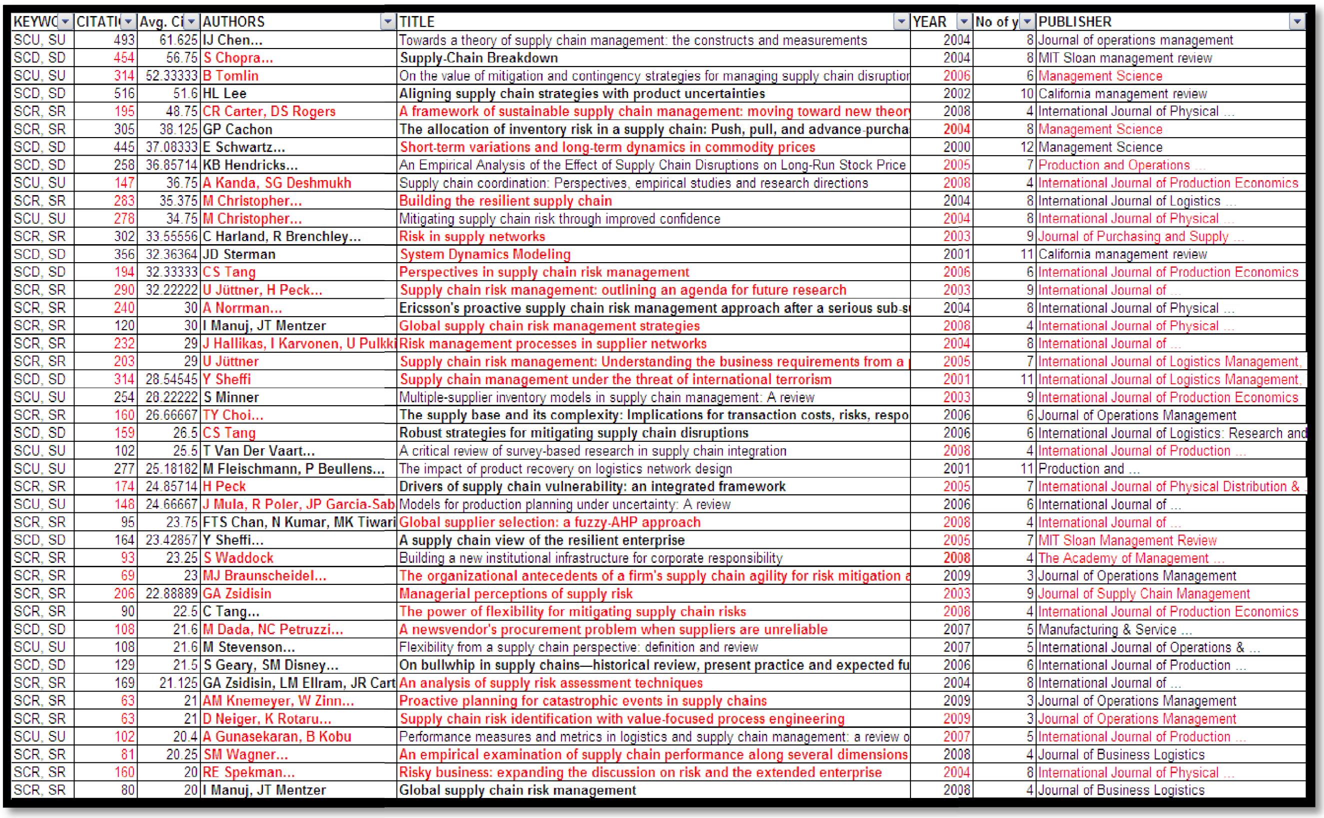
Risk management is becoming an integral part of a holistic SCM design (Christopher and Lee, 2004). There are various schools of thought that differentiate between uncertainties, risks, disruption, vulnerability and disaster in field of supply chain risk management. Supply chain risk can be broadly defined as an exposure to serious disturbance arising within a supply chain. This exposure will affect the capability of a supply chain to deliver the product/ service as per the requirements set by the customer. The literature identifies that the supply chain risk management approach will add value to industry by providing a methodology for identifying risks, assessing them and suggesting strategies to mitigate these risks. The method will provide a greater influence and control over suppliers, increased quality and reliability of products with increased efficiency and reduced operational costs by having systems in place to handle uncertainties and disruptions. There are various papers written on the subject of risk identification (for e.g. Peck (2005)) and identifying sources of risks.

RESEARCH METHODOLOGY

The aim of this research is to study the contribution and impact that has been generated by the most important journal papers in the last ten years on the subject of supply chain risks. Towards the end of the last decade the academic community has seen a proliferation in the papers on the subject of supply chain risks, resilience and disruptions. The discussion point here is whether all this global research has produced any novel contributions or theories which have the potential to influence the next decade with regards to supply chain management. The most difficult part of this process was to create a filtering methodology to select the most impactful papers. The research is conducted in two stages. The first stage was desk research which comprised of an extensive literature review using journal publications and professional magazine articles. The second stage consisted of analysing industrial case studies which depict instances of supply chain disruption and failure. The information on the cases was derived from secondary data. The cases were analysed to identify themes and concepts that have been utilised within the industrial setting to overcome the disruption. A comparison between the results of the literature analysis and the case analysis will be done to identify whether there is a commonality between the academic output and industrial implementation.

'Publish or Perish' was used for searching the papers. Various keywords were used to generate lists. 'Supply chain risk' and 'supply risk' generated >600 publications, whereas 'supply chain uncertainty' generated >450 and 'supply chain disruption' generated >330 publications. These publications were combined and only journal papers were considered followed by removing the duplicates, the final list consisted of >210 papers. Using the Association of Business School's journal quality guide only those journals that were listed under 'operations management' were considered and the list was narrowed down to 74. The next filter to consider the most impactful papers was the number of citations per year. This was chosen to remove the bias involved in selecting only those papers with the highest cumulative citation score which may tend to favour the oldest papers from the cohort. Hence, even if a paper was relatively new but had a good citation /year score the paper was considered for the final list. The minimum level or the cut-off point for the lists was a citation /year score of 20. This could mean that the paper could be 12 years old with a citation score of 240, or a 2010 paper with a citation score of 40. Applying this condition of a citation score/year of 20, the final list of the most impactful papers consisted of 43 papers. These papers were analysed to find the relevant theories form the papers.

As shown in table 1, the list consists of 22 papers under the keyword of 'supply chain risk' and 'supply resilience (SCR, SR). 11 papers represent 'supply chain disruption' (SCD, SD) and 10 papers represent the keyword 'supply chain uncertainty' (SCU, SU). All 74 papers could have been considered however it was decided to restrict numbers on the basis of the citation/year measure. Also, the decision to take into consideration a cumulative list involving the three keywords may bring in a limitation. However, it was also necessary to perceive whether supply chain - 'disruption', 'uncertainty', resilience' come under the umbrella of supply chain risk or are these completely separate academic areas. The papers are depicted in table1.



KEYWO	CITATI	Avg. Ci	AUTHORS	TITLE	YEAR	No of y	PUBLISHER
SCU, SU	493	61.625	IJ Chen...	Towards a theory of supply chain management: the constructs and measurements	2004	8	Journal of operations management
SCD, SD	454	56.75	S Chopra...	Supply-Chain Breakdown	2004	8	MIT Sloan management review
SCU, SU	314	52.33333	B Tomlin	On the value of mitigation and contingency strategies for managing supply chain disruptio	2006	6	Management Science
SCD, SD	516	51.6	HL Lee	Aligning supply chain strategies with product uncertainties	2002	10	California management review
SCR, SR	195	48.75	CR Carter, DS Rogers	A framework of sustainable supply chain management: moving toward new theor	2008	4	International Journal of Physical ...
SCR, SR	305	38.125	GP Cachon	The allocation of inventory risk in a supply chain: Push, pull, and advance-purcha	2004	8	Management Science
SCD, SD	445	37.08333	E Schwartz...	Short-term variations and long-term dynamics in commodity prices	2000	12	Management Science
SCD, SD	258	36.85714	KB Hendricks...	An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price	2005	7	Production and Operations ...
SCU, SU	147	36.75	A Kanda, SG Deshmukh	Supply chain coordination: Perspectives, empirical studies and research directions	2008	4	International Journal of Production Economics
SCR, SR	283	35.375	M Christopher...	Building the resilient supply chain	2004	8	International Journal of Logistics ...
SCU, SU	278	34.75	M Christopher...	Mitigating supply chain risk through improved confidence	2004	8	International Journal of Physical ...
SCR, SR	302	33.55556	C Harland, R Brenchley...	Risk in supply networks	2003	9	Journal of Purchasing and Supply ...
SCD, SD	356	32.36364	JD Sterman	System Dynamics Modeling	2001	11	California management review
SCD, SD	194	32.33333	CS Tang	Perspectives in supply chain risk management	2006	6	International Journal of Production Economics
SCR, SR	290	32.22222	U Jüttner, H Peck...	Supply chain risk management: outlining an agenda for future research	2003	9	International Journal of ...
SCR, SR	240	30	A Norrman...	Ericsson's proactive supply chain risk management approach after a serious sub-s	2004	8	International Journal of Physical ...
SCR, SR	120	30	I Manuj, JT Mentzer	Global supply chain risk management strategies	2008	4	International Journal of Physical ...
SCR, SR	232	29	J Hallikas, I Karvonen, U Pulkki	Risk management processes in supplier networks	2004	8	International Journal of ...
SCR, SR	203	29	U Jüttner	Supply chain risk management: Understanding the business requirements from a	2005	7	International Journal of Logistics Management,
SCD, SD	314	28.54545	Y Sheffi	Supply chain management under the threat of international terrorism	2001	11	International Journal of Logistics Management,
SCU, SU	254	28.22222	S Minner	Multiple-supplier inventory models in supply chain management: A review	2003	9	International Journal of Production Economics
SCR, SR	160	26.66667	TY Choi...	The supply base and its complexity: Implications for transaction costs, risks, respo	2006	6	Journal of Operations Management
SCD, SD	159	26.5	CS Tang	Robust strategies for mitigating supply chain disruptions	2006	6	International Journal of Logistics: Research and
SCU, SU	102	25.5	T Van Der Vaart...	A critical review of survey-based research in supply chain integration	2008	4	International Journal of Production ...
SCU, SU	277	25.18182	M Fleischmann, P Beullens...	The impact of product recovery on logistics network design	2001	11	Production and ...
SCR, SR	174	24.85714	H Peck	Drivers of supply chain vulnerability: an integrated framework	2005	7	International Journal of Physical Distribution &
SCU, SU	148	24.66667	J Mula, R Poler, JP Garcia-Sab	Models for production planning under uncertainty: A review	2006	6	International Journal of ...
SCR, SR	95	23.75	FTS Chan, N Kumar, MK Tiwari	Global supplier selection: a fuzzy-AHP approach	2008	4	International Journal of ...
SCD, SD	164	23.42857	Y Sheffi...	A supply chain view of the resilient enterprise	2005	7	MIT Sloan Management Review
SCR, SR	93	23.25	S Waddock	Building a new institutional infrastructure for corporate responsibility	2008	4	The Academy of Management ...
SCR, SR	69	23	MJ Braunscheidel...	The organizational antecedents of a firm's supply chain agility for risk mitigation a	2009	3	Journal of Operations Management
SCR, SR	206	22.88889	GA Zsidisin	Managerial perceptions of supply risk	2003	9	Journal of Supply Chain Management
SCR, SR	90	22.5	C Tang...	The power of flexibility for mitigating supply chain risks	2008	4	International Journal of Production Economics
SCD, SD	108	21.6	M Dada, NC Petruzzi...	A newsvendor's procurement problem when suppliers are unreliable	2007	5	Manufacturing & Service ...
SCU, SU	108	21.6	M Stevenson...	Flexibility from a supply chain perspective: definition and review	2007	5	International Journal of Operations & ...
SCD, SD	129	21.5	S Geary, SM Disney...	On bullwhip in supply chains—historical review, present practice and expected fu	2006	6	International Journal of Production ...
SCR, SR	169	21.125	GA Zsidisin, LM Ellram, JR Cart	An analysis of supply risk assessment techniques	2004	8	International Journal of ...
SCR, SR	63	21	AM Knemeyer, W Zinn...	Proactive planning for catastrophic events in supply chains	2009	3	Journal of Operations Management
SCR, SR	63	21	D Neiger, K Rotaru...	Supply chain risk identification with value-focused process engineering	2009	3	Journal of Operations Management
SCU, SU	102	20.4	A Gunasekaran, B Kobu	Performance measures and metrics in logistics and supply chain management: a review o	2007	5	International Journal of Production ...
SCR, SR	81	20.25	SM Wagner...	An empirical examination of supply chain performance along several dimensions	2008	4	Journal of Business Logistics
SCR, SR	160	20	RE Spekman...	Risky business: expanding the discussion on risk and the extended enterprise	2004	8	International Journal of Physical ...
SCR, SR	80	20	I Manuj, JT Mentzer	Global supply chain risk management	2008	4	Journal of Business Logistics

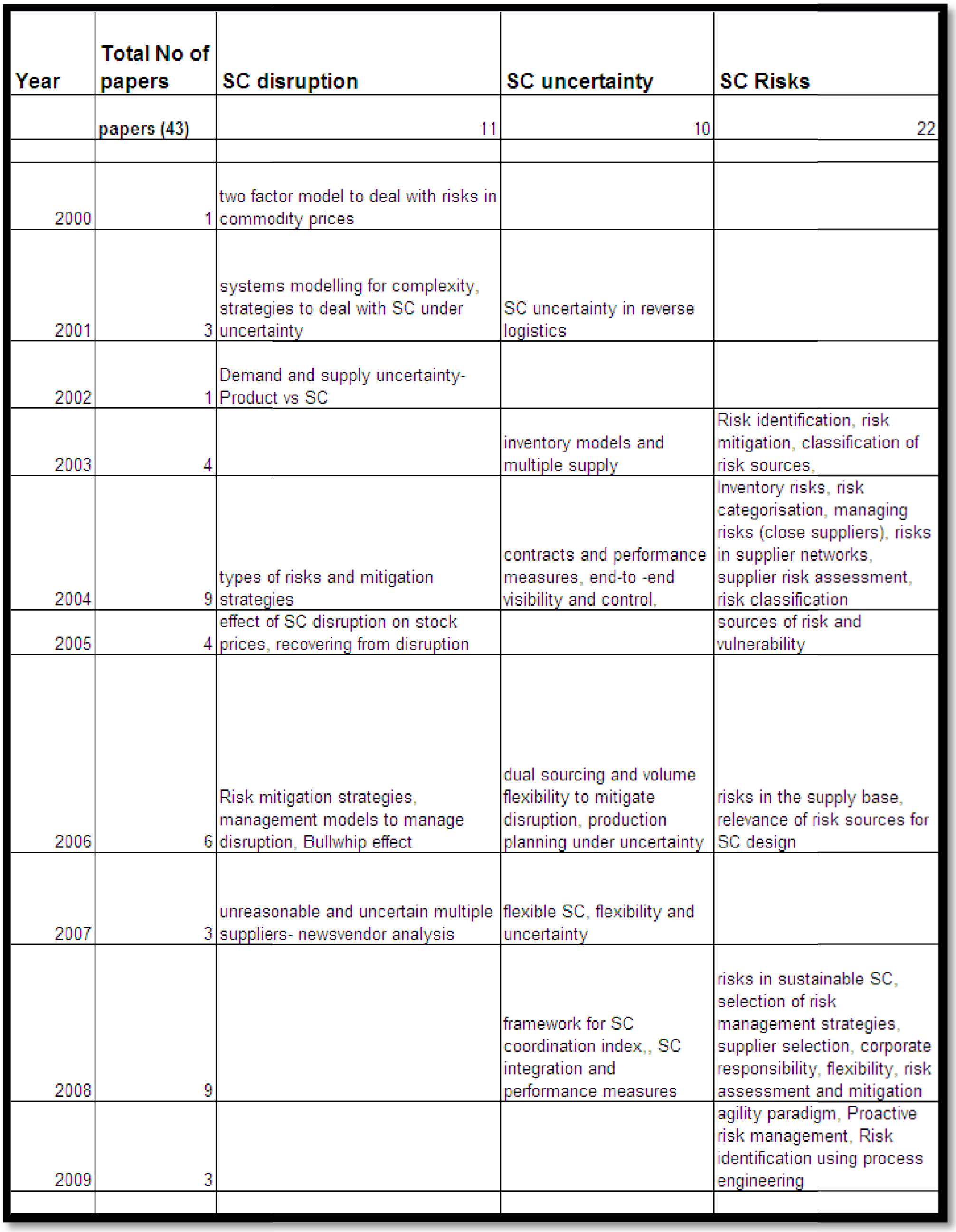
Table 1: 43 papers selected for the analysis

ANALYSIS AND FINDINGS

The selected papers were analysed to understand the various theories, frameworks, models that were put forth by the authors. It was decided to differentiate the papers according to the 3 keywords 'risk', 'disruption' and 'uncertainty' to locate whether the concepts studied under these areas are common or different. The areas covered in the selected papers are represented in table 2.

With regards to '**supply chain disruption',** the papers in the cohort are until 2007 and range from the relation between 'commodity prices', 'demand uncertainty', 'supply uncertainty' and 'supply chain disruption'. One paper studies the influence of supply chain disruption on stock prices. There are ten papers in the cohort on '**supply chain uncertainty'**. The discussion in these papers deals with trying to manage uncertainty and hence the topics range from 'flexibility', 'performance measures', 'end-to-end visibility'. The numbers of papers under the keyword of '**supply chain risk'** cover 50% of the selected cohort. Table 2 depicts that the focus on supply chain risks gained momentum from 2003 and has had a steady increase until 2010 (the range for this study). Although there have been papers before 2003 on uncertainty and disruption, the major papers on 'risk' started achieving impact since 2003. A majority of the papers from the 'supply chain risks' cohort feature on 'risk identification', 'risk assessment' and 'risk mitigation strategies'. The major focus is on risk identification (supply side risks) and the earlier papers discuss risk mitigation strategies. Interestingly, in recent years (2008 and 2009) risks have been discussed within the context of **sustainability** ('triple bottom line effect'), **corporate responsibility** and the context of '**proactive risk management'**.

The limitation of this analysis is that some of the papers have not been considered due to the limits set for filtering. These papers have been shown in the Appendix. Considering the papers in the appendix, it can be inferred that it depicts a similar pattern to the selected cohort with the initial years having a focus on risk management but the latter years having varied topics and the focus towards ‘sustainability’.



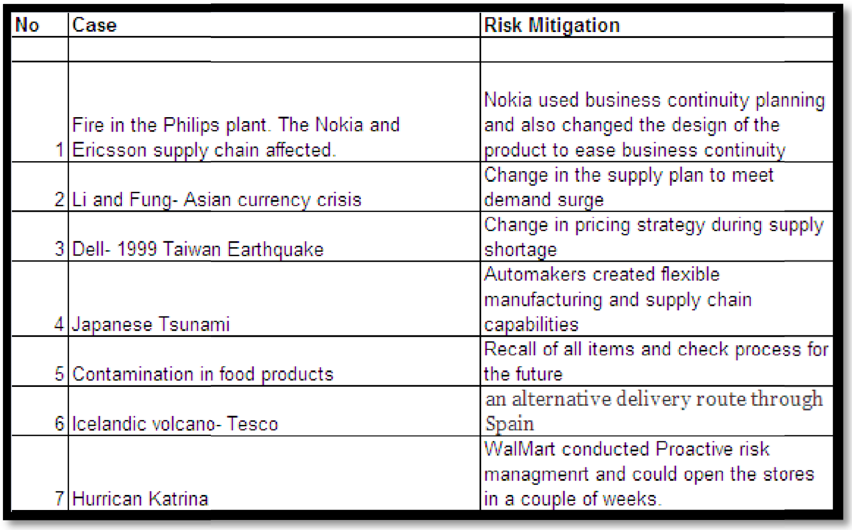
Year	Total No of papers	SC disruption	SC uncertainty	SC Risks
	papers (43)	11	10	22
2000	1	two factor model to deal with risks in commodity prices		
2001	3	systems modelling for complexity, strategies to deal with SC under uncertainty	SC uncertainty in reverse logistics	
2002	1	Demand and supply uncertainty- Product vs SC		
2003	4		inventory models and multiple supply	Risk identification, risk mitigation, classification of risk sources,
2004	9	types of risks and mitigation strategies	contracts and performance measures, end-to -end visibility and control,	Inventory risks, risk categorisation, managing risks (close suppliers), risks in supplier networks, supplier risk assessment, risk classification
2005	4	effect of SC disruption on stock prices, recovering from disruption		sources of risk and vulnerability
2006	6	Risk mitigation strategies, management models to manage disruption, Bullwhip effect	dual sourcing and volume flexibility to mitigate disruption, production planning under uncertainty	risks in the supply base, relevance of risk sources for SC design
2007	3	unreasonable and uncertain multiple suppliers- newsvendor analysis	flexible SC, flexibility and uncertainty	
2008	9		framework for SC coordination index,, SC integration and performance measures	risks in sustainable SC, selection of risk management strategies, supplier selection, corporate responsibility, flexibility, risk assessment and mitigation
2009	3			agility paradigm, Proactive risk management, Risk identification using process engineering

Table 2: analysis of the selected papers

CONCLUSION AND FUTURE SCOPE

The paper has presented a snapshot of the most popular supply chain risk papers in the last ten years. The study was limited to only those papers that have a high citation/year score. The analysis has depicted that in the last decade academics across the globe focussed on understanding the concepts of risk management as applied to supply chain risks. The initial years focussed on looking at establishing a definition of supply chain risk management with a multi disciplinary approach to understanding ’risks’. Academics presented frameworks and models to identify risks, assess the importance of these risks and suggested strategies to mitigate these risks. In the latter half of the decade the number of papers on this subject increased and the discussion was focussed on research into the areas of supply risks and supplier side issues, coupled with the increasing focus towards sustainability challenges. Increasingly, natural disasters and 'black swans' have been affecting supply chains and multinational companies greatly towards the end of the decade. The research primarily started as 'qualitative' in nature. As the subject area was being researched deeply, the papers started getting more 'quantitative' in nature, utilising survey based statistics, OR methods and mathematical modelling.

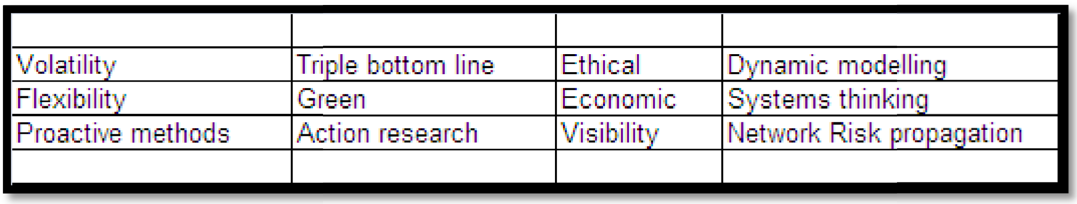
One of the challenges facing academics within the area of supply chain risks is to determine whether the knowledge generated creates an impact within industry. Most papers on this subject tend to reflect on events affecting supply chains and the strategies used by the companies involved. Although the papers present models and strategies, and are qualitative in nature, very few papers present the validation of the suggested frameworks as a proactive methodology. Some of the cases are as follows:



No	Case	Risk Mitigation
1	Fire in the Philips plant. The Nokia and Ericsson supply chain affected.	Nokia used business continuity planning and also changed the design of the product to ease business continuity
2	Li and Fung- Asian currency crisis	Change in the supply plan to meet demand surge
3	Dell- 1999 Taiwan Earthquake	Change in pricing strategy during supply shortage
4	Japanese Tsunami	Automakers created flexible manufacturing and supply chain capabilities
5	Contamination in food products	Recall of all items and check process for the future
6	Icelandic volcano- Tesco	an alternative delivery route through Spain
7	Hurrican Katrina	WalMart conducted Proactive risk managmenrt and could open the stores in a couple of weeks.

Table 3: Industry examples of supply chain risk mitigation

The next decade will see a focus on the following sub-areas:



Volatility	Triple bottom line	Ethical	Dynamic modelling
Flexibility	Green	Economic	Systems thinking
Proactive methods	Action research	Visibility	Network Risk propagation

Table 4: future research areas

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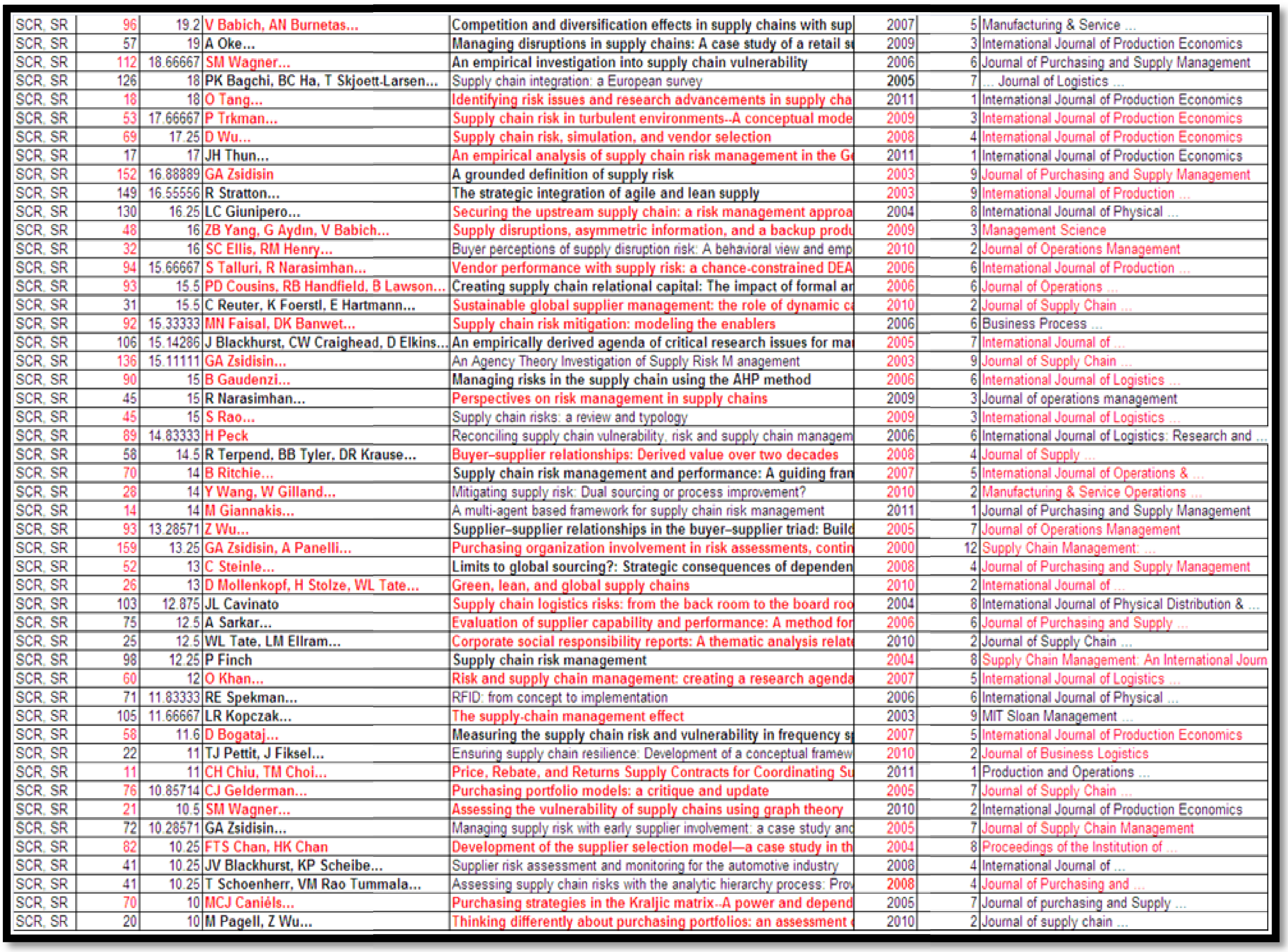
Appendix: the other papers not considered (**Citation per year** of 10 ~ 20)



SCR, SR	96	19.2	V Babich, AN Burnetas...	Competition and diversification effects in supply chains with sup	2007	5	Manufacturing & Service ...
SCR, SR	57	19	A Oke...	Managing disruptions in supply chains: A case study of a retail s	2009	3	International Journal of Production Economics
SCR, SR	112	18.66667	SM Wagner...	An empirical investigation into supply chain vulnerability	2006	6	Journal of Purchasing and Supply Management
SCR, SR	126	18	PK Bagchi, BC Ha, T Skjoett-Larsen...	Supply chain integration: a European survey	2005	7	... Journal of Logistics ...
SCR, SR	18	18	O Tang...	Identifying risk issues and research advancements in supply cha	2011	1	International Journal of Production Economics
SCR, SR	53	17.66667	P Trkman...	Supply chain risk in turbulent environments--A conceptual mode	2009	3	International Journal of Production Economics
SCR, SR	69	17.25	D Wu...	Supply chain risk, simulation, and vendor selection	2008	4	International Journal of Production Economics
SCR, SR	17	17	JH Thun...	An empirical analysis of supply chain risk management in the G	2011	1	International Journal of Production Economics
SCR, SR	152	16.88889	GA Zsidisin	A grounded definition of supply risk	2003	9	Journal of Purchasing and Supply Management
SCR, SR	149	16.55556	R Stratton...	The strategic integration of agile and lean supply	2003	9	International Journal of Production ...
SCR, SR	130	16.25	LC Giunipero...	Securing the upstream supply chain: a risk management approa	2004	8	International Journal of Physical ...
SCR, SR	48	16	ZB Yang, G Aydın, V Babich...	Supply disruptions, asymmetric information, and a backup produ	2009	3	Management Science
SCR, SR	32	16	SC Ellis, RM Henry...	Buyer perceptions of supply disruption risk: A behavioral view and emp	2010	2	Journal of Operations Management
SCR, SR	94	15.66667	S Talluri, R Narasimhan...	Vendor performance with supply risk: a chance-constrained DEA	2006	6	International Journal of Production ...
SCR, SR	93	15.5	PD Cousins, RB Handfield, B Lawson...	Creating supply chain relational capital: The impact of formal ar	2006	6	Journal of Operations ...
SCR, SR	31	15.5	C Reuter, K Foerstl, E Hartmann...	Sustainable global supplier management: the role of dynamic ca	2010	2	Journal of Supply Chain ...
SCR, SR	92	15.33333	MN Faisal, DK Banwet...	Supply chain risk mitigation: modeling the enablers	2006	6	Business Process ...
SCR, SR	106	15.14286	J Blackhurst, CW Craighead, D Elkins...	An empirically derived agenda of critical research issues for ma	2005	7	International Journal of ...
SCR, SR	136	15.11111	GA Zsidisin...	An Agency Theory Investigation of Supply Risk M anagement	2003	9	Journal of Supply Chain ...
SCR, SR	90	15	B Gaudenzi...	Managing risks in the supply chain using the AHP method	2006	6	International Journal of Logistics ...
SCR, SR	45	15	R Narasimhan...	Perspectives on risk management in supply chains	2009	3	Journal of operations management
SCR, SR	45	15	S Rao...	Supply chain risks: a review and typology	2009	3	International Journal of Logistics ...
SCR, SR	89	14.83333	H Peck	Reconciling supply chain vulnerability, risk and supply chain managem	2006	6	International Journal of Logistics: Research and ...
SCR, SR	58	14.5	R Terpend, BB Tyler, DR Krause...	Buyer–supplier relationships: Derived value over two decades	2008	4	Journal of Supply ...
SCR, SR	70	14	B Ritchie...	Supply chain risk management and performance: A guiding fran	2007	5	International Journal of Operations & ...
SCR, SR	28	14	Y Wang, W Gilland...	Mitigating supply risk: Dual sourcing or process improvement?	2010	2	Manufacturing & Service Operations ...
SCR, SR	14	14	M Giannakis...	A multi-agent based framework for supply chain risk management	2011	1	Journal of Purchasing and Supply Management
SCR, SR	93	13.28571	Z Wu...	Supplier–supplier relationships in the buyer–supplier triad: Build	2005	7	Journal of Operations Management
SCR, SR	159	13.25	GA Zsidisin, A Panelli...	Purchasing organization involvement in risk assessments, contin	2000	12	Supply Chain Management: ...
SCR, SR	52	13	C Steinle...	Limits to global sourcing?: Strategic consequences of dependen	2008	4	Journal of Purchasing and Supply Management
SCR, SR	26	13	D Mollenkopf, H Stolze, WL Tate...	Green, lean, and global supply chains	2010	2	International Journal of ...
SCR, SR	103	12.875	JL Cavinato	Supply chain logistics risks: from the back room to the board roo	2004	8	International Journal of Physical Distribution & ...
SCR, SR	75	12.5	A Sarkar...	Evaluation of supplier capability and performance: A method for	2006	6	Journal of Purchasing and Supply ...
SCR, SR	25	12.5	WL Tate, LM Ellram...	Corporate social responsibility reports: A thematic analysis relat	2010	2	Journal of Supply Chain ...
SCR, SR	98	12.25	P Finch	Supply chain risk management	2004	8	Supply Chain Management: An International Journ
SCR, SR	60	12	O Khan...	Risk and supply chain management: creating a research agenda	2007	5	International Journal of Logistics ...
SCR, SR	71	11.83333	RE Spekman...	RFID: from concept to implementation	2006	6	International Journal of Physical ...
SCR, SR	105	11.66667	LR Kopczak...	The supply-chain management effect	2003	9	MIT Sloan Management ...
SCR, SR	58	11.6	D Bogataj...	Measuring the supply chain risk and vulnerability in frequency s	2007	5	International Journal of Production Economics
SCR, SR	22	11	TJ Pettit, J Fiksel...	Ensuring supply chain resilience: Development of a conceptual framew	2010	2	Journal of Business Logistics
SCR, SR	11	11	CH Chiu, TM Choi...	Price, Rebate, and Returns Supply Contracts for Coordinating Su	2011	1	Production and Operations ...
SCR, SR	76	10.85714	CJ Gelderman...	Purchasing portfolio models: a critique and update	2005	7	Journal of Supply Chain ...
SCR, SR	21	10.5	SM Wagner...	Assessing the vulnerability of supply chains using graph theory	2010	2	International Journal of Production Economics
SCR, SR	72	10.28571	GA Zsidisin...	Managing supply risk with early supplier involvement: a case study and	2005	7	Journal of Supply Chain Management
SCR, SR	82	10.25	FTS Chan, HK Chan	Development of the supplier selection model—a case study in th	2004	8	Proceedings of the Institution of ...
SCR, SR	41	10.25	JV Blackhurst, KP Scheibe...	Supplier risk assessment and monitoring for the automotive industry	2008	4	International Journal of ...
SCR, SR	41	10.25	T Schoenherr, VM Rao Tummala...	Assessing supply chain risks with the analytic hierarchy process: Prov	2008	4	Journal of Purchasing and ...
SCR, SR	70	10	MCJ Caniëls...	Purchasing strategies in the Kraljic matrix--A power and depend	2005	7	Journal of purchasing and Supply ...
SCR, SR	20	10	M Pagell, Z Wu...	Thinking differently about purchasing portfolios: an assessment	2010	2	Journal of supply chain ...

FOOD SECURITY AND FOOD LOSSES: A PRODUCER TO PROCESSOR PERSPECTIVE

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ABSTRACT

This paper presents an exploratory analysis of the challenges faced by producers and processors in the agriculture produce supply chain in order to reduce food losses. Using data from secondary sources and by deploying a web-questionnaire to respondents within the food industry, this exploratory study identifies the key factors that contribute to post harvest food losses and the barriers and the enablers to reduce them. The findings are utilised and a framework is developed proposing solutions to those challenges. Future research directions are also identified.

INTRODUCTION

Food supply chain and particularly food security has received a great deal of attention lately due to issues related to scarcity of natural resources, population growth, fluctuating food prices, changing consumer habits and climate change etc (FAO, 2011). It has been estimated that between 25% and 50% of food produced is lost or wasted along the supply chain and does not reach consumers, depending on its position in the supply chain (FAO, 2010; Lundqvist et al, 2008). Reducing food losses can increase grain supply, food availability and food security without wasting any other resources such as land, labour, water and inputs (The World Bank, 2011; APO, 2006).

According to a recent study conducted by the FAO titled 'Global Food Losses and Food Waste' (Gustavsson et al, 2010), "food is lost or wasted throughout the supply chain, from initial agricultural production down to final household consumption". The authors suggest that food losses and waste in developing low income countries are related to the upstream supply chain (farm to processor), whereas the losses in the affluent world are related to the downstream supply chain (retailer to final consumer). This research provides an exploration of challenges with food losses in the upstream chain. The purpose of this paper is to identify the challenges producers and processors face in reducing food losses and proposes ways to address these challenges.

FOOD SECURITY & FOOD LOSSES

The World Food Summit (1996) was the first to define food security as "availability at all times of adequate world food suppliers of basic food stuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices". In recent times, food security is defined as "*A situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" (FAO, 2011). Food security comprises of four elements: food availability, food access, food utilisation and food stability (Defra, 2009). This research focuses on the aspect of food availability and its effect on food security. Food availability is the consistent availability of sufficient quantity of food. Improving food availability can increase food security (Yang et al, 2009). As much as it is important to increase the production of food to feed an ever increasing population, it is of utmost importance to utilise the currently produced food (available food) effectively and without wasting it.

From the literature reviewed it can be observed that there are a number of different interpretations defining food waste and food loss (Hodges et al, 2010; Kader, 2005; Williams et al, 2011; Atanda et al, 2011; WRAP, 2009). The World Economic Forum (2011) defines food loss as upstream loss in agriculture and transport prior to processing, and food waste as food fit for human consumption that is wasted in all further downstream parts of the value chain. Others refer to food loss as decrease of edible food mass throughout the supply chain from farm to fork or from production to consumption which is actually the same (Kader, 2005; Sharma et al, 2011; Paull et al, 1997). In some cases food waste is termed as as food loss occurring at the end of the food chain (Hodges et al, 2010; The World Bank, 2011). Food waste is food loss occurring during the retail, final consumption and post-consumption stages due to the behaviour of retailers and consumers (FAO, 2011; Parfitt et al, 2010). This research aims to address the food losses problem as one that occurs from producers to processors and does not consider any other entities or the consumers' side.

KEY FACTORS CONTRIBUTE TO FOOD LOSSES

Through an extensive literature review the main factors contributing to food losses between producers and processors are formed and can be classified into environmental, product related, process related, management related, and industry related factors. Table 1 lists the categories of factors affecting food losses, and also presents the different components in each category and the relevant literature identified.

Categories of factors	Different Factors affecting food losses	Authors
Environmental factors	seasonality, catastrophic failures, weather patterns, disease & insect infestation.	Basavaraja et al, 2007; Hodges et al, 2010; FAO, 2006; Mena et al, 2011; WRAP, 2011
Product related factors	highly perishable, shelf life, inappropriate packaging, product damage during transportation.	Kantor et al, 1997; Paull et al, 1997
Process related factors	inappropriate warehouses, inappropriate transportation, lack or inappropriate, equipment.	Kantor et al, 1997; FAO, 2011; Paull et al, 1997; Stuart, 2009
Management related factors	poor demand forecasting, inventory management, lack of knowledge about how to handle the crops, relationship factors among partners.	Defra, 2006; Mena et al, 2011; FAO, 2011; Kader, 2005; FAO, 2006
Industry related factors	international and national food policies, food safety and food quality standards.	Kader, 2010; Paull et al, 1997; FAO, 2006; Mena et al, 2011

Table 1. Generic factors contributing to food losses

The factors to be examined first may include those related to management issues. The management issues can be directly addressed by the chain members. For example, food chain members can influence inventory management and demand forecasting in faster pace than any other industry related factors such as food policies and food quality standards.

DESCRIPTION OF THE PROBLEM

Food losses inhibit worlds' food security. Food availability needs to be increased; however there are major constraints such as scarcity of natural resources and availability of land for production. Reducing food losses seems to be an important way to increase food security without requiring or wasting any other resources. Although there are studies available to understand this issue, the rate of reduction in losses is still very low. The problem of food loss is quite well represented in industrial reports; however there is a lack of empirical academic research. Identifying the challenges (key factors contributing to food losses and the barriers) producers and processors face in reducing food losses helps in proposing a framework to overcome them.

RESEARCH METHODOLOGY

The research stems from two research questions:

RQ1: What are the challenges faced by the upstream entities in the agriculture produce supply chain to reduce food losses?
RQ2: How can the value chain provide the necessary processes to reduce food losses?

A qualitative approach was conducted in two stages. The first stage involved secondary data analysis in the form of an extensive literature review examining journal papers, industry reports and websites of professional organisations. The second stage consisted of a web-survey questionnaire deployed via 'surveymonkey' to respondents within the upstream segment of the food supply chain. The respondents were producers, processors, marketeers, manufacturers, retailers, consultants and managers from the food sector. The respondents were represented in a 'Linkedin' group of the same subject. The survey aimed to identify the perceptions of the food chain members with regards to the following issues:

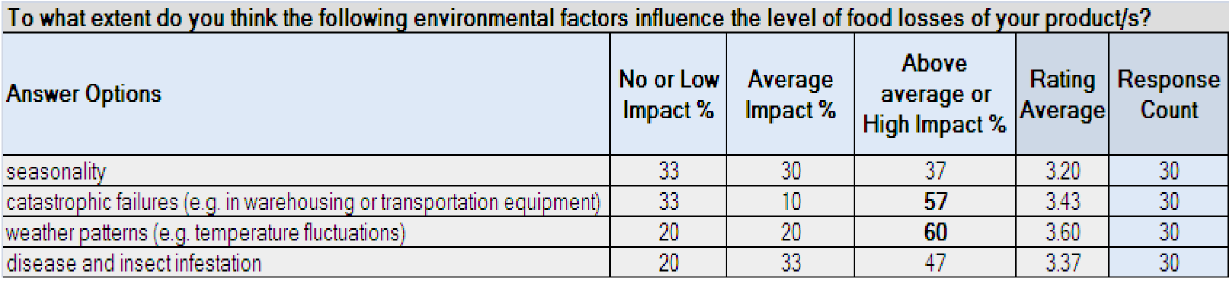
a. The key factors identified in the literature to contribute to food losses,
b. The main barriers that supply chain entities face in reducing the food losses;
c. what are the most appropriate practices that the supply chain entities perceive as important in reducing food losses.

RESULTS & ANALYSIS

Participants of the conducted web-survey were currently based in India (38.1%), Europe (23.8%), Eastern Europe (9.5%), South East Asia (9.5%) and USA (4.8%). Although, forty six respondents attempted the questionnaire, on an average thirty respondents attempted most of the key questions.

Key factors contributing to food losses

The questions were formed in a 5 point likert scale format. Based on the key factors contributing to food losses identified through the extensive literature review, respondents were asked to choose the impact of each factor (from no impact to high impact) for their products. The analysis shown in table 2 has depicted the results in three columns instead of five. Table 2 shows that two factors (weather patterns and catastrophic failures) have been identified by the respondents as being important for considering food losses.

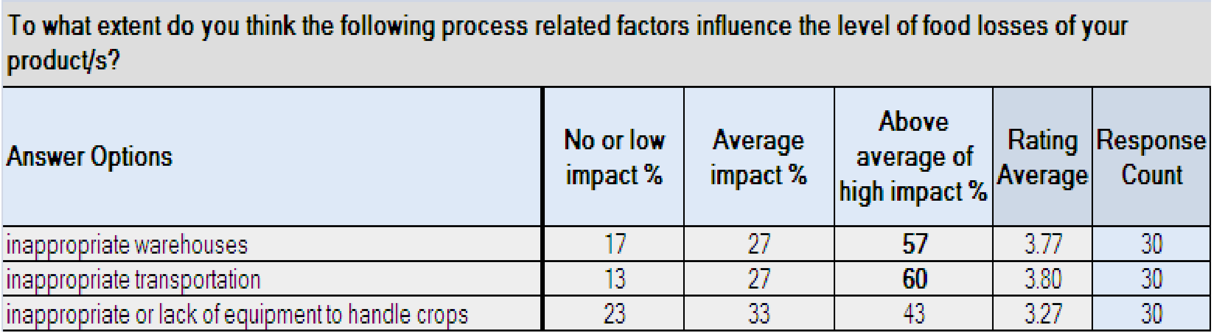


To what extent do you think the following environmental factors influence the level of food losses of your product/s?

Answer Options	No or Low Impact %	Average Impact %	Above average or High Impact %	Rating Average	Response Count
seasonality	33	30	37	3.20	30
catastrophic failures (e.g. in warehousing or transportation equipment)	33	10	**57**	3.43	30
weather patterns (e.g. temperature fluctuations)	20	20	**60**	3.60	30
disease and insect infestation	20	33	47	3.37	30

Table 2: Environmental factors influencing post harvest food losses

Table 3 depicts the perspectives of the respondents with regards to process related factors. Inappropriate transportation (60%) and Inappropriate warehouses (57%) were identified as being factors influencing food losses. This also highlights the requirement of appropriate assets within the upstream food supply chain.

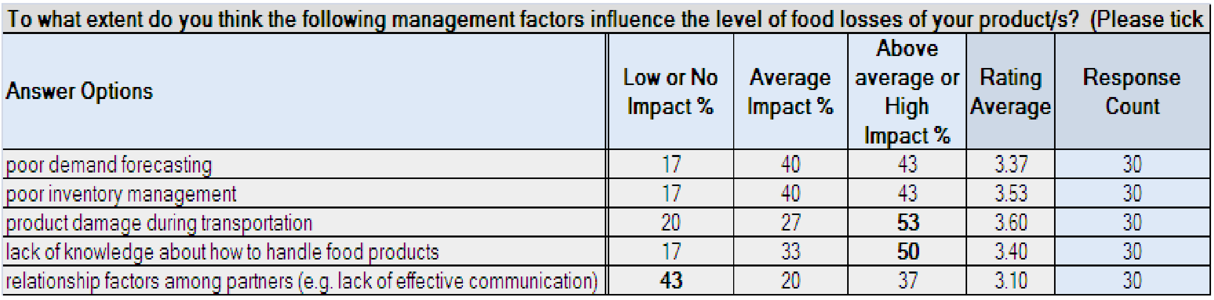


To what extent do you think the following process related factors influence the level of food losses of your product/s?

Answer Options	No or low impact %	Average impact %	Above average of high impact %	Rating Average	Response Count
inappropriate warehouses	17	27	**57**	3.77	30
inappropriate transportation	13	27	**60**	3.80	30
inappropriate or lack of equipment to handle crops	23	33	43	3.27	30

Table 3: process factors affecting post harvest food losses

Table 4 depicts the influence of management factors (within the supply chain) on the extent of food losses. Product damage during transportation and lack of knowledge in handling food were the significant factors which had a high impact on the level of food losses. This also highlights the challenges of training and availability of skilled people within the upstream food supply chain. Relationship and communication among supply chain partners' featured as having a low impact on the level of food losses.



To what extent do you think the following management factors influence the level of food losses of your product/s? (Please tick

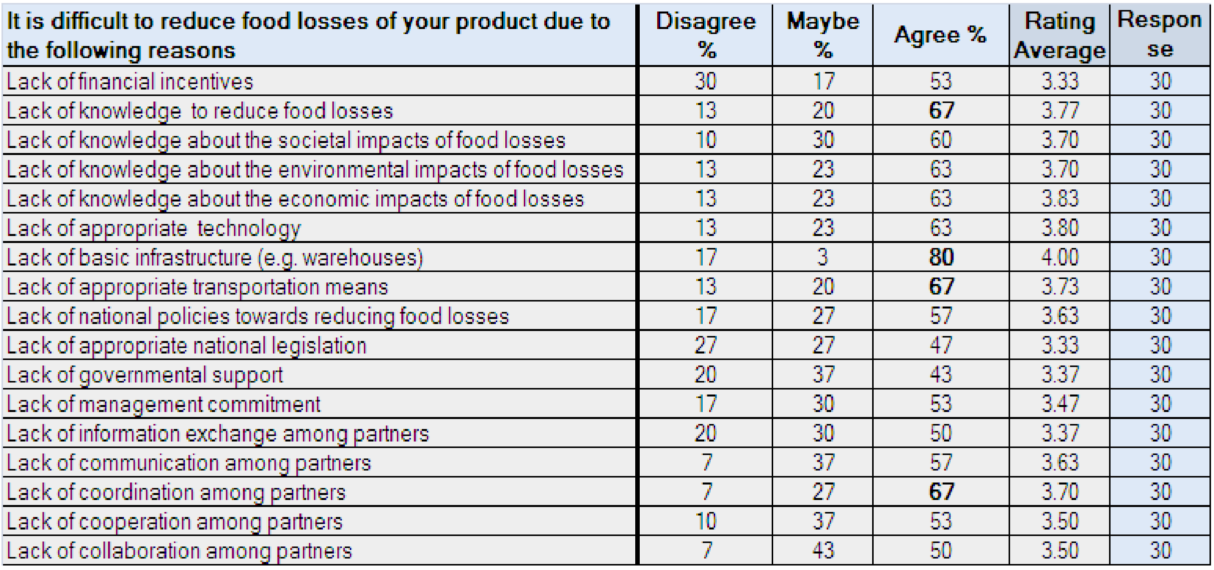
Answer Options	Low or No Impact %	Average Impact %	Above average or High Impact %	Rating Average	Response Count
poor demand forecasting	17	40	43	3.37	30
poor inventory management	17	40	43	3.53	30
product damage during transportation	20	27	**53**	3.60	30
lack of knowledge about how to handle food products	17	33	**50**	3.40	30
relationship factors among partners (e.g. lack of effective communication)	**43**	20	37	3.10	30

Table 4. Key factors contributing to post harvest food losses

Barriers in reducing food losses

The questions were formed in a 5 point Likert scale format. Based on the key factors contributing to food losses identified through the extensive literature review, respondents were asked to choose whether they agree or disagree with the factors listed out as barriers to reduce food losses. The analysis shown in table 5 has depicted the results in three columns instead of five. Thirty respondents completed this section of the questionnaire. Although the table depicts a number of factors as having a high value of agreement, the most striking are: lack of basic infrastructure (80%), lack of appropriate transportation means (67%), lack of knowledge to reduce food losses (67%), lack of coordination among partners (67%). Although the previous table depicted that relationship among partners to be of low impact, considering table 3 and table 4, it is evident that the two most barriers are:

1. Lack of appropriate infrastructure (including storage and transport).
2. Lack of coordination and skills (including training) across supply chain entities.

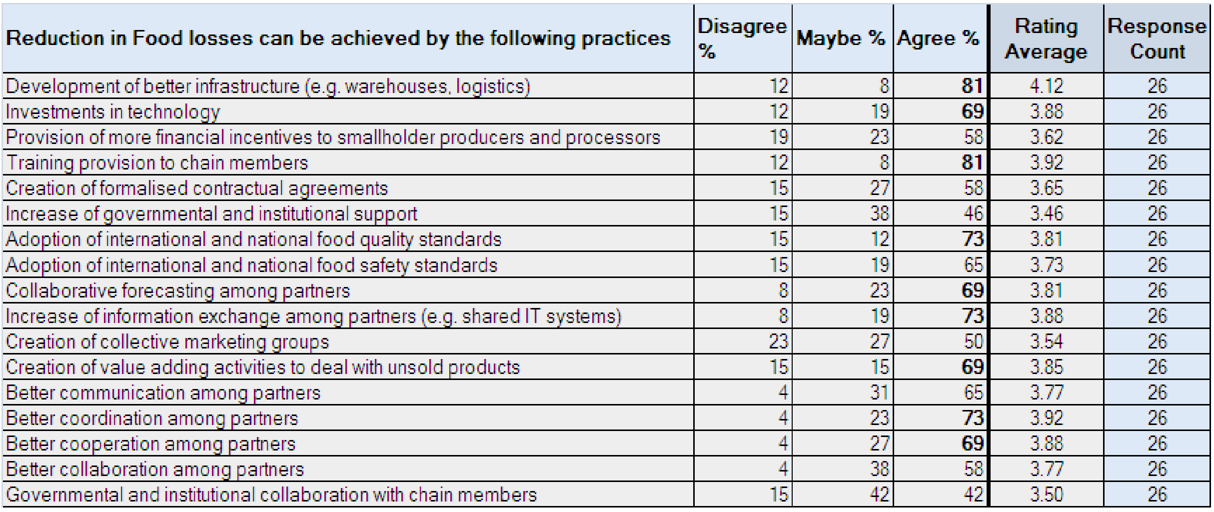


It is difficult to reduce food losses of your product due to the following reasons	Disagree %	Maybe %	Agree %	Rating Average	Response
Lack of financial incentives	30	17	53	3.33	30
Lack of knowledge to reduce food losses	13	20	**67**	3.77	30
Lack of knowledge about the societal impacts of food losses	10	30	60	3.70	30
Lack of knowledge about the environmental impacts of food losses	13	23	63	3.70	30
Lack of knowledge about the economic impacts of food losses	13	23	63	3.83	30
Lack of appropriate technology	13	23	63	3.80	30
Lack of basic infrastructure (e.g. warehouses)	17	3	**80**	4.00	30
Lack of appropriate transportation means	13	20	**67**	3.73	30
Lack of national policies towards reducing food losses	17	27	57	3.63	30
Lack of appropriate national legislation	27	27	47	3.33	30
Lack of governmental support	20	37	43	3.37	30
Lack of management commitment	17	30	53	3.47	30
Lack of information exchange among partners	20	30	50	3.37	30
Lack of communication among partners	7	37	57	3.63	30
Lack of coordination among partners	7	27	**67**	3.70	30
Lack of cooperation among partners	10	37	53	3.50	30
Lack of collaboration among partners	7	43	50	3.50	30

Table 5. Barriers in reducing post harvest food losses

Enablers in reducing food losses

The questions were formed in a 5 point likert scale format. Based on the key factors contributing to food losses identified through the extensive literature review, respondents were asked to choose whether they agree or disagree with the factors listed out as barriers to reduce food losses. The analysis shown in table 5 has depicted the results in three columns instead of five. Twenty six respondents completed this section of the questionnaire. Although the table depicts a number of factors as having a high value of agreement, the most striking are: Development of better infrastructure (e.g. warehouses, logistics) (81%), Training provision to chain members (81%), Adoption of international and national food quality standards (73%), Increase of information exchange among partners (e.g. shared IT systems) (73%), Better coordination among partners (73%), Better cooperation among partners (69%), Creation of value adding activities to deal with unsold products (69%), Collaborative forecasting among partners (69%),Investments in technology (69%).



Reduction in Food losses can be achieved by the following practices	Disagree %	Maybe %	Agree %	Rating Average	Response Count
Development of better infrastructure (e.g. warehouses, logistics)	12	8	**81**	4.12	26
Investments in technology	12	19	**69**	3.88	26
Provision of more financial incentives to smallholder producers and processors	19	23	58	3.62	26
Training provision to chain members	12	8	**81**	3.92	26
Creation of formalised contractual agreements	15	27	58	3.65	26
Increase of governmental and institutional support	15	38	46	3.46	26
Adoption of international and national food quality standards	15	12	**73**	3.81	26
Adoption of international and national food safety standards	15	19	65	3.73	26
Collaborative forecasting among partners	8	23	**69**	3.81	26
Increase of information exchange among partners (e.g. shared IT systems)	8	19	**73**	3.88	26
Creation of collective marketing groups	23	27	50	3.54	26
Creation of value adding activities to deal with unsold products	15	15	**69**	3.85	26
Better communication among partners	4	31	65	3.77	26
Better coordination among partners	4	23	**73**	3.92	26
Better cooperation among partners	4	27	**69**	3.88	26
Better collaboration among partners	4	38	58	3.77	26
Governmental and institutional collaboration with chain members	15	42	42	3.50	26

Table 6. Enablers in reducing post harvest food losses

From the analysis it is evident that there are three factors important from the aspect of enablers:

1. Better infrastructure
2. Better coordination among supply chain partners
3. Better skills, training and information sharing

DISCUSSION

The challenges faced by producers and processors in the agriculture chain towards reducing food losses are related to the key factors contributing to food losses and the key barriers to reduce them. Taking into consideration the secondary source analysis and the survey results, recommendations to overcome challenges in reducing food losses are proposed and a framework for systemic thinking is created (Figure 1). In order to reduce food losses the management and process related practices need to be considered:

Coordination, cooperation, collaboration: Coordination involves more efficient communication among partners with regards to how they should work and act together (Lozano, 2007). Cooperation is about sharing goals and objectives, while collaboration involves creating common plans and sharing responsibilities (Denise, 1999). Collaboration among food chain members is speculated to be an initial step to address key factors contributing to food losses (Mena et al, 2011). Better relations and collaborative action could enable reduction in food losses (WRAP, 2011).

Transparency: Transparency in the form of information exchange and collaborative forecasting emerges as a significant way for the development of better relationships among partners.

Human management: Human management in terms of training provision and creation of formalised contractual agreements found to accelerate food losses reduction. Managing humans in ways that facilitate food production and simultaneously control relationships appears to be a crucial way in reducing food losses.

Technology & infrastructure development: Investments in technology are considered to be essential for better processing of food and better management of processed food (Hodges et al, 2010). Development of better infrastructure is a crucial step for reducing food losses including creation of better warehouses and logistics development such as cold chain facilities and handling equipment (Choudhury, 2006). Both technological and infrastructural improvements are needed for a holistic solution to the food loss problem.

Alternative ways to process food: Creation of value adding activities and formation of collective marketing groups in order to process unsold food are proposed as ways to reduce food losses (FAO, 2011). The respondents of the web-survey indicated that value adding activities and collective marketing groups could possibly enable food losses reduction.

All possible ways to reduce food losses mentioned above need to be considered in relation to the existing international and national food safety and quality standards.

CONCLUSION & FURTHER RESEARCH

This paper has presented insights from a qualitative exploratory study conducted to identify the challenges faced by the upstream food chain members towards reducing food losses. The survey has identified the barriers affecting the reduction in food losses. The survey has also been successful in identifying the enablers to overcome the barriers and there is consistency between the identified barriers and enablers.

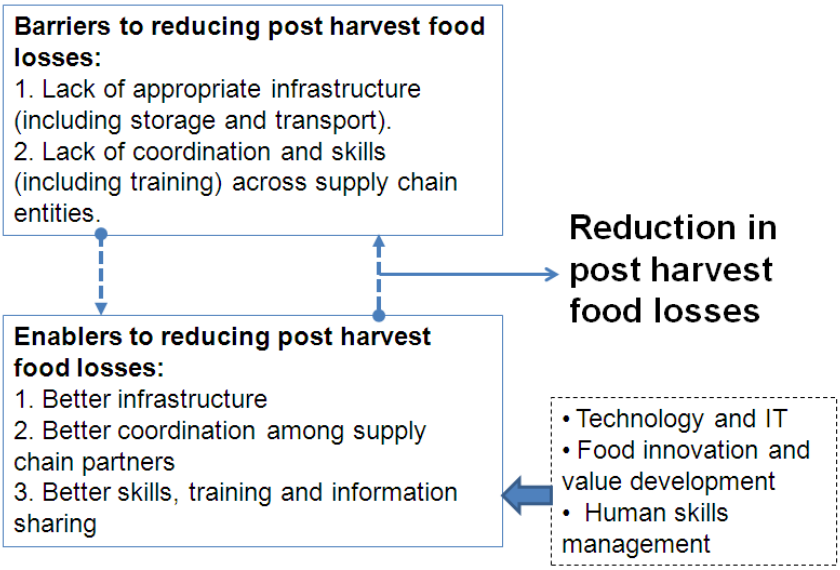


Figure 1. Framework for systemic thinking towards reducing post harvest food losses

The paper also presents a research framework to address reduction in food losses. The main limitation of this study is that the respondents of the web-survey could not be controlled in terms of appropriate sampling. However, the exploratory nature of the questionnaire overcomes this limitation to some extent. In the future it will be beneficial to conduct the survey with purposeful sampling so that the appropriate respondents can be identified and surveyed. The framework needs to be operationalised and the connections between various factors need to be tested for better implementation of food loss reduction programmes.

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DYNAMIC COMPLEXITY IN SUPPLY CHAIN MANAGEMENT

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INTRODUCTION

The overall aim of this paper is to demonstrate the validity of the complex adaptive systems (CAS) perspective (Choi et al, 2001) in considering the operational decision-making processes within a healthcare manufacturing supply chain. The focus of the research is on the supply chain elements associated with customer demand forecasting and the scheduling of production. A classic symptom of CAS as evidenced in such elements is the bullwhip effect (Wycisk et al., 2008) which has implications for supply chain costs. The various elements that make up a supply chain may be described as detail complexity while the variance seen in demand, as per the bullwhip effect, often resulting from how those various elements interact is called dynamic complexity (Bozarth et al., 2009). Many management performance measures are associated with the former, such as service levels, schedule adherence and defect rates.

The paper seeks to answer the following research questions;

1. Are CAS attributes and associated symptoms, such as the bullwhip effect, evidenced in a real-world healthcare supply chain?
2. Does management understanding of dynamic complexity provide opportunities for supplementary forms of performance measure?

LITERATURE REVIEW

The challenge of supply chain management (SCM) is to generate an optimal configuration within the value-chain, or system, taking into account supply inputs, manufacturing processes, different product characteristics, distribution requirements and customer demands and the workforce "in order to form an effective and efficient supply chain in a simultaneous and integrated manner" (Huang et al., 2005 p.268).

SCM decisions relating to strategies and objectives are under constant pressure due to the dynamic environment within which they are taken. Managers within the supply chain have to take into account growing amounts of information as more data continues to become available from the environment, partners in the supply chain and internal sources. Compounding this, is that the greater the task uncertainty the greater the amount of information that must be processed among decision makers deciding on task execution to achieve a desired level of performance. The consequence of such a situation is that organisations that are unable to interpret and lever vast amounts of information will likely fail to maintain adequate performance in their competitive environment.

It is within this context that understanding the complexity of the supply chain has gained importance. Complexity results in increased uncertainty (measured, for example as missed orders, material and cost variance, lack of raw materials etc.) which "propagates through a manufacturing network" (Davies 1993, p.35) and makes a supply chain "inflexible and inefficient" (Hoole, 2006, p.4).

A means of conceptualising complexity in a supply chain is to use a complex systems perspective. This mirrors the supply chain, in that it recognises the existence of individual agents in the system, but focuses on the 'interconnectedness' of the relationships that exist. Supply chains tend to be viewed as closed systems, not affected by their surroundings and therefore inward looking. If a snap shot of the supply chain were to be taken it would appear stable and orderly.

Choi et al.'s (2001) seminal paper on the CAS perspective within SCM, defines a CAS as an "interconnected network of multiple entities that exhibit adaptive response to changes in both the environment and the system of entities itself". This is expanded on by Pathak et al. (2007, p. 550) by stating that "collective performance or behaviour emerges as a non-linear and dynamic function of the large number of activities made in parallel by interacting entities". This can therefore be considered within a learning context in that they are "capable of evolving and changing themselves to adapt to a changing environment" (Surana et al, 2005, p. 4238).

Complexity may be further divided into two types; detail and dynamic Bozarth et al. (2009, p.79) define detail complexity as the "distinct number of components or parts that make up a system" and the second type, dynamic complexity, is the "unpredictability of a system's response to a given set of inputs, driven in part by the interconnectedness of the many parts that make up the system". To further expand this concept, Sterman (2001, p.11) offers that dynamic complexity is "the often counterintuitive behaviour of complex systems that arises from the interactions of the agents over time" while Senge (1990, p.71) states that it involves "situations where cause and effect are subtle, and where the effects over time of interventions are not obvious".

A classic symptom of complex systems is output variance, of which in supply chains the pheneomenon known as the Bullwhip effect is the best known (Paik and Bagchi, 2005) where "as moving backward from a downstream member to an upstream member, the variance of order quantities placed by the downstream member to its (immediate) upstream member tends to be amplified" (Duc et al., 2008, p.244). Uncertainty caused in the SC planning and management systems due to this distorted information flow down the length of the SC can lead to tremendous inefficiencies and cost (Fisher et al., 1997, Shukla et al., 2009). These on-costs will be reflected in company metrics such as customer service levels, lost sales, distribution costs and failure to hit production targets, for example. Also of concern is the inventory, or net stock, variance. This is important because as Disney et al. (2006, p.152) explains it affects the supply chain's ability to "meet service levels in a cost-effective manner".

RESEARCH METHOD

A deductive approach is utilised. Building on existing theory the literature review synthesises existing research in order to develop the research gaps and questions. A case study approach is then adopted with a researcher working closely with a host organisation. The case manufacturing company is a global manufacturer of healthcare products. It supplies disease diagnosing, monitoring and screening solutions to the transfusion medical community including hospitals, laboratories and blood centres worldwide. The unit of analysis is a divergent network consisting of the manufacturing plant with inbound supply of material with finished products passing through two different distribution channels, one via North America and the other via Europe.

A key strategy of the company is to offer the best customer service possible. This has to be done within a turbulent environment, in terms of changing customer demand and internal variations in the production process. The company's performance measures are driven by a fundamental requirement to ensure it consistently delivers its customers the high quality products that they expect with the specified product life, on time and in full. However, the optimal balance has to be found in terms of delivering the maximum customer utility while protecting the company's profitability.

Various methods were utilised in the data collection including interrogating existing documentation (e.g. value stream maps), interviews (e.g. open-ended with operations personnel), direct observations (e.g. walking the process) and analysing archival data (e.g. sales data). The latter includes measurements of bullwhip, BW, and net-stock amplification, NSAmp. BW, is taken as ${CoV_{OUT}}/{CoV_{IN}}$, where CoV_{IN} is the covariance of the demand coming into an echelon, D_{in} and CoV_{OUT} is the covariance of the demand being placed by an echelon. NSAmp, is the ratio ${\sigma_{NS}^2}/{\sigma_{D_{IN}}^2}$, where σ_{NS}^2 denotes the variance of the net stock and $\sigma_{D_{IN}}^2$ denotes the variance of input demand. The analysis is supplemented with cumulative sum (CUSUM) calculations.

FINDINGS

As shown in Figure 1, the factory operation can be divided into five separate areas: distribution, assembly, testing, component manufacture and raw material control (consisting of intake, testing and storage). The manufacturing plant distributes to two distribution centres (DC), one situated in continental Europe (EU) and the other situated in the United States (US). The US DC supplies directly to the final customer in the United States only whilst the EU DC covers the rest of the world – through affiliates in each particular country and then onto the final customer.

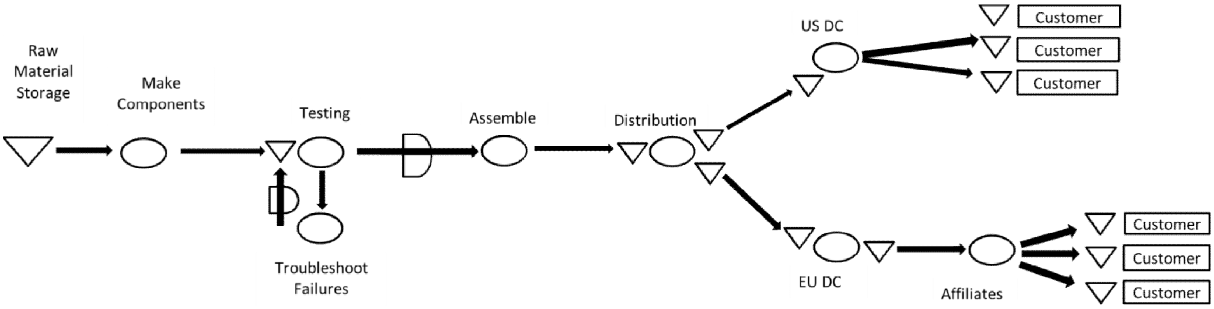

Figure 1: Supply chain overview

The components produced can be broken down into four different manufacturing streams, S1-S4, which are then brought together in the assembly stage to produce the finished product. For the purpose of this study the S1 production was focussed on as it is the largest volume product within the production process.

The number of S1 items produced by the company is 85. Within this there are items which, while having individual material codes, are treated the same within the planning process. There were a number of items for which the data is incomplete so are not considered. Therefore, for the purpose of this study 59 items were subsequently analysed based on their distribution channel attributes and a Pareto analysis.

The items can be categorized into three channels; EU specific, US specific or dispatched to both DC hubs. The two DC channels have different characteristics as shown in Figure 1 which are:

Modes of transportation
A. Length of supply chain to the final customer
B. The company has higher visibility of US operations than the EU DC hub
C. Potential differences in operations management of these globally dispersed operations

Based on these characteristics the items produced where segregated according to their distribution attributes.

Slack et al (2009, p.302) puts forward that ABC Pareto analysis is potentially misleading because the impact that lower ranked items are not fully considered. By considering the distribution attributes in combination with ABC analysis 22 individual Category A items are focussed upon. This is achieved by a combined consideration of volume and value of the items that go through both distribution channels, US only and EU only.

Bullwhip and Net Stock Amplification analysis

The aim when considering the bullwhip level and its relationship to NSAmp is to achieve an optimal ratio for the supply chain. A base position would be a bullwhip level of 1 and ensuring NSAmp as low as possible. However, there is a trade-off between the two that needs to be considered. Bullwhip increases production costs which can be amplified as orders are translated upstream in the supply chain. But care is needed if in an attempt to reduce the bullwhip effect customer service levels deteriorate. In the same vein the NSAmp affects the supply chain's ability to meet service levels in a cost effective manner. While the downstream organisation may want to reduce inventory levels the upstream supplier may look to maintain them proportionally higher to buffer against demand uncertainty (Disney et al., 2006). A comparison between of bullwhip and NSAmp for the different distribution channels is displayed in Figure 3.

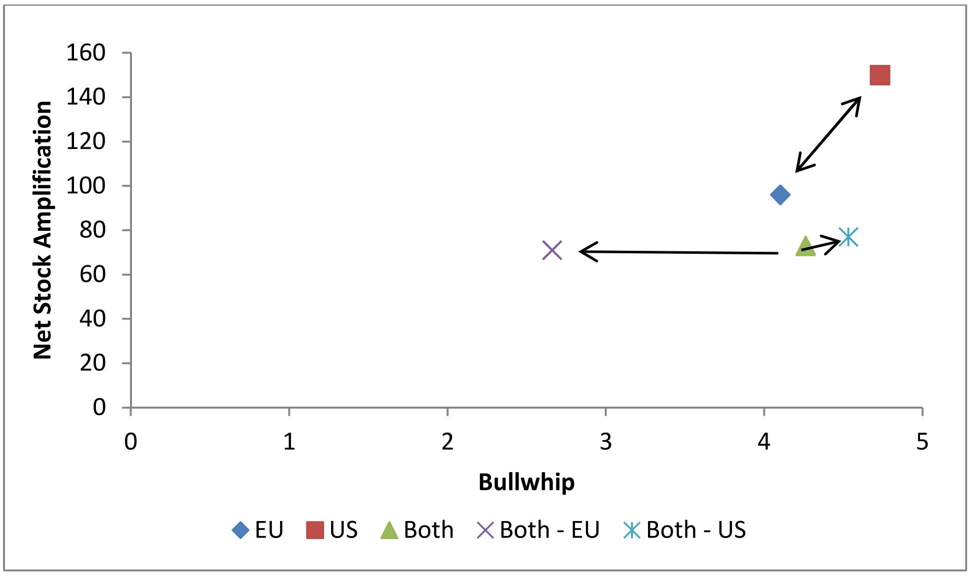

Figure 3: Net stock variance and bullwhip relationship by item distribution channe

NSAmp is higher for specific US items; yet the US items associated with both DC channels are at a similar level for those associated with the EU DC hub. This association offers a clear point of difference between US items, taking into account they have similar bullwhip levels. A potential reason for the increase in bullwhip for US items over EU items may be an element of 'phantom order' gaming on the part of US customers who are conscious of the perceived length of the supply chain linkage from the factory to the DC. Also to be considered is the role of the affiliates in the EC channel. They serve to collate customer demand together, on the other hand individual customers order directly so there can be smaller, more frequent and variable. However, such a conclusion needs to be weighed against the linkage from the EU DC to its customers who are globally dispersed. The notion that the goal must be to move the ratios shown in Figure 3 towards as low as posible needs to be taken in the context of the organisation. As Potter et al (2009) concluded resources and capacity limits affect the ability to achieve this and therefore bullwhip can in fact be useful. What is important is to acknowledge its existence and its effect on supply chain costs.

The above analysis was completed for the Category A items only. The average bullwhip and NSAmp is highlighted by the solid black lines in Figure 4. While this analysis does not identify a trend by distribution channel it can identify individual item outliers from the overall trend.

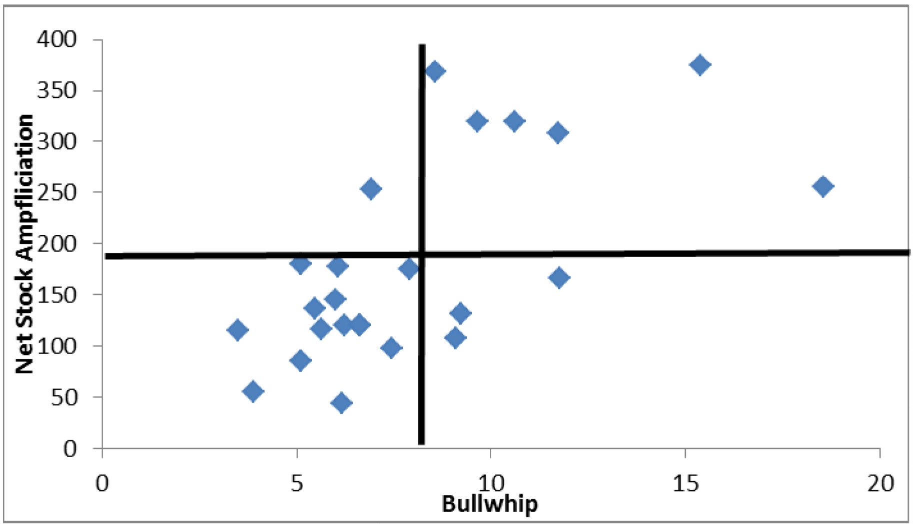

Figure 4. Net stock variance and bullwhip relationship for category A items

A cumulative sum analysis can be undertaken for the Category A items, based on their relationship to the average bullwhip, as given in Figures 5 and 6.

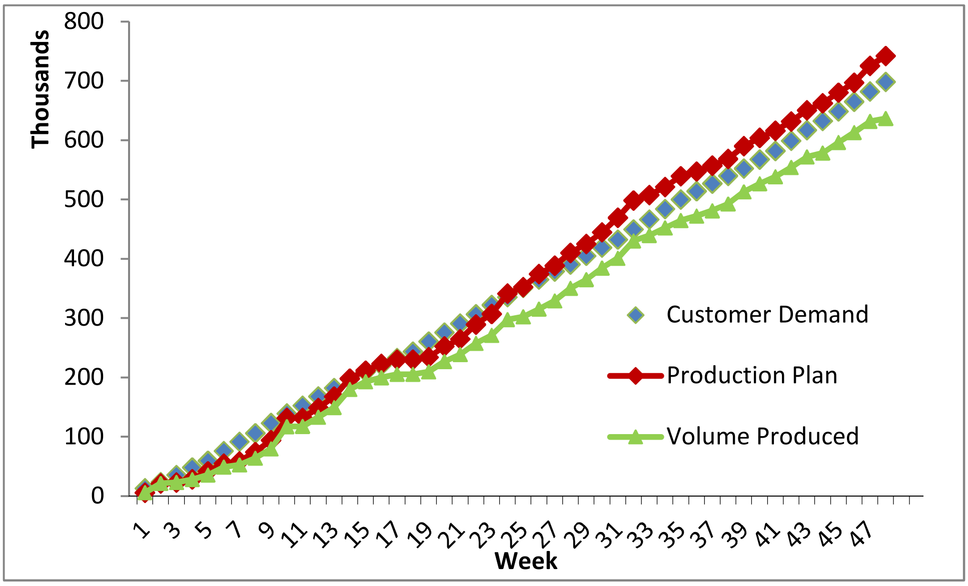

Figure 5. Category A items with bullwhip below overall average

This provides an interesting comparison. The items with lower bullwhip look to match demand; in fact there is a chase strategy with the volume made lower than the demand. In contrast, those items with higher bullwhip lead customer demand, that is to say there is a stock building policy, which is reflected in the NSAmp. What also has to be taken into consideration is the level of customer demand. Those with lower bullwhip have three times the volume, which is reflected in the frequency the items are produced each month; 85% for those in Figure 5 but only 76% for those in Figure 6.

What this highlights is that the bullwhip measurement captures many elements of production scheduling, such as frequency of production, batch size, chase or stock builds strategy and relates it to customer demand. By linking it with NSAmp it allows its relationship with inventory levels to be determined, analysed, trended and can be a powerful decision making tool.

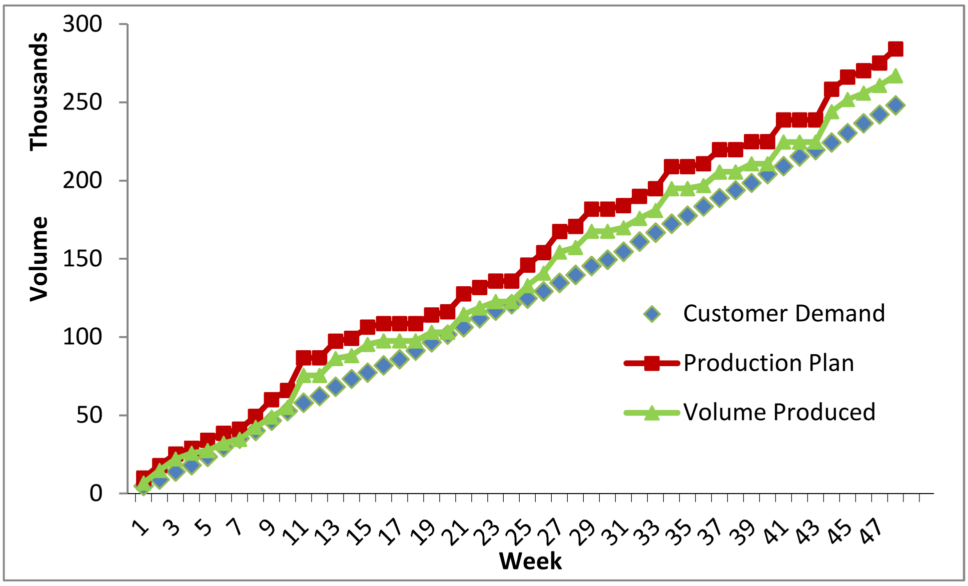

Figure 6. Category A items with bullwhip above overall average

CAS characteristics

While the previous section focused on the quantitative analytical aspects of the case study, in this section the supply chain activities as captured through the qualitative research methods are presented. are related to the CAS characteristics to determine if the CAS perspective can be applied to a specific supply chain. To undertake this comparison the CAS supply network framework Choi et al (2001, p.358) is used. The company examples are tabulated against the CAS characteristics in Table 1.

CONCLUSIONS

It was found that the case organisation did display examples of all of the CAS characteristics and therefore is a valid perspective with which to consider a supply chain. The effects of dynamic complexity on plant performance were evaluated. Bullwhip was found to exist in the distribution channels. Bullwhip levels were related to the net stock levels and gave a fuller picture of the relationship between customer demand, inventory levels, and production volume and frequency. Three distinct patterns of dynamic complexity were identified using CUSUM analysis; matching, chase and stock build.

While previous research has been conceptual the paper provides empirical evidence, albeit in the form of a single case, of CAS in a manufacturing supply chain and in particular dynamic complexity as evidenced by the bullwhip effect. Furthermore, it is found that bullwhip in not the only appropriate symptom of CAS that can be monitored but net-stock amplification is also an example of dynamic complexity. While the former has implications for production costs the latter is directly contributing to inventory costs.

The CAS framework provides a valid perspective to consider strategic decision making in a supply chain. In particular it then leads to metrics to measure dynamic complexity. Bullwhip and net stock inventory levels supplement the traditional metrics which are normally associated with detail complexity. The representation of data as in Figure 4 can be used as a KPI / decision-making tool to determine the criticality of managerial interventions. In Red-Amber-Green (RAG) terms the bottom left quadrant is green, top left and bottom right quadrants are amber and the top right is red. This is a powerful representation to aid in identifying what to focus on in driving improvement programmes. The CUSUM analyses of customer demand and production volumes provide an overview of items and highlight discrepancies that can be investigated before they turn into potential service failures. A specific outcome for the case company was a data set to qualify an opportunity for the case study company to link its operations more closely to the customers' requirements, thus contributing directly to the operational strategy.

	Description of CAS	**Company Illustration**
Internal Mechanisms		
Agents and schema	Agents share interpretative and behavioural rules and fitness criteria at different levels of scale	• SOP used • Factory KPI broken down to individual departments
Self-organisation and emergence	Patterns are created through simultaneous and parallel actions of multiple agents	• Building safety stock into the process • Running capacity at a certain rate to handle an expected FPA failure rate
Connectivity	Extensive inter-relationships are possible	• Open forum process review and improvement meetings

	even at low levels of connectivity	• Inter-agent meetings (marketing, sales, distribution, planning etc.) • New internal process to replace existing well contractor
Dimensionality	Negative feedback and controls reduce dimensionality, while autonomy and decentralisation increase dimensionality	• Long, medium and short term forecasting, planning and scheduling in place • Pack assembly can prioritise run order based on product volume
Environment		
Dynamism	Changes are constant and inter-dependent	Agents operate autonomously • Planning generating the schedule from sales forecasts • But become highly inter-dependent when facing performance issues that affect their autonomous processes • Product FPA failure rate affecting schedule and therefore requires operation and technical support
Rugged Landscapes	Global optimisation is simple when criteria are independent but become very complex when criteria are interdependent	• DC's look to optimise scrap rate over customer service in the knowledge the SC can expedite replacement stock • The company looks to maximise customer service and smooth the production schedule.
Co-evolution		
Quasi-equilibrium and state change	Attractors are sensitive to change as the CAS is pulled away from quasi-equilibrium state to a far-from-equilibrium state	Individual customer requirements do not match the standard protocols, • Japan customer requirements differ from European DC capabilities • Largest customer in the USA requires segregated logistic handling and packing requirements
Non-linear change	There is a lack of linear correlation between cause and effect	The variable nature and sources of the raw material leads to random test failures
Non-random future	Common patterns of behaviour are observable	The size of the batch determines the effect on the schedule in relation to when there is a test failure

Table 1: Supply chain activities compared to CAS characteristics

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SECTION 5 – DECISION SUPPORT SYSTEMS, KNOWLEDGE MANAGEMENT AND ICT IN SUPPLY CHAINS

CLOUDLOGISTIC – LINE-BASED OPTIMIZATION FOR THE DISPOSITION OF LTL SHIPMENTS

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ABSTRACT

As a real application of the in [1] introduced problem class m-VRPTWAR - the "multi-depot heterogeneous fleet vehicle routing problem with time windows and assignment restrictions" - this paper will introduce the so-called "CloudLogistic" concept. The problem addresses the assignment of a set of shipments to a set of freight routes in order to minimize unused cargo volume of the vehicles. The assignment of each shipment is restricted to a subset of freight routes. Furthermore, the shipment has to be delivered in a specific time window. Therefore, it is necessary to determine an order of shipments for each freight route that guarantees the observance of all time windows. The problem class m-VRPTWAR abstracts the implied optimization problem. Besides the introduction of the "CloudLogistic" concept, the main requirements for the software-based shipment processing are discussed, which is the central part of a software-based solution for an implied freight cooperation of Less Than Truckload (LTL) shipments. For the evaluation of problem-specific solvers, as well as for an improved evaluation of the feasibility of the m-VRPTWAR, realistic test data come into place according to [2]. Besides a detailed description of the concept a method for the generation of realistic test data will be presented. Finally the evaluation of a Repacking First Fit approach (RFF) as a solution for the discussed feasibility check will be extended by considering different choices of repacking depths.

KEYWORDS

Vehicle Routing, Freight Cooperation, SME, Cooperation Model, Logistic Model,
LTL Shipments, Line-Based Optimization

INTRODUCTION

In its recent study for traffic linkages in Germany the Federal Ministry for Transport, Building and Urban Development (BMVBS) forecasts a substantial growth of the traffic volume in road haulage up to the year 2025 [3]. Especially the long-haul road transportation contributes to this trend. A growth of transport volume of about 55% and an increase in traffic of about 84% is expected. From the ecological and the economic point of view, these trends should not only be faced with an adjustment of the road network, but also with a more efficient use of the existing infrastructure [4]. In Germany, every fifth truck in commercial freight traffic is already driving without any load at all [5].

The Project "CloudLogistic" – funded by the state North Rhine-Westphalia of the Federal Republic of Germany and by means of the European Regional Development Fund (ERDF) – addresses these challenges. "CloudLogistic" focuses its research on a more innovative logistics concept for freight cooperation to strengthen the market position of Small and Medium-sized Enterprises (SME). In this concept the strengths of already existing general cargo and Full Truck Load (FTL) networks are transferred to the area of Less than Truck Load (LTL) transports.

Usually it is not possible for a Small and Medium-sized Logistic Service Provider (LSP), to transport several LTL shipments together in one truck because there are not enough shipments within similar source and target areas. Hence, for a single LSP, several trucks are required for the transport of several LTL shipments. The basic idea of "CloudLogistic" is to bundle LTL shipments of several cooperating LSP's, via a cooperation network, by combining corresponding LTL shipments to generate synergetic effects. Therefore, the "CloudLogistic" concept relies on a line-based logistics model.

The addressed problem deals with the assignment of a set of shipments to a set of freight routes in order to minimize unused cargo volume of the vehicles. The assignment of each shipment is restricted to a subset of freight routes. Furthermore, the shipment has to be delivered in a specific time window. Thus, it is necessary to determine an order of shipments for each freight route that guarantees the observance of all time windows.

RELATED WORK

The described problem of shipment assignment corresponds with the problem [1] that is worked out as a mathematical model in the form of an Integer Linear Program (ILP). Analogues to the literature taxonomy this problem was classified as "Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions" (m-VRPTWAR). Paper [2] has established a heuristic for the implied evaluation of the feasibility of the m-VRPTWAR based on [1].

Since [6] first addressed the issue of vehicle routing problems, the subject has become an area of intensive research in logistics. In [7] a multilevel solution method has been shown for the "Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows". First the algorithm determines reasonable clusters of nodes with the help of a heuristic approach. Afterwards, it distributes these nodes over the trucks in a valid order by solving a Mixed Integer Linear Program (MILP). The same problem class was covered by [8]. This work didn't focus on the development of a solution method, but the development of an efficient mathematical formulation of the problem model. Considering the more general problem class of the "Vehicle Routing Problem with Time Windows'', the papers of [9], [10] and [11] may be referred to.

THE CLOUDLOGISTIC-CONCEPT

Similar to the IT term "Cloud Computing", the "CloudLogistic" concept describes the ability and opportunity of the LSP's to share unused resources by participating in a freight cooperation network. This is done by using its infrastructure, its resources and scaling them locally while even sharing their own infrastructure and resources with the network. The basic principle is visualized in Figure 1. Several shipments of different network-partners will initially be bundled and assigned to previously established freight routes (A). Each route is operated by a partner of the cooperation. For a combined disposition of LTL shipments, freight routes are established, i.e. the relation between a source and a target area that is operated regularly by several trucks via point-to-point transportation (B). The trucks are provided by the cooperating partners. Shipments will be collected in the source area of the route and then carried without any turnover directly to the corresponding target area, where they are locally distributed (C).

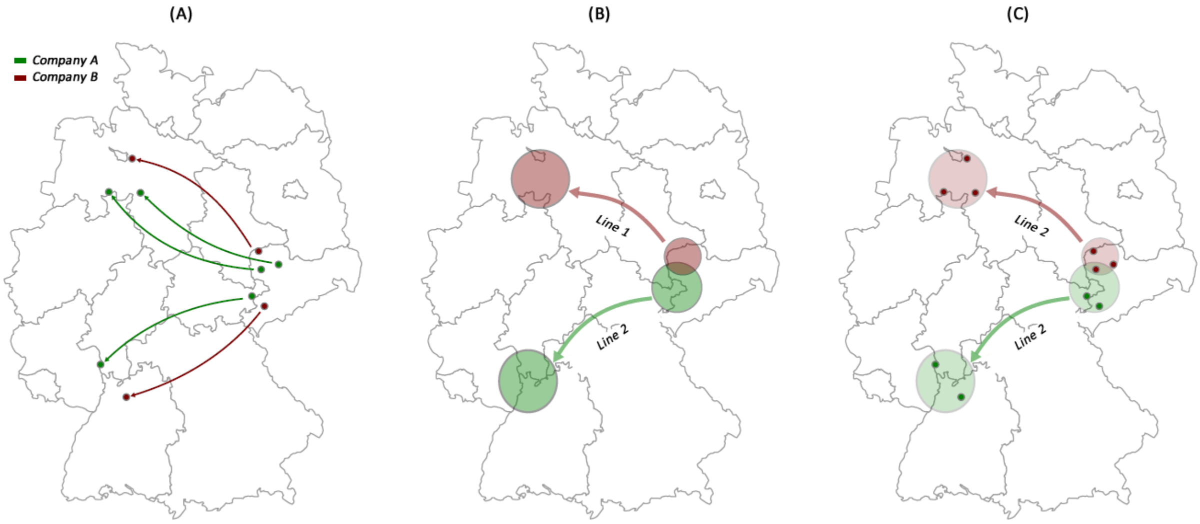


Figure 1: Visualization of the "CloudLogistic-Concept"

The basic aim of the "CloudLogistic" concept is to determine an assignment of shipments to a certain set of freight routes while decreasing the number of needed trucks, respectively the needed FTL capacity. Other goals like the minimization of the distance in the target area, the minimization of the total cost or a multi-criterian goal could also be implemented. The CloudLogistic-approach initially assumes – based on the investigations of [5] – that the ecological and the economic benefits of the overall optimization potential is maximized if the minimization of the needed FTL capacity is chosen as the main optimization goal. The assignment of shipments to a set of certain freight routes is classified as a NP-hard optimization problem [1]. The problem is illustrated in

Figure **2**.

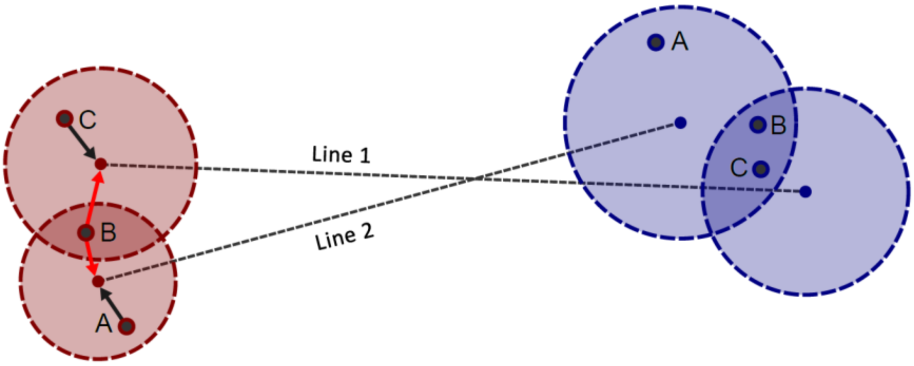


Figure 2: Visualization of the assignment problem

First, shipment A is pushed into the system – which can only be assigned to freight route 2. In contrast, both routes are feasible for the transportation of shipment B. If shipment B is assigned to freight route 1 and freight route 2 does not have sufficient unused capacity, shipment C may not be delivered because C can only be assigned to freight route 2. The number of such collisions increases, if the source and target areas of multiple freight routes overlap and additionally a large number of corresponding shipments have to be distributed.

REQUIREMENTS FOR THE SHIPMENT PROCESSING

The "CloudLogistic" concept represents a novel freight cooperation model. To realize this concept the creation of software-based centralized solutions which fulfil the requirements of the inducted business processes is needed. One of the main processes, which have yet to be investigated, is the processing step for new shipments pushed into such a kind of system. In this section the main requirements for shipment processing are discussed.

As explained above, the formation of freight cooperation is intended – in contrast to common freight exchanges. Therefore, the shipment processing has to ensure that all accepted shipments can and will be delivered and consequently, can be allocated to a certain freight route. Otherwise, the shipment will be rejected. This essential requirement has far-reaching consequences for the design of the architecture, the construction of the needed software-based platform and used optimization techniques. If there is not enough capacity to deliver all shipments or the assignment always fails because there occur other conflicts like violation of the defined time windows, no assignment can be found. The existence of such a situation has to be prevented. Therefore, the existence of a fitting assignment has to be ensured to make sure that all shipments can and will be delivered.

For this purpose the shipment processing has to be split into two components, as shown in

Figure 3. The first component represents the evaluation of the feasibility that incrementally checks if a new shipment can additionally be assigned to a certain freight route. It has to be ensured that an allocation that fits all restrictions for each shipment and freight route always exists. If no assignment can be determined, then the shipment may not be accepted by the freight cooperation. On the other hand a component is needed, which represents the final optimization step. This step has to calculate the optimal allocation of shipments to corresponding freight routes under the defined restrictions.

In the following part some basic requirements for both introduced components are described. Firstly the requirements for the final optimization techniques are addressed. Then they will be supplemented by additional requirements for the pre-processing phase and the evaluation of the feasibility. These requirements have to be taken in to account for developing the platform. The requirements are summarized in
Table **1**. In addition to the requirement analysis the use of realistic test data is essential to evaluate different implementations of the whole shipment processing step. In the following a method for the generation of realistic test data will be introduced.

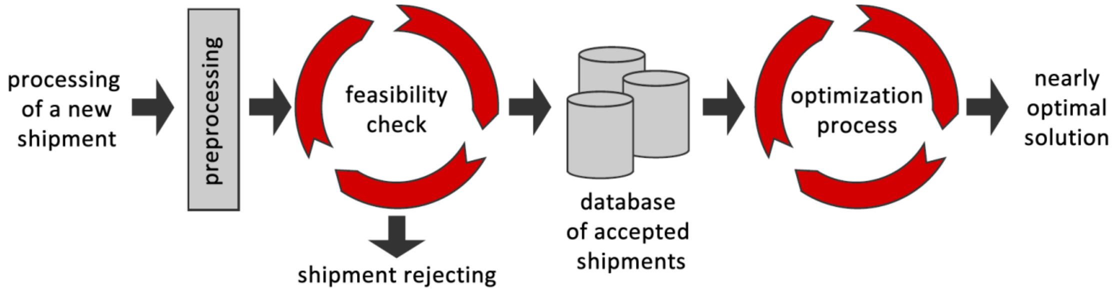


Figure 3: Overview of the fundamental IT-based shipment processing steps.

Table 1: Requirements for the multilevel shipment processing

Requirements concerning the "optimization process"	
capacity-based constraints	The total weight and the amount of loading meters may not be exceeded for each truck.
time window-based constraints	By observing all delivery time windows, sequences for delivering of allocated shipments have to be identified for each freight route.
routing-based constraints	A shipment may only be allocated to the permitted freight routes.
additional assignment constraints	Additional assignment restrictions have to be addable.
optimization step time constraint	The main optimization step must not take more than 1.5 hours to estimate a "good" allocation.
Requirements concerning the „feasibility check"	
feasibility check time constraint	At least 50 shipments per minute have to be tested.
Requirements concerning the „pre-processing"	
pre-processing time constraint	Shipment data of at least 50 shipments per minute must be processed in the pre-processing step.

Capacity-based constraints

In addition to the formulated optimization target, there are several restrictions which have to be considered by the optimization. One of these restrictions is given by the total capacity of the freight routes. The capacity of a truck is defined by the maximum load weight and the corresponding number of loading meters. The considerations of driving and rest times of the truck drivers, as well as the observance of pick-up time windows, do not matter for the main optimization problem at this time.

Time window-based constraints

In contrast, it has to be ensured that the delivery time window is accurate. Therefore the optimization step has to calculate a possible delivery sequence for each freight route in which the shipments are deliverable. The delivery sequence has to consider unexpected delays, like traffic jams or delays while unloading in terms of appropriate temporal buffers.

Routing-based constraints

A further requirement addresses a special property of the introduced logistic model which is denoted in the following as an assignment restriction (according to [12]). For each shipment a set of freight routes which is able to handle the assigned shipments is defined. Therefore a shipment cannot be assigned to all available freight routes. An obvious allocation constraint is created by the source and target areas of the freight route. A shipment can only be assigned to routes, where source and target areas cover the pickup coordinates and the destination of the shipment.

Additional assignment constraints

Restrictions concerning certain shipment types respectively some categories of goods (i.e. dangerous goods) also need to be taken into consideration. Additionally, different optimization goals lead to a combined multicriterian definition. Especially the use of a fairness model, which prefers or punishes certain LSP's, the goals of the national economy, the goals of the LSP's and the goals of the freight cooperation as an independent company are competing against each other. The possibility of an expansion and adaption of the optimization process considering such constraints has to be taken into account.

Optimization step time constraint

There are some given performance requirements for the optimization process. The calculation of an optimal allocation of shipments to freight routes has to be completed within a period of 1.5 hours on a defined test system. A longer time for the processing step is not acceptable to ensure a frictionless integration into the running business processes of the LSP's.

Feasibility check time constraint

The requirements presented up to this point, except the non-functional requirement R5, are also requirements for the processing step of the feasibility evaluation. For this step, more restrictive performance requirements have to be met. The feasibility check has to be able to handle shipments requests as quickly as possible, so that waiting periods for the LSP's not arise. The notice for acceptance or rejection of a shipment has to occur within seconds. Since there is no reliable history data about the frequency of receiving shipments of LTL cooperation networks, the order of an existing general cargo network of an average business day shall be used as an indicator (
Figure 4). Accordingly, the feasibility check has to process 50 shipments per minute at maximum.

Pre-processing time constraint

The pre-processing step shown in

Figure 3 is needed to determine the geographical coordinates of the shipments origin and its destination. Additionally, it has to be determined which freight routes are suitable to deliver the shipment under consideration of all known restrictions. In this case, a lot of temporal distances have to be determined using a software-based routing planner. Naive approaches would produce thousands of unnecessary distance requests. This would hurt temporal constraints given here. A time line of a few seconds must be observed, for example, by using appropriate index structures to significantly reduce the number of distance requests.

In addition to the requirement analysis the use of realistic test data is essential to evaluate different implementations of the whole shipment processing step. In the following a method for the generation of realistic test scenarios will be introduced.

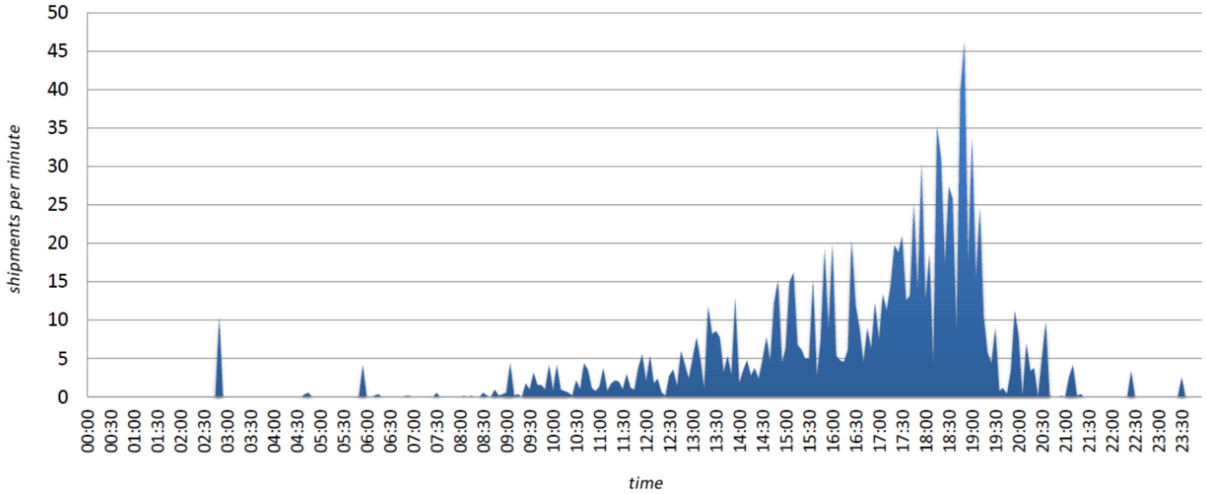


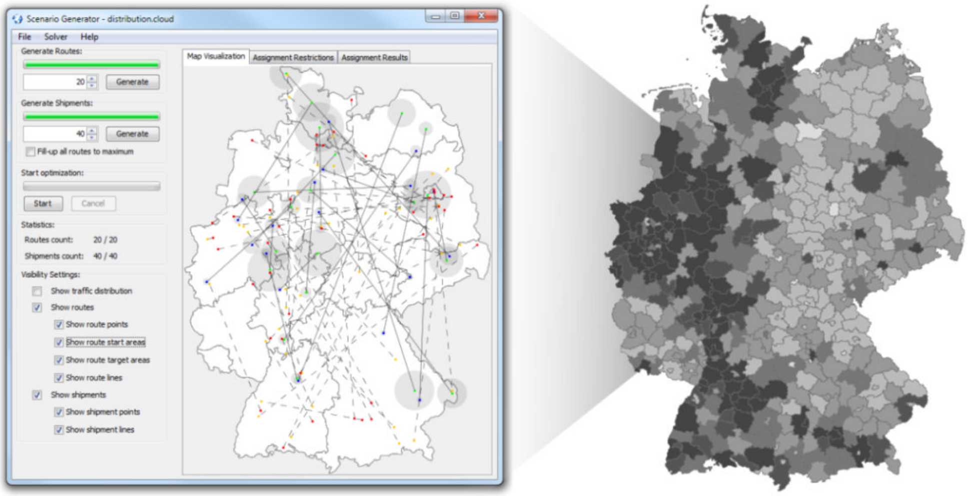
Figure 4: Orders of a general cargo freight cooperation

TEST-DATA GENERATION

In context to the introduced "CloudLogistic" concept and to the evaluation of solutions for its implied optimization and feasibility problems, the use of realistic test data is essential. So, a set of test data shall illustrate a nearly realistic compilation of freight routes and shipments. Besides the generation of realistic test data, it is also conceivable using different (and sometimes unrealistic) worst-case-scenarios for the tests to evaluate a solution method even in such extreme cases. To give an example, the allocation limit for all shipments could be eliminated. This would dramatically increase the possible combinations of shipment and freight routes and it would be difficult to evaluate the applicability of the solution method for treating this problem. Instead, the applicability of an algorithm for solving a general optimization problem of the class m-VRPTWAR would be evaluated. The following assumptions are the results of requirement workshops with experts in logistics and different experts of local LSP's.

It is reasonable to choose the distribution of companies across Germany as an indicator for the distribution of realistic source and target areas. It also is reasonable to generate shipments corresponding to these areas. For the freight routes themselves a realistic extension of the area is assumed. For simplification source and target areas are defined as Euclidean circles. For the generation of test data the Euclidean model holds and is easily changeable to other approaches. Here a source area with an extension of 5 up to 20 kilometres and for the target area an extension of 10 to 50 kilometres is considered to be realistic. For a single shipment all other parameter besides the source and target location are needed. Those are the number of needed loading metres, the weight and the time period for unloading. In our definition a LTL shipment usually consist of 7 up to 27 pallets. For each pallet 0.4 loading meters as well as a random weight of 100 up to 800 kilograms is valid. For unloading a time period of one up to two minutes for each pallet is considered. The time window for the delivery is chosen randomly between 8:00 a.m. and 6:00 p.m.

For the generation of test scenarios a tool has been developed. It realizes a projection of the distribution of German companies (Figure 5) to a probability distribution. For densely populated regions (in the map shown as dark regions) a higher probability is assumed. For sparsely populated regions (in the map shown as bright regions) a lower probability is chosen. Using the presented tool (based on the shown probability distribution) randomized coordinates will be chosen and used as center of the source and target areas. Figure 5 shows a screenshot of the developed tool and an example of generated source and target areas as certain freight routes as well as the source and target locations of several shipments.



Generate Routes: 20

Generate Shipments: 40

☐ Fill-up all routes to maximum

Start optimization:

Statistics:

Routes count: 20 / 20

Shipments count: 40 / 40

Visibility Settings:

☐ Show traffic distribution

☑ Show routes

  ☑ Show route points

  ☑ Show route start areas

  ☑ Show route target areas

  ☑ Show route lines

☑ Show shipments

  ☑ Show shipment points

  ☑ Show shipment lines

Figure 5: Screenshot of the developed tool for test data generation

In order to evaluate the goodness of the feasibility check the number of shipments which are rejected incorrectly has to be identified. If a shipment is generated as described previously and if this shipment is refused by the feasibility check, we don't know whether it was rejected because it could not be scheduled or whether the feasibility check didn't found the matching assignment. Therefore it has to be ensured that all shipments of a test case can be scheduled. Then a useful evaluation of the feasibility check is possible. In addition the behaviour of a solution method shall be investigated, in case the available trucks are already reaching their capacity limits.

So, to evaluate a solution which represents the feasibility check the generation of shipments has to be changed slightly. First a number of freight routes are generated according to the assumptions above. In a second step shipments are created by dividing the available capacity of the freight routes in certain pieces according to the restrictions and assumptions we made for the shipment properties. Then for each piece a source and a target location within the source area respectively the target area of the freight route is randomly selected. For the generation of realistic and practicable delivery time windows the time span of 8 a.m. to 6 p.m. will be divided into intervals of equal size according to the partition of the freight capacity. The delivery time windows for each shipment now are generated by a randomized deviation around the intervals central point. This approach ensures that all shipments can be scheduled within its spatial and temporal requirements and there are enough shipments for reaching the capacity limit of all freight routes. Moreover, such kind of scenario can be assumed as realistic.

EVALUATION OF THE FEASIBILITY-CHECK

In addition to the in [2] presented Repacking First Fit algorithm (called RFF) as a first implementation of a feasibility check, based on the here introduced generation of test data a scenario with 3500 freight routes and 14495 shipments was used to additionally evaluate different repacking depths. The RFF algorithm first tries to find a freight route to which the shipment can be assigned, using a first fit approach. If no such freight route exists, the repacking-phase is initiated. Thereby it is tried to take back an already assigned shipment in such a way, that the freight route is preferably filled completely, after assigning the new shipment to it. On the one hand this approach is supposed to make room for the new shipment; on the other hand it ensures that as the cargo volume of the freight routes is utilized as much as possible.

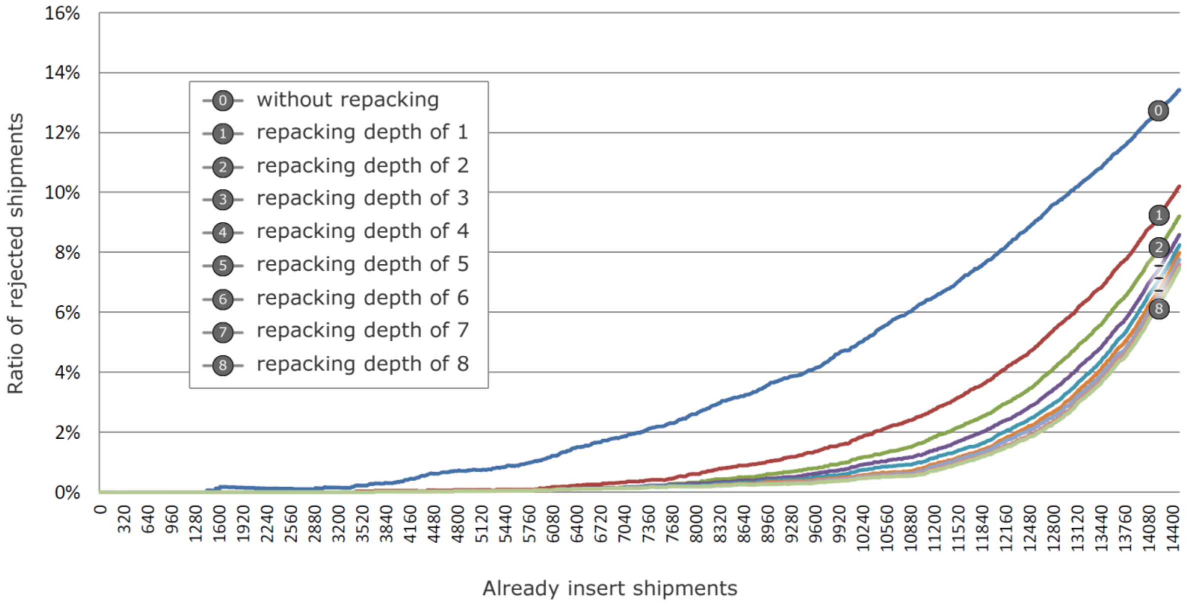


Figure 6: Rejection rate of the RFF algorithms for using different repacking depths

A more detailed description of the algorithms is presented in [2]. Figure 6 and Figure 7 show the results of the evaluation of the RFF algorithm for eight different repacking depths and for a scenario without any repacking step.

As presented in Figure 6 the use of a repacking approach significantly reduce the ratio of rejected shipments. By scaling up the repacking depth the ratio of rejected shipment decreases logarithmical. Corresponding to the rejection rate in Figure 7 the required execution time is shown in order to check all shipments in terms of ability to deliver. Here by scaling up the repacking depth the derivation of each function increases exponentially resulting in increasing execution time for a single shipment. Considering Figure 7 with a repacking depth of 6 the execution time raises up to 37.9 milliseconds. So a violation of the introduced *feasibility check time constraint* – "At least 50 shipments per minute have to be tested" – is not given. In this case the rejection rate in the given scenario decreases down to 7.77%. The choice of a higher repacking depth leads to a marginal decrease of this ratio. For reaching an optimal result the repacking depth can be chosen dynamically with respect to the current number of requests.

The measurements were carried out on an Intel Core 2 Quad Q9650 CPU with 4 Cores (3.0 GHz each) and 8 GB RAM. Windows 7 Professional 64-bit has been used as operating system. Furthermore the Java Virtual Machine (JVM) of SUN Java Development Kit (JDK) 1.6.0-20 has been employed, since the reference implementation of the heuristic method has been programmed in Java.

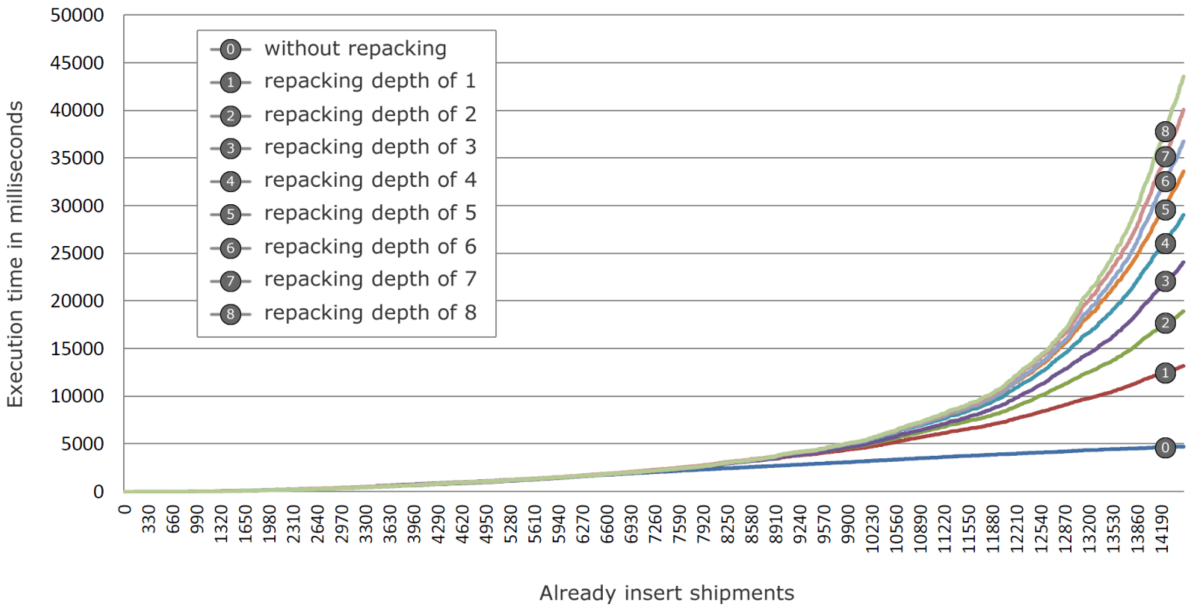


Figure 7: Execution time of the RFF algorithms using different repacking depths

CONCLUSION & OUTLOOK

In this paper, the problem class m-VRPTWAR developed in [1] and [2] was transferred to the application domain of the "CloudLogistic" concept. For this purpose, the concept was presented in its fundamentals. Based on this description, the basic requirements for the shipment processing within an implied cooperation platform have been developed. By doing this, the shipment processing has been divided into two separate phases. We developed a set of basic requirements for the feasibility check, as well for the final optimization and as well for the pre-processing of the shipment data and their preparation. Based on these requirements, the generation of test data was introduced. In the development of the test data generator, in particular the unique requirements of the multi-staged shipment processing were considered.
By using the described generator tool different realistic test scenarios are generated automatically. These scenarios were used for the evaluation of the feasibility check and the final optimization process.

An extension of the in [2] introduced evaluation of the RFF algorithm was used as an example for using the generated test data to reflect the investigated requirements. In further research it should be deferred to the extension of the first as circular assumed area schema to an elliptical model. Here the used Euclidean approach is converted into a time-based model with isochrones. Also the construction of an index structure for decreasing the number of distance queries and speeding up the whole pre-processing is a focus of future research.

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CASE STUDY: DYNAMIC DISCRETE EOQ MODEL FOR INVENTORIES IN WATER-COOLERS DISTRIBUTION

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ABSTRACT

The main purpose of paper is examination of dynamic discrete EOQ model applicability for inventory control in La Fantana company in Serbia. Company La Fantana, Serbia is a leader in the field of bottling and distribution of water and water coolers in Serbia. This paper analyzes La Fantana company inventory system, with continuously changing state and varying demand. Changes of state are registered at the ends of the defined time period. Considered time period is one year. Dynamics of system are described by discrete equations and inequalities. Structure of inventory system is generally known and has deterministic character, while the variables in the system may have deterministic and stochastic character. Inventory control problem set in this paper is modeled and presented in spreadsheets, in accordance with the problems defined in company La Fantana. Spreadsheets are used for building of simulation model of a discrete controlled object. The results obtained from discrete dynamic spreadsheet models are compared with actual inventory data obtained in La Fantana company for year 2011. The main objective of this case study was to develop a dynamic discrete inventory simulation EOQ model in spreadsheets, in accordance with the problems defined in company La Fantana. Simulation model should be able to present a dynamic of inventory system, and to give solution of the inventory control problem in an acceptable simulation time for discrete periods in one year. Mathematical apparatus, that is used to solve the problem of managing, is optimal control of the discrete system. Inventory problem, set in this paper, is modeled and presented in spreadsheets. Spreadsheet is used for building of simulation model of a discrete controlled object. Discrete controlled object is represented by simulation model of inventory management problems, with clearly separated: the law of dynamics, control domain and performance criterion. In this paper it will be present that the dynamic simulation spreadsheet inventory model can be used as reliable and easy way to present a static inventory models. The contribution of this paper by should be prove that the dynamic simulation spreadsheet inventory model can be used as reliable and easy way for inventory control in company La Fantana, Serbia. Model will be applied over the real data collected in the company in 2011. Model results will be compared with company's data for year 2011.

Keywords: Inventory control, spreadsheets simulation, discrete controlled object

1. INTRODUCTION

Basic EOQ model can be presented as object of discrete control and simulation model of inventories in a spreadsheet in the case of the fixed order quantity for the finite time horizon with or without allowed shortages. Model is developed in a spreadsheet in order to perform simulation, and table analysis. EOQ model belongs to group deterministic, static and continuous models, where inventory dynamics is observed for one period of time. Results of model output are the fixed amount of order quantity per year and number of orders per year. Continuous time period, we can present as the sequence of discrete time periods with discrete quantities of inventories in it. There is a clear separation between a discrete object (a low of behaviour and the control domain), a performance criterion, and a method used to find an optimal solution. Further, it is presented the performance criterion which including all costs considered significant by the user. Finely, it is shown how to use Spreadsheet Data Table function (one-parameter or two parameter function) to find optimal number of replenishments. Shortages in this model are not allowed.

New books which are dealing with inventory control, studied by Axsäter (2006), Chase and Aquilano (2006), Barlow (2003), Muller (2003), Wild (2002), Anderson, Sweeney and Williams (2003), Chopra et al. (2007) is described a classical static economic order quantity model in the fixed-order quantity system at the finite time horizon and its variants when demand rate is constant and known, as a starting point for further understanding of inventory dynamics. The study of inventory problems dates back to 1915, by Harris (1915), where the inventory problem was first selected for mathematical analysis. As result, was established the simple but famous EOQ (Economic Order Quantity) formula that was also derived, apparently independently, by Wilson (1934). Donaldson (1977) came out with a full analytic solution of the inventory replenishment problem with a linear trend in demand over a finite-time horizon. The discrete version of this problem was discussed by Wagner and Whitin (1958). Resh et al. (1976) and Donaldson (1977) established an algorithm to determine the optimal replenishment number and timing for a linearly increasing demand pattern. Barbosa and Friedman (1978) then generalized the solutions for various, similar EOQ models. Goyal (1985) is the first person who developed the EOQ model under conditions of permissible delay in payments. One method of dealing with EOQ models with time-varying demand and cost over a finite planning horizon is the use of discrete Dynamic Programming (Bellman, 1957), Wagner and Whitin, 1958). As stated in Friedman (1982), Wagner and Whitin use Dynamic Programming to formulate a dynamic version of the economic lot size model.

Kostic (2009) showed how to modeling dynamic discrete EOQ problem to find optimal number of replenishments in the fixed-order quantity system as a basic problem of optimal control of the discrete system. The decision environment is deterministic and the time horizon is finite. A discrete system consists of the law of dynamics, control domain and performance criterion. It is primarily a simulation model of the inventory dynamics, but the performance criterion enables various order strategies to be compared. A discrete time system is a more natural manner to describe inventory dynamics. Model of discrete system control is both a simulation model of inventory dynamics and an optimization model which can give optimal control according to the defined performance criterion.

Dynamic descrete EOQ model is developed in spreadsheets software. Smith (2003) stated that the spreadsheet software can be used effectively for analyzing logistics and supply chains issues. Also, he resumed that the use of spreadsheets as logistics decision making software tool has exploded in the last decade driven by the need to optimize and integrate the supply chain. These tools are extremely effective in determining the optimum number of distribution fascilities, the appropriate mix of transportation modes, production scheduling, inventory optimization, product rationalization and strategic planning exercises. Vazsonyi (1992) state that deterministic "what-if" simulation methodology is the most popular decison making tool.

The traditional EOQ model assumes infinite time horizon and the number of replenishments obtained is often non-integer. It is often necessary to make certain approximations in order to use in practise a traditional EOQ model for the finite time inventory problems. It is practically inconvenient to apply 4.7 replenishments and that a replenishment cycle is 77.66 days long. Furthermore, ordering cost is linked to the replenishment occurrence (which can be merely integer) but EOQ model often multiplies the ordering costs with the fractional number of replenishments giving inaccurate total inventory cost. The infinite time horizon inventory models assume that the rate of the annual demand is known (and constant) over several consecutive years. The finite time horizon inventory models assume the demand is pertaining only to the determined time horizon (often shorter than one year period). Kostic (2009) has shown that modelling inventory problems as the discrete object optimal control is more appropriate to the reality. He has developed a general approach to inventory models and has shown that all variants of EOQ model applications can be considered as scenarios of the inventory control model as the model of optimal control of the discrete system.

In the simulation-based optimization Glover (1996), there is a complete separation between the model that represents the system and the procedure that is used to solve optimization problems defined within this model. The simulation model can change and evolve to incorporate additional elements, while the optimization routines remain the same, see Swisher and Hyden (2000) and Fu et al. (2005) for an overview.

2. DISCRETE CONTROLLED OBJECT

2.1 Law of dynamics and Control domain

For mathematical relations of the discrete object the following notation will be used:

t - discrete time
T - number of days of the time horizon
X_t^1 - stock at the end of time t
Y_t^1 - quantity item received at time t
Y_t^2 - demand at time t
D - item demand for the observed time horizon
$u^1 \, or \, u_t$ - number of replenishments

Graphical interpretation of material flow in block-diagram, with "action – accumulation – action" flow, is present in Figure 1.

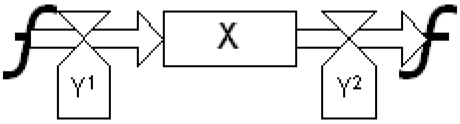


Figure 1.

Main characteristic of the inventory control in the case of the fixed order quantity for the finite time horizon is that the replenishment quantity is constant and performed through several replenishments that occur at the beginnings of the equal portions of the time horizon. The sum of replenishment quantities over time horizon is equal to demand in time horizon (D). In accordance to the Kostic (2009) this type of the flow is called "Discrete input and continuous output". There are inventory flows without and with allowed shortages. We will develop one model without shortages, where flow consist of the alternating subsequence "action – accumulation – action": input action increases accumulation and output action decreases accumulation. Dynamics of accumulations can be expressed as follows:

$$X_0^i = known = 0 \qquad ,$$
$$X_t = X_{t-1} + Y_t^1 - Y_t^2 , \; t = 1,2,...T$$

where X^1 is a state variable pertaining to the flow of the inventory. The initial inventory is zero The discrete time t can take only integer values t=0,1,2,..T, representing days. T is a number of days over the time horizon. In our model T=302 working days, t=1,2...,302.

When the replenishment occurs, the level of inventory X_t^1 is increased instantaneously. The level X_t^1 is decreasing in accordance to daily demand (D/T). When the level X_t^1 meet the zero, we get a new replenishment. Regulator Y_t^1 represents input action increasing the inventory on hand. Its value over the time horizon is equal zero, except in the moment when the replenishment is occurred. Denote the number of replenishments as a control variable u^1. The replenishment quantity is u^1-th part of the whole demand for the encompassed time horizon, D/ u^1. The whole time horizon is divided into T time buckets representing days, t=1,2,…,T. If we divide the number of time buckets T with the number of replenishments u^1, the result could be non-integer number inappropriate to determine time bucket at which the replenishment will occur.

The first replenishment occurs at first day and lead time is zero (LT=0).

$$Y_1^1 = \begin{cases} D\ (t', & X_{t-1} + 0{,}0001 < D\ (t' \\ 0, & \text{other} \end{cases}, \quad t = 1.$$

for t=2,3,4...,T, mahatematical relation is:

$$Y_t^1 = \begin{cases} \min(\ D(t)\ ,\ D - \sum_{t=2}^{T} y_{t-1}^1), & X_{t-1} + 0{,}0001 < D(t) \\ 0, \quad , & \text{other} \end{cases}, t = 2,\dots,T.$$

The demand over the time horizon equals real situation data, and will occur according to the next mathematical relations:

$$Y_1^2 = D\ (t), \quad t = 1$$

for t=2,3,4...,T, mahatematical relation is:

$$Y_t^2 = \min(\ D\ (t)',\ D - \sum_{t=2}^{T} y_{t-1}^2) \quad t = 2,\dots T$$

The control domain is defined by ensuring non-negativity of the state variables for each t.

$$0 \le u_t = N_0^I \le T$$
$$u_t = \text{int}\,eger,$$
$$0 \le X_{t-1} + Y_t^1 - Y_t^2$$
$$t = 1,2,3,\dots\dots\dots T.$$

2.2 Performance criterion $J = \sum f(X_{t=1}, p_t, u)$

The goal to ensure that anticipated demand be met is achieved by keeping stock nonnegative. However, the primary purpose of inventory control is to ensure that the right amount of the right item is ordered at the right time, according to known demand, existed constraints and the objective to minimize total cost, where cost is given by the equation: cost = ordering_cost + holding_cost +purchase_cost

This function can be broaden by additional costs according to the real nature of the inventory problem.

Ordering cost includes costs arising from the preparation and dispatch of the order, checking of the goods on delivery, and other clerical support activities. It can be constant (EOQ model) or variable throughout time horizon, depending, or not, on the ordered quantity. Ordering cost per order Cs is greater than zero only in time t when order arrives in the stock or when the batch is started.

Holding (or carrying) cost is the cost of holding one unit of an item in stock per day (for instance $20/T a unit per day or as a percentage of the unit cost of the item divided by T, where T is the number of days of time horizon). Holding costs include interest on the capital tied up in stock, insurance, storage charges (rent, lighting, heating, refrigeration, etc.), deterioration and obsolescence of stock. It can be constant (EOQ model) or variable throughout time horizon, depending or not of the quantity carried in inventory. Holding (carrying) cost per one unit Ch per day multiplies a day average inventory. If we retain a classical inventory control model approach, a day average (dav) inventory can be counted as:

$$dav(t) = X_{t-1}^{1} + Y_t^1 - Y_t^2 / 2 \quad ,t = 1,2,...,T$$

Purchase (unit) cost is the price charged by suppliers for one unit of the item. It can be constant (EOQ model) or variable throughout time horizon, depending or not on the ordered quantity. Purchase (unit) cost Cu multiplies quantity purchased in time t.

The general pattern of the performance criterion is

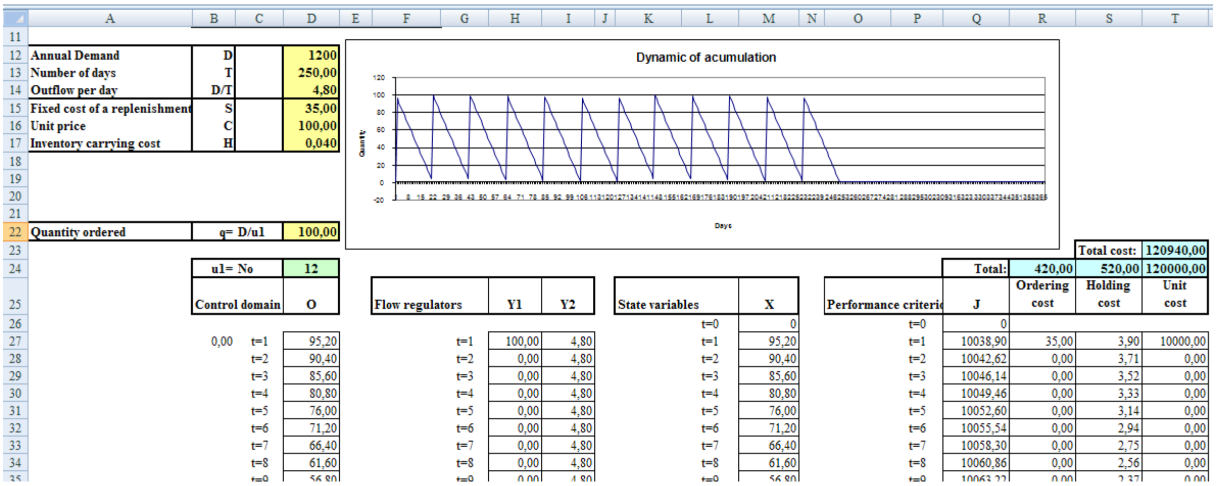
$$J = \sum_{t=1}^{T} [Cs \cdot \begin{cases} 1, & if \ Y_t^1 > 0 \\ 0, & if \ Y_t^1 = 0 \end{cases} + Ch \cdot dav(t) + Cu \cdot Y_t^1]$$

that should be minimized.

It is obvious that the value of performance criterion depends on the inflow dynamics Y^1. The function of the performance criterion can contain additional information according to the real decision environment. Values of each partial functions of the performance criterion J over the time horizon T can be presented in separate columns of the spreadsheet. The values of the performance criterion J should cumulate values of its partial functions over the time horizon.

The Figure 2. below shows an example how to present an inventory control model in the case of fixed ordered replenishment for the finite time horizon. For input data reserve following spreadsheet cells (see Figure 2.):

D12: Anual Demand
D13: Number of days
D15: Ordering cost
D16: Unit purchase cost
D17: Unit holding cost
D24: Number of replenishments



12	Annual Demand	D	1200
13	Number of days	T	250,00
14	Outflow per day	D/T	4,80
15	Fixed cost of a replenishment	S	35,00
16	Unit price	C	100,00
17	Inventory carrying cost	H	0,040
22	Quantity ordered	q= D/u1	100,00
24		u1= No	12

23												Total cost:	120940,00
24										Total:	420,00	520,00	120000,00
25	Control domain		O	Flow regulators	Y1	Y2	State variables	X	Performance criteri	J	Ordering cost	Holding cost	Unit cost
26							t=0	0	t=0	0			
27	0,00	t=1	95,20	t=1	100,00	4,80	t=1	95,20	t=1	10038,90	35,00	3,90	10000,00
28		t=2	90,40	t=2	0,00	4,80	t=2	90,40	t=2	10042,62	0,00	3,71	0,00
29		t=3	85,60	t=3	0,00	4,80	t=3	85,60	t=3	10046,14	0,00	3,52	0,00
30		t=4	80,80	t=4	0,00	4,80	t=4	80,80	t=4	10049,46	0,00	3,33	0,00
31		t=5	76,00	t=5	0,00	4,80	t=5	76,00	t=5	10052,60	0,00	3,14	0,00
32		t=6	71,20	t=6	0,00	4,80	t=6	71,20	t=6	10055,54	0,00	2,94	0,00
33		t=7	66,40	t=7	0,00	4,80	t=7	66,40	t=7	10058,30	0,00	2,75	0,00
34		t=8	61,60	t=8	0,00	4,80	t=8	61,60	t=8	10060,86	0,00	2,56	0,00

Figure 2.

Next formulas in model are developed in spreadsheets in Table 1.:

Table 1.

Reference	Spreadshee formula	Equation
D27:	=M26+H27-I27	$0 \leq X_{t-1} + Y_t^1 - Y_t^2$
H27:	=IF(M26+0,0001<V27;$D$22;0)	$Y_1^1 = \begin{cases} D\ (t), & X_{t-1} + \mathbf{0{,}0001} < D\ (t) \\ \mathbf{0}, & \text{other} \end{cases}, \ t = \mathbf{1}.$
H28:	=IF(M27+0,0001<V28;MIN($D$22;$D$12-SUM($H$27:H27));0)	$Y_t^1 = \begin{cases} \mathbf{min(}\ \mathrm{D(t)}\ , D - \sum_{t=2}^{T} y_{t-1}^1\mathbf{)}, & X_{t-1} + \mathbf{0{,}0001} < \mathrm{D(t)} \\ \mathbf{0}, \quad , & \text{other} \end{cases}, t = \mathbf{2}, \ldots, T.$
I27:	=V27	$Y_1^2 = D\ (t), \quad t = \mathbf{1}$
I28:	=MIN(V28;$F$3-SUM($I$27:I27))	$Y_t^2 = \mathbf{min(}\ D\ (t)', \ D - \sum_{t=2}^{T} y_{t-1}^2\mathbf{)} \quad t = \mathbf{2}, \ldots T$
M27:	=M26+H27-I27	$X_t = X_{t-1} + Y_t^1 - Y_t^2, \ t = 1,2,\ldots T$
Q27:	=Q26+R27+S27+T27	$J = \sum_{t=1}^{T} [Cs \cdot \begin{Bmatrix} 1, & if\ Y_t^1 > 0 \\ 0, & if\ Y_t^1 = 0 \end{Bmatrix} + Ch \cdot dav(t) + Cu \cdot Y_t^1]$
R27:	=IF($H27>0;$D$15;0)	$Cs \cdot \begin{Bmatrix} 1, & if\ Y_t^1 > 0 \\ 0, & if\ Y_t^1 = 0 \end{Bmatrix}$
S27:	=$D$17*($M26+$H27-$I27/2)	$dav(t) = X_{t-1}^1 + Y_t^1 - Y_t^2 / 2 \quad , t = 1,2,\ldots,T$
T27:	=$D$16*$H28	$Cu \cdot Y_t^1$

Formulas should be copied and pasted into the cell range D27:T391. In the cell T23 is formula that links to the cell with the value of performance criterion at the time T+1. Chart Data Range is M26:M391.

2.3 Using Data Table function to solve the problem

In order to find optimal number of replenishments giving minimal value to the performance criterion J, we have to check less than T values for the control variable u^1. A spreadsheet function Data Table is a dynamic range that summarizes formula cells for varying input cells. A One-Input Data Table function displays the results of one or more formulas for various values of a single input cell. A Two-Input Data Table lets you vary two input cells. Data table is dynamic. Once created worksheet with data table can remain a template for further decision environment analyses by changing merely input data or even adding new formulas for the performance criterion expanding. The model of the inventory control as the discrete system control can be successfully used as a general dynamic model for analyzing inventory dynamics over a finite time horizon in the case of the fixed-order quantity system. When developed in a spreadsheet (tables and charts) it is a great tool for both academics and professionals to better understand dynamics of the inventory on the day by day basis.

3. CASE STUDY: DYNAMIC DISCRETE EOQ MODEL FOR INVENTORIES IN WATER-COOLERS DISTRIBUTION WITH VARYING DEMAND

La Fantana is a leading company in Serbia in the field of water bottling and distribution via water cooler devices in the corporative segment. La Fantana goal is to become the leader in the household sector too, and to be the first choice when it comes to delivery of fresh, high quality water using water cooler devices. Their slogan „It Comes to You" describes in the best way the nature of La Fantana service. Their business is based on the principle of subscription packages adapted to the needs of families and companies. Today, company has more than 10.000 clients with 25.000 water cooler devices installed with private and legal entities. La Fantana Company produces and distributes yearly over 16.000.000 litres of natural noncarbonated mineral water. Diversity of company offer is reflected in subscription packages adapted to various requests of our clients, as well as in the functionality of water cooler devices, enabling to enjoy cold, hot, carbonated or water heated to room temperature. La Fantana carries out water production and bottling in its own modern factory located in Mitrovo Polje, near Aleksandrovac Župski in Serbia.

La Fantana has 6 logistics distribution centers (LDC), positioned in all different parts of country. From these LDCs company La Fantana is supplying customers whith small truck fleet about 30 vehicles. All deliveries are done in 24h, and company has 99,6% rate of success deliveries in 24h. Full truck loads (FTL) are supplying LDC, from the plant and Less then full trucks loads (LTL) shipments are supplying customers.

Intesity of FTL shipments in 2011 are described in Table 2.:

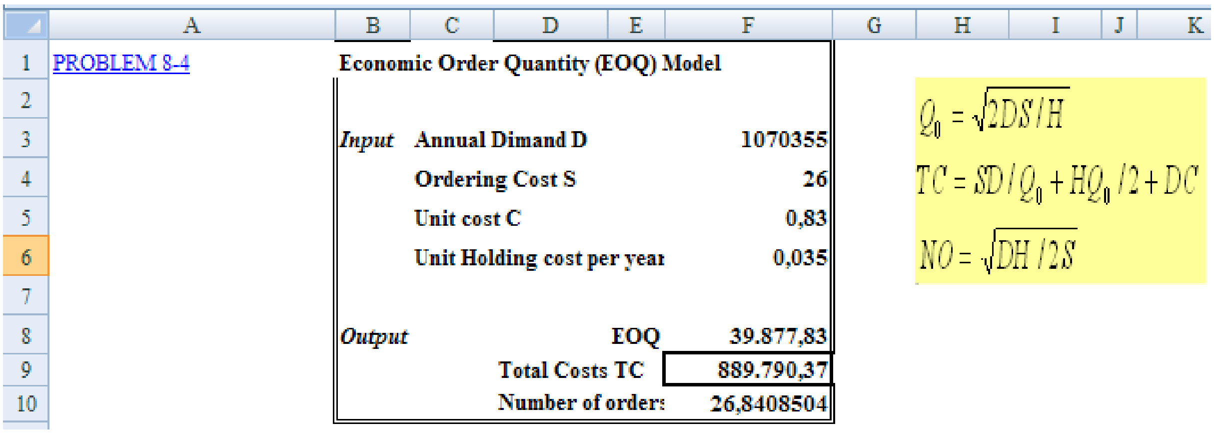
Table 2.

Destination (from - to)	**FTL per week**	**Number of bottles deliver per week (bottle 19l and bottle 11l cummulative)**
Plant - Belgrade	15	15600 bottles
Plant - Novi Sad	4	4160 bottles
Plant - Subotica	2	2080 bottles
Plant - Čačak	1	1040 bottles
Plant - Kragujevac	1	1040 bottles
Plant - Niš	1	1040 bottles
TOTAL per week:	**24**	**24960 bottles**
Total per year:	**48weeks x 24 per week = 1152 FTL**	
Average number of replenishment:	**4 per week; 48weeks x 4 = 192**	
Average quantity of inventory in system:	**21000 bottles**	
Daily reciving capacity of system	**around 5000 bottles**	

The input data for La Fantana EOQ model are: T=302 working day, Annual demand = 1.070.355 bottles, Fixed ordering cost = 26 euro per order, Unit price = 0,83 euro/bottle, Unit holding cost per year = 0,035 euro. Annual demand is varying per each period t=1...302 days (real data for demand from company La Fantana).

3.1 Discussion and comparison of the results

The results of classical static EOQ model is shown in Figure 3.



PROBLEM 8-4

Economic Order Quantity (EOQ) Model

Input	Annual Dimand D	1070355
	Ordering Cost S	26
	Unit cost C	0,83
	Unit Holding cost per year	0,035
Output	EOQ	39.877,83
	Total Costs TC	889.790,37
	Number of orders	26,8408504

$Q_0 = \sqrt{2DS/H}$

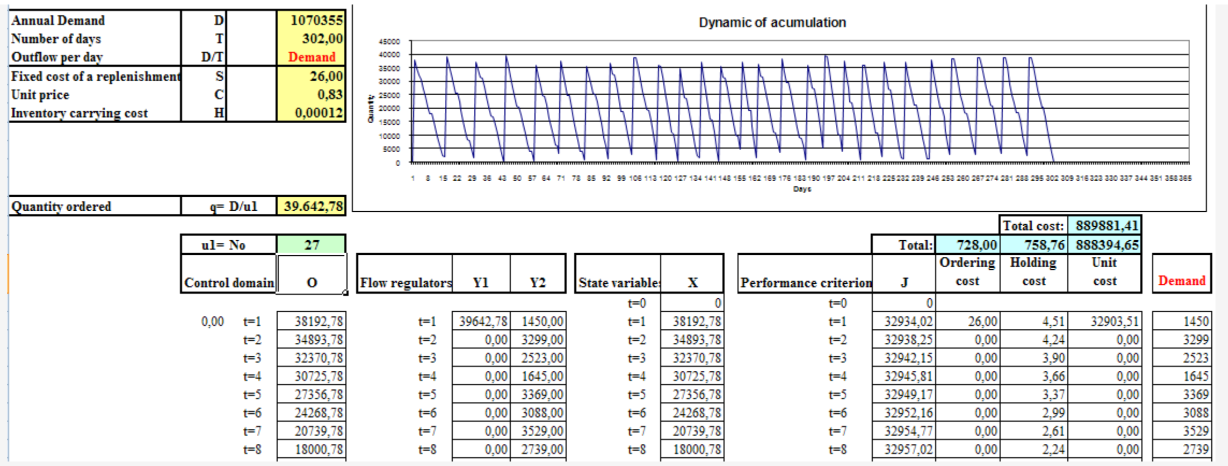
$TC = SD/Q_0 + HQ_0/2 + DC$

$NO = \sqrt{DH/2S}$

Figure 3.

Results of classical EOQ model are showing that the optimal number of replenishments is 26,8 orders per year and EOQ quantity per each order is 39.877,83 bottles and minimal total cost is 889.790 euro. This result is not applicable in real situation, becouse EOQ quantity is greater then reciving capacity of inventory in system (5000 bottles), and greater then average quantity of inventory in system (21000 bottles), which shows us that the storage capacities in system are insufficient for EOQ quantity. Also, it is practically inconvenient to apply 26,84 replenishments and order EOQ quantity of 39877,83 bottles per order. These variables have to be integers, becouse they are integers in real bussines situation.

Validation of results of static model we obtain when apply input data for EOQ model in dynamic descrete EOQ model in spreadshet. Results of dynamic discrete EOQ model are presented in Figure 4.



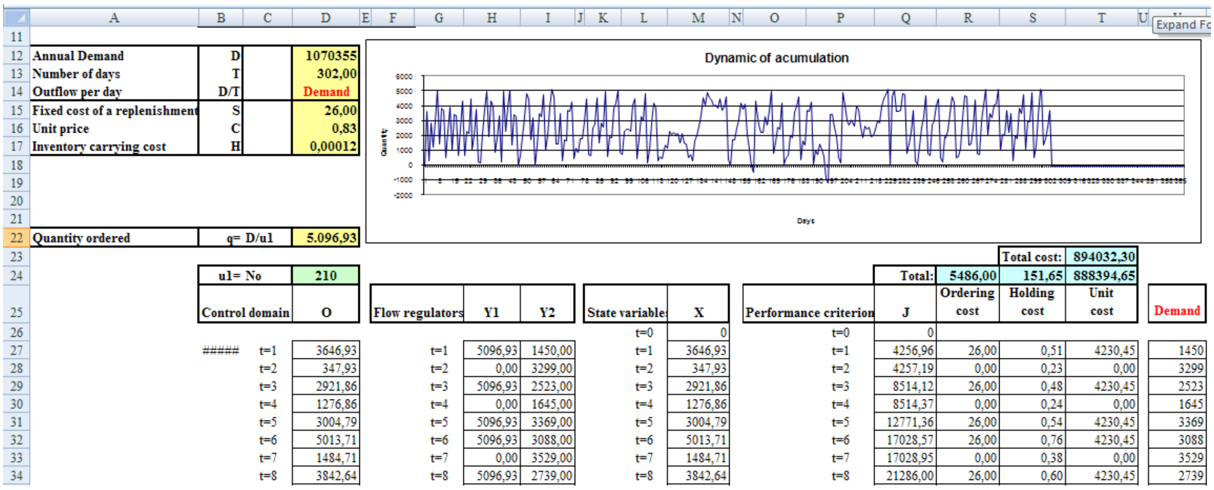
Annual Demand	D		1070355
Number of days	T		302,00
Outflow per day	D/T		Demand
Fixed cost of a replenishment	S		26,00
Unit price	C		0,83
Inventory carrying cost	H		0,00012
Quantity ordered	q= D/ul		39.642,78

											Total cost:	889881,41	
	ul= No	27							Total:	728,00	758,76	888394,65	
	Control domain	O	Flow regulators	Y1	Y2	State variable	X	Performance criterion	J	Ordering cost	Holding cost	Unit cost	Demand
						t=0	0	t=0	0				
0,00	t=1	38192,78	t=1	39642,78	1450,00	t=1	38192,78	t=1	32934,02	26,00	4,51	32903,51	1450
	t=2	34893,78	t=2	0,00	3299,00	t=2	34893,78	t=2	32938,25	0,00	4,24	0,00	3299
	t=3	32370,78	t=3	0,00	2523,00	t=3	32370,78	t=3	32942,15	0,00	3,90	0,00	2523
	t=4	30725,78	t=4	0,00	1645,00	t=4	30725,78	t=4	32945,81	0,00	3,66	0,00	1645
	t=5	27356,78	t=5	0,00	3369,00	t=5	27356,78	t=5	32949,17	0,00	3,37	0,00	3369
	t=6	24268,78	t=6	0,00	3088,00	t=6	24268,78	t=6	32952,16	0,00	2,99	0,00	3088
	t=7	20739,78	t=7	0,00	3529,00	t=7	20739,78	t=7	32954,77	0,00	2,61	0,00	3529
	t=8	18000,78	t=8	0,00	2739,00	t=8	18000,78	t=8	32957,02	0,00	2,24	0,00	2739

Figure 4.

It should be noted that the state variable (quantity of inventory per day) never reaches zero, what is basic assumption for static traditional EOQ model. In order to find optimal number of replenishments giving minimal value to the performance criterion J, we have to check less than T values for the control variable number of orders per year using One-Input Data Table function. The result of One-Input Data Table function is u^1=30, and minimal total cost is 889.854,384 euro.

In case, we want to make dynamic discrete model more realistic to meet the condition of reciving storage capacity for inventories in system, we should change number of orders per year and see result of simulation. Maximum daily capacity of storage for reciving FTL deliveries is approximately 5000 bottles or 5 FTLs, (see Figure 5.).



	A	B	C	D
11				
12	Annual Demand	D		1070355
13	Number of days	T		302,00
14	Outflow per day	D/T		Demand
15	Fixed cost of a replenishment	S		26,00
16	Unit price	C		0,83
17	Inventory carrying cost	H		0,00012
18				
19				
20				
21				
22	Quantity ordered	q= D/ul		5.096,93

23												Total cost:	894032,30	
24		ul= No	210							Total:	5486,00	151,65	888394,65	
25		Control domain	O	Flow regulators	Y1	Y2	State variable	X	Performance criterion	J	Ordering cost	Holding cost	Unit cost	Demand
26							t=0	0	t=0	0				
27	#####	t=1	3646,93	t=1	5096,93	1450,00	t=1	3646,93	t=1	4256,96	26,00	0,51	4230,45	1450
28		t=2	347,93	t=2	0,00	3299,00	t=2	347,93	t=2	4257,19	0,00	0,23	0,00	3299
29		t=3	2921,86	t=3	5096,93	2523,00	t=3	2921,86	t=3	8514,12	26,00	0,48	4230,45	2523
30		t=4	1276,86	t=4	0,00	1645,00	t=4	1276,86	t=4	8514,37	0,00	0,24	0,00	1645
31		t=5	3004,79	t=5	5096,93	3369,00	t=5	3004,79	t=5	12771,36	26,00	0,54	4230,45	3369
32		t=6	5013,71	t=6	5096,93	3088,00	t=6	5013,71	t=6	17028,57	26,00	0,76	4230,45	3088
33		t=7	1484,71	t=7	0,00	3529,00	t=7	1484,71	t=7	17028,95	0,00	0,38	0,00	3529
34		t=8	3842,64	t=8	5096,93	2739,00	t=8	3842,64	t=8	21286,00	26,00	0,60	4230,45	2739

Figure 5.

In order to fullfill the condition of daily limit of storage for reciving EOQ quantity, number of orders become 210 orders per year, and EOQ quantity is 5096 bottles and total cost is 894.032 euro per year. When we compare results of optimal total cost from static EOQ model, we see diffrence of 4241 euro, what is in real situation insignificant amount of money. Also, we should noticed, becouse of varying demand, we have stock-out in t=157, and t=158 period in amout of 32 and 424 bottles, what is also insignificant amount of sock-out.

4. CONCLUSION

This model clearly distinguish the discrete controlled object, performance criterion and method for solving the problem. Firstly, this paper gives the mathematical rationale of the discrete object (Low of dynamics and Control domain) representing dynamics of the inventory stock over the time horizon. Secondly, it gives real case study of inventory control in company La Fantana. Thirdly, paper shows the user is freed of making cumbersome spreadsheet formulas by himself. It is proved to be very useful to add a spreadsheet chart depicting stock and shortage dynamics over the time horizon. Also, user can perform "what if" analyzes or a meta-heuristics search in order to find the optimal solution which can be simulated and analyzed.

This paper also details how to use one-input spreadsheet data table function to find optimal number of replenishments giving minimal total inventory cost.

In order to prove superiority over the classical EOQ model, several prominent papers tackling the inventory problem where compared with our approach. The conclusion can be that our approach is more convenient for education and training of both students and practitioners.

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TOWARDS OPEN FORESIGHT? THE COMPETITIVENESS MONITOR AS AN IT-BASED FORESIGHT TOOL FOR THE LOGISTICS INDUSTRY

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Dr. Heiko von der Gracht
EBS Business School, Wiesbaden, Germany

1 Introduction

Supply chains have become highly complex systems with many different actors involved. They span the entire globe, are getting ever more specialized and operate in a turbulent environment under volatile conditions (Pettit et al., 2010). This translates into a heightened need for future-oriented planning in the logistics sector (Sodhi, 2003), especially as logistics has developed into a strategic priority for companies and organizations (Yeung, 2008). Against this background, we design and introduce a futures-oriented decision support software tool. The so called Competitiveness Monitor (CoMo) is funded by the German Federal Ministry of Education and Research and will be employed by the leading-edge cluster LogistikRuhr[1].

2 Logistics as a strategic discipline

In the past decades, logistics has evolved into a complex process, with many steps of the increasingly longer supply chain integrated and comprehensively managed (e.g. Ballou, 2007, Jain and Benyoucef, 2008, Meixell and Gargeya, 2005). This coincides with the globalisation of production, which lifts efficient and reliable logistics to a strategic position for many companies and may even form the basis of the corporate strategy (Yeung, 2008, Qi et al., 2009). Globalisation has also led to increased competition among logistics service providers. Consequently, logistics products have to be offered faster, more flexibly as well as more reliably and logistics service providers must keep up with the latest technology (such as e.g. RFID) in order to stay competitive (Bhatnagar and Teo, 2009, Jain and Benyoucef, 2008, Gunasekaran et al., 2008).

The discussion of these issues shows that uncertainty in the business environment of logistics services has increased dramatically. This is especially true when international trade’s rising volatility due to the synchronisation of business cycles is taken into account (e.g. Inklaar et al., 2005, Frankel and Rose, 1998). Accordingly, logistics service providers are often faced with highly complex – or wicked (Rittel and Webber, 1973) – problems in strategic decision making. One response to such complex challenges has been the adoption of foresight processes (Chermack, 2011), especially as foresight is also seen as a way to tackle wicked problem (Sardar, 2010). At the same time – as logistics can now be considered a strategic issue for many companies - long-range planning is directly applicable to impactful logistics decisions. A recent study by consultants A.T. Kearney shows that companies planning with longer time horizons are more successful (Violani et al., 2011). Thus, a futures orientation should become a priority for companies active in supply chain management. In fact, several studies suggest that it would be especially important to develop a futures orientation in logistics and to employ techniques such as the Delphi or scenario technique in strategic logistics planning (Sodhi, 2003, Deep and Dani, 2010). Sadly, that is not the case for many companies so far.

3 Developments in IT-based Corporate Foresight Tools

Use of IT-tools in foresight has increased steadily in recent years and this trend isexpected to hold on (e.g. Rohrbeck, 2010). The potentials of IT in foresight range

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[1] For the leading-edge-cluster see http://www.bmbf.de/en/15162.php.

Joint research partners in the Competitiveness Monitor project are Bayer MaterialScience, BrainNet, dilotec, EBS Business School. Project duration: 06/2010 – 05/2013. Responsibility for the content is with the authors.

from internationalization over indexing to brain research (Gordon et al., 2005). But even today foresight processes are supported by a large variety of tools. Apart from quantitative software for trend extrapolation this prominently includes real-time Delphi surveys (e.g. Gordon and Pease, 2006, Dalal et al., 2011) and trend databases. An overview over prominent trend databases for foresight is given in Table 1. Additionally many firms nowadays also rely on software for scenario building, such as Parmenides EIDOS, while consultancies support their projects with their own similar software packages.

Trend database	Method	Further features	URL
iknow	Crowd-filled	Real-time Delphi	Community.iknow.futures.eu
Shaping Tomorrow	Crowd-filled	Trend analysis	www.shapingtomorrow.com
Techcast	Expert-filled	n/a	www.techcast.org
TrendONE	Expert-filled	n/a	www.trendexplorer.de
Trendwatching	Network-filled	n/a	www.trendwatching.com
Trend Wiki	Network-filled	n/a	www.trendwiki.de
Z_Punkt	Team-Edited	n/a	www.z-punkt.de

Table 1: Overview of Trend Databases

While these instruments for futures-relevant information gathering and information management have already had an impact on foresight processes, this is only a beginning process. When it comes to more complex support systems, foresight – as a qualitative process – has long been lagging more quantifiable disciplines in implementation and quality and it is thus believed that the outcomes can still be greatly enhanced by the employment of IT (Courtney, 2001, Vaccaro et al., 2010).

As is usually the case with decision support systems, the main goal of IT-based foresight tools is to raise efficiency and quality of decision making process (cf. Shim et al., 2002). Various approaches to achieve these goals are undertaken in the literature. Applications such as the real-time Delphi make away with cumbersome paper-work while maintaining at least the same quality, thus enhancing efficiency (Gnatzy et al., 2011). They also involve larger numbers of people and in this way draw on the "wisdom of the crowds" theorem in order to even improve outcome quality (Dalal et al., 2011, Surowiecki, 2004). Prediction markets follow the same rationale for achieving more accurate results (e.g. Wolfers and Zitzewitz, 2004). Such crowd approaches thus potentially involve outside stakeholders in companies' foresight processes and just might steer some foresight processes – analogous to some developments in innovation – in the direction of "Open Foresight" (cf. Daheim and Uerz, 2008). Other approaches are more technical in nature: many authors draw on existing knowledge stored in database or on other websites by using data-mining techniques for their forecasting methods (e.g. Olson et al., 2012, Lee et al., 2012). In this way linkages among many different data sources allow for scanning more data in less time. Other authors suggest the inclusion of complex modelling in decision support and scenario building (Macal and North, 2010, Ahmed et al., 2010).

Overall it stands to reason that most progress will come from the combination of different methods with one another, as this provides for a more holistic picture of future developments (Tseng et al., 2009). Banuls and Salmeron (2011) call for Foresight Support Systems (FSS) and propose a system of databases, communications, scenario software and a prediction market. Other attempts for integrated systems include combinations of the Delphi method with Systems Cross Impact Analysis and interpretive structural modelling (Bañuls and Turoff, 2011) and a combination of multi-criteria and scenario methods (Bañuls and Salmeron, 2007). However, these systems have not been developed for regular application in business processes. Of course, some of the databases listed above include further features for the analysis of trends and development – most notably the "iknow" and "shaping tomorrow" projects. Yet, these are very general and lack particular emphasis on business processes, let alone the logistics industry.

4 Requirement Analysis

As a joint research project in the Leading-edge Cluster Logistics, CoMo is designed by a team of experts stemming from four diverse partners: a large manufacturing corporation, a supply chain management consultancy, an IT service provider, and an academic research institution. This mix ensures high levels of diversity, methodological interdisciplinary and industry relevance. Against the background of the above discussion of deficiencies in foresight among logistics service providers and the developments in IT-based foresight tools, CoMo was from the beginning envisioned as a future-oriented IT platform where science-, business-, and politics-partners of the cluster can co-operate to ensure a sustainable competitive advantage for all stakeholders.

For the further specification of the project, a multi-method requirement analysis was conducted. After intensive desk research, several participatory workshops were organized. During a systematic process according to the Volere Requirement Template (Robertson and Robertson, 2006, Robertson and Robertson, 2010), more than 1,000 specific requirements for the tool were identified and prioritized along the criteria of *feasibility, innovativeness* and *importance.* A stakeholder and use-case analysis in order to address dependencies and underlying assumptions was implemented. This process cut down the number of requirements.

Simultaneously, we asked the 130 cluster partner organizations (overall 178 potential contacts) about their expectations towards an innovative foresight tool that meets the requirements of the logistics industry. Overall, 21 respondents (a response rate of 11.8%) assessed 13 questions. We further conducted a study among the world's leading foresight experts about expected future developments in ICT-based foresight tools. For this we used the Delphi method, a proven iterative survey process that aggregates experts' opinions, while encouraging consensus by giving controlled feedback of the other experts' opinions (Linstone and Turoff, 2011, Rowe and Wright, 2001). Of almost 1,000 experts contacted, 177 participated in the study.

The analysis revealed the following major requirements for CoMo:

(1) Creating, linking, and processing information about future macro- and microeconomic developments in logistics and its environment in order to better establish futures-relevant knowledge in the logistics industry.
(2) Providing educative information on futures studies and teaching future skills to overcome the resource-constraints of SMEs in the sector.
(3) Incentivizing stakeholders to systematically deal with their futures and to foster innovation, thus increasing the competitiveness of participating companies.
(4) Stimulating co-operation among cluster stakeholders, so that the benefits of crowd wisdom can be reaped by the participating partners.

The developments discussed prompted us to opt for an integrated multi-method tool consisting of a futures platform, a trend database (TDB), a futures workshop and a prediction market application (PMA). A particular focus on collaboration among different stakeholders underscores the goal to develop the cluster in the direction of a system of "open foresight". The Delphi study confirmed that integrated tools seem to be the most elaborated way forward for achieving efficiency and effectiveness in IT-based foresight. The overall framework design of CoMo is depicted in Figure 1.

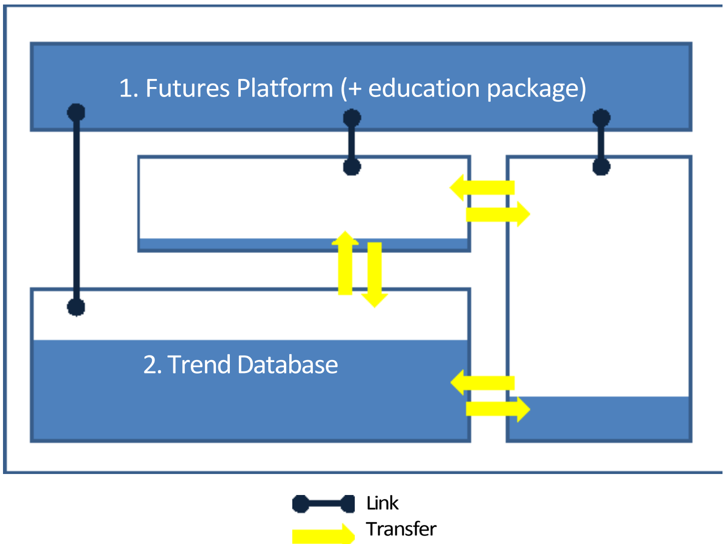

Fig. 1: CoMo Framework Design

Three facts led us to refrain from introducing more advanced tools such as modelling of complex systems: (1) a high degree of difficulty in implementation; (2) a high degree of preference for easy to use systems by the cluster partners and (3) a relatively low probability of occurrence for advanced methods in the Delphi indicates too slow technological progress for implementation. Yet, as an integrated tool, CoMo employs elements of crowd-sourcing, linkages, data-mining and qualitative methods. Therefore it represents a contribution to the ongoing research described in section 3.

5 The Competitiveness Monitor for Logistics

In the following, the features derived from the requirement analysis for all four applications of the CoMo are briefly described.

5.1 The Futures Platform

The users logs in through the futures platform. Here they have access to the other three tools. They are provided with personalized information and can save their individual favourites and work. The platform also offers opportunities for communication among CoMo users, so as to encourage collaboration among partners and to provide for a transparent work environment. An educational self-learning package will be included with the platform. This covers the functionalities of CoMo as well as the principles and advantages of corporate foresight. The educational package will be designed specifically for users stemming from SMEs.

5.2. The Trend Database

The CoMo futures knowledge is generated, stored, linked and further developed inside the TDB. The other application can draw data from the TDB, yet can also store new or complement information created during their application in the TDB. Analysis of existing TDBs showed that missing focus on a specific topic renders the TDB less effective, because the extensiveness and quality of trend information tends to be limited and consequently too unspecific for a single industry. The TDB of CoMo therefore will be clearly focused on trends relevant to the logistics industry.

The requirement analysis showed that the database needs to be structured and presented in a way not to lead to an overload of information for the user. In contrast to many existing TDBs, which rely on professionals to collect and edit trend information, the CoMo TDB will also employ crowd wisdom. Thereby, users are incentivized to collaboratively generate, edit and assess future-oriented knowledge. Yet, a combination of the two methods is the most promising concept, because the incorporation of expert knowledge ensures validity and actuality of the provided information even in case of low interest in certain trends (Cuhls, 2003).

An important challenge for this TDB-design is the incentivization of users, not only to consume the knowledge but to also actively contribute their own insights to the system by creating new trends and evaluating or tagging new trends. The CoMo will employ the concept of "lead-user" to achieve this (Leimeister et al., 2009): through participation, users will gain status as well as credits which they can later user e.g. in the prediction market application or for special educative sessions.

The intelligent inter-connection of the TDB's knowledge creates additional value mainly via two kinds of linking mechanisms. First, related trends within the CoMo TDB will be linked with each other so that a holistic and more complete picture for the future logistics environment is created. High-impact, low probability events – so-called wildcards – will also be included in order to additionally help decision makers by alerting them to possible disruptions with severe consequences for their own business. Second, the TDB will be linked with the other CoMo tools "Prediction Markets" and "Future workshop": TDB information will be used to run these tools, while newly their newly created data will archived in the TDB.

5.3 The Futures Workshop

The Future Workshop application builds on the TDB by giving CoMo users the opportunity to project the TDB's general developments into their individual futures. They can collaboratively build scenarios, assess options and derive plans of action. Traditional Future Workshops were developed by Robert Jungk and Norbert R. Muellert in the 1970s (Jungk and Muellert, 1988). They originally conceptualized four phases for a workshop: (1) Preparation, (2) Critique, (3) Fantasy, and (4) Implementation. The CoMo transfers the idea to the digital level. However, according to requirement analysis' outcome, the first two phases will be combined for the CoMo workshop. Hence, the CoMo it will consist of the phases (1) Preparation (2) Analysis and (3) Implementation.

For phases 2 and 3 best practice from a multitude of foresight methods will be applied in order to better position CoMo as an integrated multi-method foresight tool. The Analysis Phase will include elements of morphological analysis (e.g. Ritchey, 2006) and cross-impact analysis (e.g. Bañuls and Turoff, 2011), while the Implementation phase will draw on ideas of roadmapping (e.g. De Laat, 2004), backcasting (e.g. Quist and Vergragt, 2006) and TRIZ (Altshuller and Rodman, 1999). In the Preparation phase, users can choose trends and wildcards from the TDB as well as add individual factors to create the individually adapted environment of the workshop. These factors must be collaboratively prioritized. The group has the opportunity to assess the factors and engage in the above described creative methods for problem evaluation and solution-identification.

The workshop guides the user through a process of problem identification, innovation, and creativity towards problem solving and thus helps to acquaint newcomers to foresight with the process. The digital implementation of the concept renders spatial boundaries irrelevant. Consequently, the workshop contributes to the facilitation of foresight in strategic logistics planning, even for resource-constraint companies. For example, participants can evaluate which strategic opportunities are most robust for the future. Using the data from the TDB and the processes of the workshop, decision makers are thus able to combine qualitative and quantitative information in order to actively shape their companies' future. Possible outcomes of a Future Workshops are action plans, priority lists, or roadmaps. The assessments of trends and factors completed during a workshop will be fed back into the TDB.

5.4 The Prediction Market Application

The CoMo PMA is an additional innovative foresight method complementing the other tools of the CoMo. Evolved in psephology, prediction markets enable traders to bet on the outcome of specific events in a virtual environment. Events are traded similar to stock in stock exchanges, so that prices indicate the likelihood of occurrence for the particular event. The theoretical basis is founded in the combination of crowd wisdom (Surowiecki, 2004) and the Hayek-Hypothesis about market efficiency (Hayek, 1945). As a result the market aggregates asymmetrically distributed knowledge in the price of one stock. Prediction markets have often outperformed classical opinion polls in accuracy. As a result they have increasingly been employed in the business world, e.g. for sales forecasts (Ho and Chen, 2007). The possibility for discretionary trading and the innovative nature of the PMA incentivize participation, while it is unimportant whether the credits are virtual (as in the CoMo-case) or real money (Servan-Schreiber et al., 2004).

Additionally to incentivizing users to think about future logistics developments, the PMA contributes to CoMo's goal of aggregating logistics companies' knowledge and capabilities. Future-relevant wisdom/knowledge for all involved companies is generated. The application will further be linked with the TDB and the Future workshop: markets can be set up for ideas stemming from a future workshop, e.g. potential benefits from investment decisions or potential sales figures for a product innovation; any trend from the TDB can also be traded in the PMA and the result from the particular market will be fed back into the system. For example this could be the probability of a price development or the potential date of a technology innovation.

6 Meeting the Challenges

As an integrated multi-method IT-tool for the logistics industry, CoMo is designed to meet all challenges identified during the requirement analysis. TDB and PMA provide the users with futures relevant information. Trends are linked with each other and all tools are interconnected to maximise the usability of the data. An educational package acquaints all users with the tools as well as with the possibilities and limitations of corporate foresight. Together with the innovative and easy-to-use tools, the crowd-induced incentives and the possible gains in competitiveness this encourages the uptake of foresight activities especially among SMEs of the logistics sector. These activities will primarily be implemented through the use of the digital futures workshop, with all participating stakeholders working together to increase their competitiveness. Achieving this goal would be a first step in establishing a system of open foresight in the leading-edge cluster Logistics.

ACKNOWLEDGEMENTS

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THE INTELLIGENT CONTAINER IN THE MARKETING MIX OF LOGISTICS SERVICE PROVIDERS - AUTONOMOUS COOPERATING TECHNOLOGIES FOR THE CREATION OF CUSTOMER VALUE?

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Introduction

Companies have to contribute to customer value in order to differentiate from competitors and to gain competitive advantages (Porter, 1985; Woodruff, 1997). However, in the field of logistics services, providers have to face the problem of a relatively homogeneous product span: Basic services like transport, storage and handling provide only limited possibilities to differentiate from competitors (Davis, Golicic & Marquardt 2008) through delivering additional customer value. Thus, the price alignment often constitutes the only possibility to convince customers of demanding a logistics service (Speh, 2008). However, price competition is limited: Low prices in connection with increasing costs (e.g. petrol) lead to a decrease of LSPs' margins. Thus, in order to overcome price competition LSPs have to offer services with a special design of value adding characteristics (Bask, 1999). Moreover, customers need to perceive these characteristics as valuable (Lappiere, 2000), in order to increase their willingness to pay higher prices (reduce price competition) for the service. Therefore the question arises: How can LSPs create customer value adding service characteristics?

The concept of autonomous cooperation is discussed as one approach to gain competitive advantages (Hülsmann, Grapp & Li, 2007). Thereby, autonomous cooperation can contribute, beside others, to the improvement of the management of organisational competences (Hülsmann, Austerschulte & Grapp, 2008) and an increased innovation capability in logistics systems (Hülsmann & Cordes, 2009). This indicates that autonomous cooperation can lead to new or improved logistics service characteristics and might therewith reduce price competition through a better configuration and use of competences as well as a higher innovation rate. The research in the field of autonomous cooperation led to the development of special, autonomous cooperation-enabling, technologies like the Intelligent Container. This special mean of transport combines different technical components: RFID tags, sensor networks and software applications (Gehrke et al., 2006). Based on that, new characteristics for logistics services occur: permanent quality control and automated intervention in case of critical events (Jedermann et al., 2007). Hence, the research question is: Can the new service characteristics provided by the Intelligent Container contribute to the creation of customer value?

In order to answer this question, the paper aims to analyze the Intelligent Containers' contributions and limitations to the creation of customer value. Hence, the structure of the paper is given as follows: After a brief introduction in the first section, the concept of autonomous cooperation and the Intelligent Container as one autonomous cooperation-enabling technology will be outlined in the second section. The third section will introduce the extended 7P marketing mix (product, price, promotion, place, personal, process, physical facilities) (Margrath, 1986) as an approach, which allows for the ascertainment of customer value (Bruhn, 2009). In the fourth section, additional service characteristics (permanent quality control and automated intervention) that can be realized through

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employing the Intelligent Container in a LSPs service portfolio, will be revealed and analyzed regarding their effects on customer value creation through the 7P marketing mix. Moreover, contributions and limitations of the Intelligent Container regarding the creation of customer value will be outlined and discussed. The paper will conclude with a summary of the main findings in the fifth section.

The Intelligent Container – an Autonomous Cooperation Enabling Technology in Logistics

The idea of autonomous cooperation originates from the necessity to better cope with complexity and dynamics in logistics (Freitag, 2004). Hülsmann and Windt (2006) identified five constitutive characteristics of autonomous cooperating logistics processes (decentralized decision-making, autonomy, interaction, heterarchy, non-determinism). Decentralized decision-making refers to the shift of decision-making power from a central management to the individual logistics objects on the lower levels of logistics systems (Hülsmann et al, 2006). Autonomy is related to the process of decision making and means that the logistics elements are responsible for their own system design and development through their rendered decisions. Interaction refers to the communication, which takes place between the elements in order to exchange information as the basis for their decision-making or money through negotiation activities (e.g. negotiation for transport space). The characteristic heterarchy describes the absence of a dominating entity on a higher system level. Finally, non-determinism refers to a general non-predictability of the system's behavior (Böse and Windt, 2007).

One particular technology that enables logistics objects to interact and decide autonomously in a heterarchic and non-determinist system is the so-called Intelligent Container (Gehrke eat al., 2006).

The Intelligent Container is a transportation system that is able to process inside data (e.g. humidity, temperature) as well as outside data (e.g. traffic jams). Based on that, the intelligent system is able to forecast good conditions (e.g. ripeness of bananas) for different points in time. That leads to the possibility to decide about good destinations according to the remaining shelf life (Lang et al., 2011). Based on the measurement and evaluation of such data, the Intelligent Container can render own decisions (e.g. adaption of temperature) under the consideration of before fixed decision routines. Thus, the Intelligent Container especially focuses on the transport of perishable goods like fruit and vegetables and realizes a paradigm shift from First in First Out (FIFO) to First Expire First Out (FEFO) (Lang et al., 2011). Therewith, it enables to cope with challenges such as increasing sensibility regarding quality and the range of logistics services as well as the requirement to offer freight related information in real-time (Jedermann et al., 2006). But how does the container functions in detail?

The Intelligent Container consists of RFID tags, wireless sensor-networks, and a system of software agents (Gehrke et al., 2006), which represent logistic entities. They are linked to container goods (e.g. packages or pallets) and process the relevant information provided by RFID tags and sensor networks (Jedermann and Lang, 2006). The container is equipped with an RFID gate at its door in order to supervise the loading process (Lang et al., 2011). That means the RFID tags (electronic way bill) are read out parallel to the loading process. The tags comprise good related information like the kind of good, the temperature range and the required supervision (Lang et al., 2011). The status data of goods (e.g. temperature, humidity) during the transport process is measured by the sensors within the container (Jedermann and Lang, 2006). Moreover, relevant data from "outside" (e.g. traffic, changing in transport orders) can be considered (Jedermann et al., 2007). This becomes possible through a communication gateway, which links the internal sensors to external networks (e.g. Internet) (Lang et al., 2011).

The software agents are able to analyze and evaluate the "inside" data, what means that they can estimate the goods condition at the point of delivery as well as the remaining transport time (Jedermann et al., 2006) under the use of a mathematical forecasting model (Lang et al., 2011). The inside data, as well as the outside data can be considered in their autonomous reaction (e.g. reaction to traffic jams through change of the transport route). Moreover, agents are in contact with the shipper to keep them informed about the freight conditions as well as about critical events in real-time. An example for an autonomous reaction might be the adaption of climate conditions within the container in order to control (accelerate, decelerate) the ripening process of fruits.

Hence, the resulting capabilities for LSPs that implement the Intelligent Container are permanent quality control plus forecasting and autonomous reaction to critical events. Therefore, the question arises, how these capabilities contribute or limit the creation of customer value?

The 7P Marketing Mix to Investigate Contributions and Limitations Resulting from the Use of the Intelligent Container

According to Flint at al. (1997), customer value can be defined as: *"The customers' assessment of the value that has been created for them by a supplier given the trade-offs between all relevant benefits and sacrifices in a specific-use situation"* (Flint et al., 1997, p.171). Hence, the customer perceives an individual value through the comparison between his individual benefits (e.g. quality) and sacrifices (e.g. the price which has to be paid) when using a product or demand a service. Authors like Ulaga and Chacour (2001) revealed a positive correlation between perceived customer value and the achievement of competitive advantages. However, two requirements have to be fulfilled: First, the perceived value has to be positive (perceived benefits > perceived sacrifices) in order to motivate a customer to demand a product or service. Second, assuming that the customer also compares products or services of different companies, the achievement of a competitive advantage requires the highest customer value in comparison to competitors. But how can a company control the delivering of customer value under the consideration of the need for positive value, which is higher than the value delivered by competitors?

According to (Bruhn, 2009) a company uses the marketing-mix decisions in order to concretize the customer value, which shall be delivered through a product. However, LSPs offer services instead of physical goods. The characteristics, which distinguish physical products from services, are intangibility (no physical ownership), inseparability (service production and consumption at the same time), heterogeneity (high variability and difficulties in standardization), and perishability (no storage possible) (Regan, 1963; Rathmell, 1966). Therefore, Magrath (1986) discussed an extension of the established 4P marketing-mix (product, price, promotion, place) (Bruhn, 2009) with three more elements (Process, Personal, Physical facilities). In conclusion the customer value of service companies is determined by decisions which belong to product, price, promotion, place, process, personal, and physical facilities. Product aims at the arrangement of different product attributes than those of competitors (competitive advantage) (Mullins et al., 2005). Thus, a Logistics company renders decisions regarding product portfolio (introduction of new transportation services), branding (differentiation of services through establishment of names or symbols, e.g. on containers), and E-Services (introduction of new Tracking & Tracing Services) (Meffert, 2009).

The Price describes the countervalue a customer has to give in order to deploy a service, whereas an appropriate price setting can aim for the achievement of a target return, maximization of profit, increasing sales volume, or to meet competition. (Etzel et al., 2004) The corresponding decisions for LSPs refer to price setting (which price for demanded transport service), price differentiation (different prices for special regions, times, customers, or bulk), and price conditions (e.g. discounts for customers with high frequency transport service demand) (Meffert, 2009).

The Promotion mix aims at the communication of the intended value, which shall be delivered to customers based on product attributes (e.g. accuracy of transport services), prices (e.g. low price transport services), or the whole company (e.g. social responsibility and "green logistics") to customers. A company can use different communication instruments, which are institutional communication (improve image of company, e.g.

through public relations, or sponsoring), marketing communication (increase sales of products or services through, e.g. media advertising or event marketing), and dialog communication (intercommunication with shareholders (direct) through, e.g. personal communication by employees, fair and showroom, or multimedia-based communication). (Meffert, 2009)

The Place addresses the establishment of distribution channels, which "*makes the right quantities of the right product available at the right time to satisfy the target customer"* (Mullins et al., 2005, p.295). That means for LSPs that the management has to assure the availability of their service portfolio. Thereby, they have to consider transport equipment (e.g. trucks), technical systems (e.g. computer systems for e-selling), humans (e.g. selling staff, truck drivers), and intangible assets (e.g. warehouse capacities). Moreover, a company has to decide about the kind of distribution (direct distribution, indirect distribution, E-commerce), and the channel design (number of levels and channel members) (Meffert, 2009).

According to (Meffert, 2009) the Personal component refers to the capabilities and qualifications of a company's staff members since the employees are highly involved in the service adduction. That means, the employee's behaviour in the service creation process is perceived directly by the customer and is included in the customer value calculation (e.g. a truck driver is in direct contact with the customers he delivers the transport goods to). The instruments, which are used in order to assure suitable employees, in terms of behaviour and capabilities, are personal recruitment, personal placement, and personal development (Meffert, 2009).

The Process element balances service demand and service supply especially in times of peak loads (Magrath, 1986). The main processes for LSPs are based on the main logistics tasks: transport, storage, and handling (Gudehus, 2005). Their optimization is based in turn on different end-customer advantages logistics activities can focus on –quality, cost, and time (Harrison and van Hoek, 2008).

Physical facilities (assets) aim at making the company's performance and the service quality experiencable and hence evident (Magrath, 1986). Thus, important physical assets for LSPs for conducting their transport, handling, and storage processes are, beside others, vehicles (e.g. trucks), handling technologies (e.g. fork lifters), buildings for storage, handling, and administration, loading units (e.g. container) and personnel.
Consequently, the question arises: How do the LSPs' capabilities resulting from the Intelligent Container (permanent quality control/ autonomous reaction to critical events) affect the 7P marketing mix elements respectively the creation of customer value?

Customer Value Creation through the Intelligent Container's Impact on the Marketing Mix

In order to reveal contributions and limitations of applying the Intelligent Container in logistics networks, two steps are necessary: First, both positive as well as negative effects on the 7p marketing mix have to be identified. Second, these effects have to be transferred into the components of the customer value concept – i.e. it has to be analyzed which effects lead to additional benefits and which to additional sacrifices for the customer. The following table summarizes the contributions and limitations of the Intelligent Container's features on the 7P marketing mix of LSPs:

7P Element	**Contributions**	**Limitations**
Product	• New services • Options for branding • Improvement of e-services	• Duration to run service profitable • Substitution of former services
Price	• Higher ranges for price setting through decrease of spoiled goods • Price differentiation and change in price conditions	• Lower ranges for price setting through costs for special equipment, special handling, maintenance
Promotion	• Highlighting innovativeness and "Greenness" • Highlighting new service in customer dialogue	• Negative promotion resulting from firing staff and data security
Place	• Possibilities in E-service distribution	• Inflexible distribution through special knowledge required
Personal	• Recognition as innovative employer • Less physical stress for personal • Less personal costs	• Higher training costs • Firing staff might be required
Process	• Increased process quality • Lower process costs • Improved time management	• Higher process costs
Physical Facilities	• Highlighting quality, and innovativeness through PF	• Higher costs for adapting PF

Table 1: Contributions and Limitations for the 7P Marketing Mix

Contributions and Limitations regarding Product

Looking at the portfolio of LSPs that use the Intelligent Container, one contribution might refer to the development of new services. One example is a food transport service, which allows for permanent quality information for the shipper as well as autonomous reaction to critical events (e.g. traffic jam) (Lang et al., 2011). Moreover, the Intelligent Container can also contribute to the branding of a LSP as being highly qualitatively oriented, and thereby to a differentiation from competitors. Regarding the establishment of e-services, the use of the container also leads to an improvement of information availability for the customer by providing data regarding temperature, good conditions, critical events, and reactions through extended Tracking and Tracing Systems.

However, since the services based on the new characteristics will probably not be established from the beginning on the immediate profitability of the service might be in doubt. This effect is also strengthened by a possible substitution of former profitable running transportation services based on normal containers.

Contributions and Limitations regarding Price

Since the use of the container can lead to a decrease of spoiled goods (Lang et al., 2011) higher ranges for price setting occur. However, this depends on the contract between customer and LSP. If the LSP has to pay for spoiled goods, the container can lead to lower costs for him. This can either lead to lower prices for the customer or to higher margins for the LSP (if prices are not adapted). If the customer has to pay, he may accept higher prices for the service itself if the saved money through the lower rates of spoiled goods compensates the increase in the service price. Options for different prices and conditions can result from the characteristics of the transported goods. That means, that a LSP can increase prices if transported goods are highly sensitive regarding the transport temperature (e.g. frozen goods) or if the transported goods are high priced (e.g. luxury goods). Thus, the customer can be willing to pay higher prices for the special service. However, the use of the Intelligent Container also causes several costs since it requires e.g. to purchase new equipment (e.g. for special handling) or up-to date technical systems (e.g. computer software), as well as maintenance, which in turn can lead to lower ranges for price setting.

Contributions and Limitations regarding Promotion

Companies can highlight themselves as very modern and innovative (Hülsmann et al., 2010) as well as environmentally friendly and sustainable in their institutional communication. Associate advertising instruments can be event and dialog marketing. One example: Members of the company can be sent directly to potential customers in order to communicate the functionalities and advantages of the container in use. However, limitations can result from the container's ability to render decisions autonomously, what makes the human intervention obsolete. Based on this rationalization of work the impression may come up that the Intelligent Container's use leads to unemployment of people. Moreover, the autonomy of the container can raise the question of data security, since the container also detects and stores data by its own, which can result in negative promotion as well (Hülsmann et al., 2010).

Contribution and Limitations regarding Place

Regarding the kind of distribution as well as regarding the channel design the container's features can lead to new options to distribute services via e-commerce. Because of the container's digital interfaces it is e.g. possible to establish a direct link between them and the company's e-commerce platforms. The container could offer its transport services directly to customers based on the relevant information (e.g. position and estimated arrival time). This would change the design of distribution channels, since the container itself would constitute one part of it. However, distribution itself can become more difficult. Since the container provides a more intelligent but also more complex service this may require special knowledge of selling personnel, which requires special trainings. This might increase the distribution's inflexibility because possible customer requests might not be handled properly due to a lack of specially educated staff.

Contribution and Limitations regarding Personal

Through highlighting an LSP as modern, innovative, and green it can be recognized as a good employer in terms of e.g. sustainability. This can influence employees in their decision making (Drumm, 2008) and hence might increase the generally available human resources. Moreover, through the autonomous reaction of the container the intervention of human beings becomes obsolete. The tasks that require personal involvement are shifting to controlling and technical related issues (e.g. maintenance of computer or sensor systems). This may reduce physical stress for the staff working with the IC. Moreover, less people are needed for the tasks. This would result in reduced personal costs. However, the shift to controlling and technical tasks also causes limitations: the new tasks require special cost intensive trainings for the staff in order to deal with their new responsibilities. Moreover, as mentioned above, controlling and technical related tasks require fewer employees in comparison to tasks occurring from handling a normal container.

Contribution and Limitations regarding Process

According to the process quality an increase can be assumed. That results from the fact, that the goods are controlled permanently by the included systems. Also in case of critical events the container's systems can react autonomously. Thus, the spoilage of goods can be decreased. Through the distribution of the transported goods according to the ripe degree (e.g. of bananas) the quality of the process is increased as well. (Lang et al., 2011) The process costs can also be increased since the lower rate of good spoilage as well as less personal needed can increase the overall costs. With regard to the process time the autonomous intervention of the container's systems can lead to a better time management and lower throughput times. The autonomous reaction to traffic jams might be one example. A positive effect of using the concept of autonomous cooperation on the improvement of throughput times by the autonomous swapping of items within a production process has already been shown by other researchers (Gebhardt et al., 2011). However, according to the process cost a decrease might also be possible, which constitutes a limitation. That results from the fact that higher costs can occur through additional required equipment and special personal trainings as it was already discussed above. This additional costs would also influence respectively decrease the overall process costs.

Contribution and Limitations regarding Physical Facilities

The options, which result for the Physical Facilities of a LSP, shall be discussed together for the different facilities (vehicles, handling technologies, buildings, loading units). As contributions, the physical facilities of the LSP can be adapted based on the use of the Intelligent Container. That means they can be used as mediums to promote the LSP respectively highlighting its innovativeness and the service quality. This can be done for instance through letterings like "Intelligence", "RFID", "Sensor Network" on vehicles, handling technologies, buildings, or loading units. However, the adaption of the physical facilities can ones more lead to higher costs for the LSP. Those costs constitute a limitation, which has to be considered as well.

When contributions lead to benefits and limitations to sacrifices for the customer the question arises, how the net customer value is affected?

Benefits for the customer

From a cost perspective the customer can gain advantage of lower service prices, resulting from a decrease of spoiled goods, less personal and lower process costs. Moreover, the customer can gain benefits from the improvement of e-services as well as the possibilities to communicate directly with the container (e-service distribution). The customers can achieve higher time efficiency in their own administrative processes and better information supply. In addition the new service as well as an increase of process quality time leads to an increase of customer benefits. He can improve his plans for the placement of transported goods, more and better information will be available regarding good conditions, and his own distribution can follow the "First Exposure – First out" paradigm (Lang et al., 2011). Further customer benefits refer to the cognitive level: The LSPs' customer also has to deal with topics like "Sustainability", "Environmental Friendliness", and "Work Life Balance". Thus, they keep attention on the development of those topics regarding their supplier. In case their supplier deals with those topics in an appropriate way, this can also constitute a benefit for them. Highlighting innovativeness of the whole company and of the new services as well as less physical stress for employees can contribute to these benefits. Moreover, the customer benefits can result from the LSPs additional branding possibilities as well as the promotion activities. This results from the fact, that the customer can base its own advertising activities on the arrangements, which have been established by the LSP before (e.g. cooperation in fairs).

Sacrifices for the customer

From a cost perspective the effects of higher process and training costs, as well as the higher costs for the adoption of physical facilities and the adoption of existing equipment have to be mentioned. However, if those costs really constitute sacrifices for customers depend on the price setting of the LSP. That means they only constitute sacrifices if the provider increases the prices cause of higher costs. If the provider allocates all upcoming costs to the final service price, it might also be possible that the price is further increased by an equivalent for the expected loss in the beginning as well as the substitution of established services. Moreover, on the cognitive level staff firing and doubts in data security as well as negative promotion that result from these activities are perceived as sacrifices. Inflexible distribution might also cause sacrifices for the customer in case that addressing questions regarding the IC's services or negotiate about service conditions becomes more time intensive through limited selling staff which is skilled with the relevant knowledge.

Customer Value (Net Effect) for the customer

In order to get the specific customer value resulting from the features of the Intelligent Container the net effect between the benefits and scarifies has to be revealed. Although, different effects, which increase as well as decrease the final customer value could be outlined for the features of the Intelligent Container the measurement of the net customer value is not possible at this stage of research. That results from different reasons: The cost effects for instance depend on the exact amount of costs and the final prices for the service, which are calculated by the providers, in the end. Also since the final customer value is perceived and calculated by the individual customer, also customer related characteristics (e.g. price sensitivity vs. quality sensitivity) influence the final customer value. A price sensitive customer would perceive a lower price as more valuable than the quality sensitive customer and vice versa. Moreover, the calculation of the customer value net effect requires quantitative data. Thus, for an exact analysis of the net customer value a quantitative measurement approach (e.g. conjoint-analysis) has to be applied in combination with customer interviews in order to get individual preferences. This could be part of further research after the container is established in daily business of LSPs.

CONCLUSION

LSPs have to differentiate from competitors in order to gain competitive advantage and market success. Therefore, their services have to deliver a higher value to their customer then services of competitors. Autonomous cooperation enabling technologies like the Intelligent Container, which enables new service features like permanent quality control and autonomous intervention in case of critical events, are discussed regarding their contributions to customer value creation. In order to reveal the creation of customer value the extended 7Pmarketing mix can be used as an approach. This paper investigated the Intelligent Container’s customer value creation based on the service features, resulting from the container’s implementation. The research founds different contributions (e.g. new services, increased process quality, and lower process costs) as well as limitations (e.g. higher training costs, negative promotion). However, the customer value net effect (customer benefits – customer sacrifices) could not be revealed, since quantitative data as well as information regarding individual customer preferences is required therefore.

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EXPERIENCES FROM THE INTELLIGENT CARGO IMPLEMENTATION

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Abstract: The EURIDICE Project (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe, and Environment-Friendly Logistics) has been a huge research and development effort for the logistics sector funded by the European Commission. This paper is the last one about the EURIDICE Project in the series of research papers presented at the ISL conferences between 2009 and 2011. EURIDICE has realized, in practice, its vision of Intelligent Cargo. The paper discusses the developed concept and architecture, and the findings and lessons learned during the EURIDICE Project research, development and implementation. With the Cargo Intelligent solution, companies can increase their logistics safety, traceability and delivery reliability already now.

Keywords: Intelligent Transport System, Intelligent Cargo, Logistics Information Flows

Introduction

Logistics is an important knowledge-based economic activity that plays a major role worldwide. Logistics deals with everything involving planning, organizing and managing activities that provide goods or services [1]. Commerce and industry rely heavily on having goods available where and when people want them. The growth of the logistics sector is thus inevitable. One of the main problems affecting freight transportation on a global scale is the fact that logistic processes are characterized by limited sharing of information on goods movements, statuses and authorizations between the various transport chain actors. The possibility of integrating and sharing operational information in the supply chain is still only put to limited use by individual transportation actors. Dullaert et al. (2009) list several reasons for this [2]:

- Low reliability and quality of mobile data connections (GSM and GPRS), especially compared with the services offered by 'fixed' connections
- Low willingness to share information due to confidentiality considerations
- Difficulties getting the idea of chain integration adopted: island automation and optimization prevail
- Fragmented knowledge and information on available communication systems
- Limited attention given to ICT in training programmes for barge operators

To produce relevant benefits for logistics stakeholders, EURIDICE has realized the vision of Intelligent Cargo. In this vision, Intelligent Cargo connects itself to logistics service providers, industrial users and authorities to exchange transport-related information and perform specific services whenever required along the transport chain. Intelligent Cargo makes the cargo self-aware, context-aware and connected in order to reduce the operational effort involved in handling goods at the right time, in the right way. The cargo itself informs the platform if something deviates from the plan.

The EURIDICE Project has developed hardware and software for the cargo level and for the common platform for the information management of the logistics flows. It was not a new idea to develop a platform for managing information flows on logistics [5]: the innovation was the cargo-centric approach. The platform was implemented in eight industrial case scenarios to have the best possible testing environment for the concept.

Methodology and Research Approach

This research was part of the FP7 project called EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe, and Environment-Friendly Logistics). The research was based on the constructive research methodology according to which the new construct for Intelligent Cargo was developed, implemented and tested in multiple case studies [8].

EURIDICE had many research streams: hardware, software and the concept itself. The hardware stream focused on the new RFID technologies for the identification of the cargo and the latest communication technologies for data transfer [3]. The software stream put great effort into the research on agent technologies. The concept research stream focused on the Intelligent Cargo concept: how the cargo itself could have a central position in the information flows of the supply chains. The implementation case studies were analysed through open observations and interviews, structured as well as semi-structured, in each case. We analysed the way the Intelligent Cargo implementation has changed business processes and how the EURIDICE Platform and services work in line with existing business processes. During the development, we compared our findings on each research stream with the findings in literature and that way evaluated the EURIDICE results.

EURIDICE Concepts and Architecture

For the management of logistic information, flows require many kinds of concept realizations, and most of the concepts that EURIDICE has developed for the realization of Intelligent Cargo in practice are described here [4].

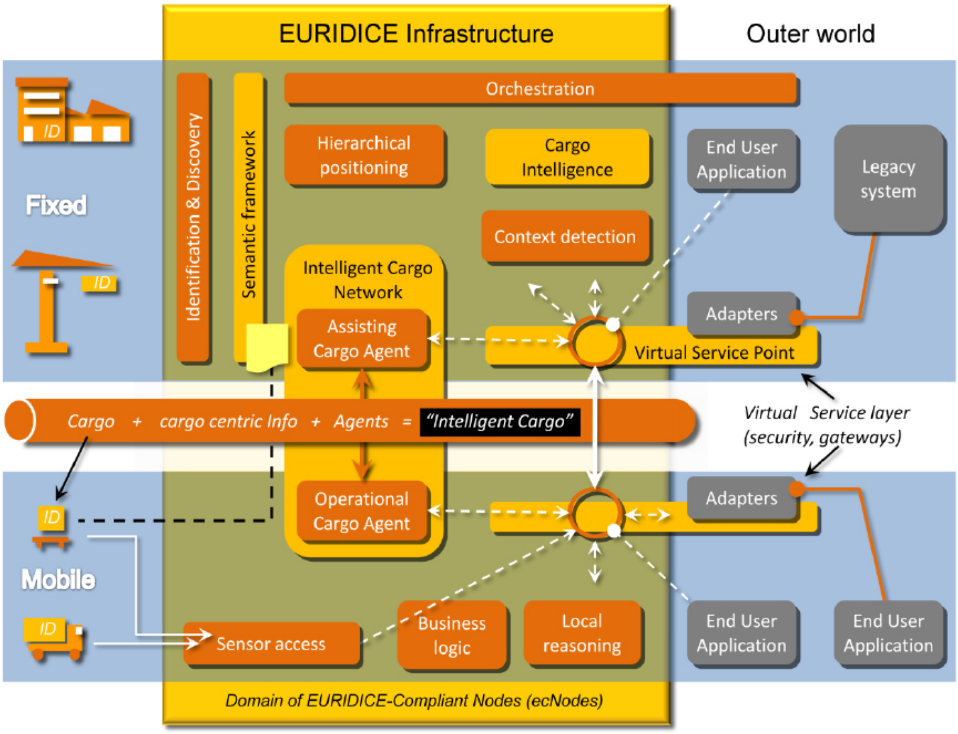

Figure 8. Overview of Euridice Concepts [4]

The Intelligent Cargo Network concept invented by EURIDICE offers and defines the concept of intelligent cargo as the combination of cargo, a cargo-centric approach to deal with information and the use of cargo agents to assist in the exchange of cargo-related information. The Assisting Cargo Agent is a special kind of information provider and part of the Intelligent Cargo Network concept. It is a single point of access for the exchange of information about cargo and it acts as a virtual reception that can also help when there is temporarily no communication with the cargo item itself. While the Assisting Cargo agent represents the cargo in the virtual world, the Operation Cargo Agent assists the cargo item in the physical world by collecting and distributing information. To reduce the complexity of all business objects (cargo, means of transportation, services and even human operators), the abstract concept of a EURIDICE-Compliant Node (ecNode) is represented. Global identification and discovery services are included in the architecture to find the applicable information provided based on the identification of an ecNode. By using common data models and ontology, the semantic barrier to cooperation across business domains can be lowered. This has been established with a semantic framework that not only supports the core services of EURIDICE but also all business-specific services including business-specific end-user applications and legacy systems. Global reasoning is another key solution by EURIDICE. Based on a standardized knowledge structure (ontology) extended with rules, relations and actual measurements (facts), trends and unusual deviations can be determined. Besides support for Business Intelligence, this technology can be used for decision support to assist the intelligent cargo and human operators. Information and services can only be accessed through a Virtual Service Point, where security will be enforced and communication services are hosted to enable one common open platform, and support a secure peer-to-peer network. EURIDICE provides a mechanism for the orchestration of services across business domains to increase cooperation between the stakeholders of the supply chain.

EURIDICE architecture is based on the concepts of ecNodes, the Virtual Service Point and the Intelligent Cargo network. The EURIDICE architecture uses layers to reduce the complexity during the design and build phase. The proposed layers enable reduced scope for handling functional and non-functional aspects, with each layer serving the layer above without the need to know the details of the layer below. To reduce the complexity, the following layers are used:

- Business layer, concerns agreements and procedures required for managing and using the application components and information to be exchanged
- Application layer, contains the business services/application processing components
- Communication layer, for secure exchange of information between applications independent of the underlying platform
- Platform layer, represents the computer hardware including the required operating system, if applicable.

There were two main reasons for using the four high-level layers. Firstly, the innovative contribution of the EURIDICE Project focuses on the Application and Platform layers. In between, standard communication protocols are used to provide the functionality required for the communication layer. Secondly, procedural and other process-related aspects are identified as required to ensure successful operation.

During the development and implementation of the EURIDICE Concept and Architecture, we have faced many challenges, and lessons have been learned that are analysed in the following chapter.

Findings in the Research and Practical Implementations

Leviäkangas et al. (2007) have noticed that international logistics requires information and communication (ICT) systems that satisfy a diversity of needs [6]. International logistics is practically always multimodal and involves a number of different players who underline the challenge of implementing information services that work to serve the needs of the whole logistics chain [6]. Recognizing the importance of having a communication platform capable of supporting multimodal transport, Dullaert et al. (2009) developed a solution consisting of a real-time decision support system in which intelligent software agents are used to handle communicative tasks and exchange desired amounts of information between different users using common exchange protocols that act as translators between different systems [2]. Coronado Mondragon et al. (2012) believe that the adoption of mobile communications in IP-based networks can have a major impact on the efficiency of multimodal logistics operations [1]. In the particular context of logistics applications, which are motivated by the need for efficiency in logistics, and visibility and transparency in the supply chain, Coronado Mondragon et al. (2012) propose the adoption of ubiquitous wireless networks in which vehicles transmit periodic information updates that can be interpreted by higher level applications [1]. According to Lo (2012), there have been significant developments in wireless networks and mobile computing technology in recent years, and it has become very important to capture mobile sources and locations of data [7].

In EURIDICE, we had many different supply chain scenarios, but we did not only focus on wireless communication technologies. It is more important for the data and communication to work for all necessary purposes than which technology the communication is based on. The combination of EURIDICE services can address specific user/cargo/context interactions based on the concept of service-oriented architecture. To perform a specific business process, several services typically need to be combined simultaneously in a specific order or as a combination of both. EURIDICE services can support interactions with business stakeholders in multiple transportation business scenarios.

As described in the EURIDICE White Paper [3], eight pilot scenarios were selected 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 is, of course, not to cover all possible activities in a generic transport process but rather to map different relevant situations in which Intelligent Cargo can be put into practice for the benefit of different stakeholders. EURIDICE Pilot Scenarios [3]:

- Scenario 1 "Connected manufacturing and transport execution" involves a manufacturing supply-chain leader, its suppliers and related logistic operators. The objective was to increase synchronization between transportation and manufacturing processes.
- Scenario 2 "Active cold-chain control" involves cold-chain logistic operators and distributors of perishable goods. The objective was to achieve higher levels of control in the cargo quality and delivery process.
- Scenario 3 "Cargo controlling transportation in 3PL services to the final customer" involves 3PL companies, truck operators and consignees in the transportation of palletized cargo. The objective was to reduce inefficiencies and errors, allowing the departure of the cargo from a hub to trigger external scheduling at destination hubs.
- Scenario 4 "Cooperative warehousing through cargo-centric information services" involves warehousing service companies, their cooperating transport operators, and the consignor and consignees. The objective was to improve storage scheduling and deliveries forwarding.
- Scenario 5 "Self-returning empty palettes and boxes" involves logistics operators transporting boxes and re-distributing empties between different branches and distribution centres. The objective was to provide full traceability, documentation and observation of transport in real time and to achieve better use of empties.
- Scenario 6 "Cargo-assisted intermodal transport" involves intermodal freight operators and railway companies. The objective was to improve customer service and efficient use of wagons in intermodal operations.
- Scenario 7 "Intelligent routing through cargo-infrastructure cooperation" involves road transport companies, inland terminals and motorway operators. The objective was to avoid congestion and accidents and to optimize the use of road and parking infrastructures.
- Scenario 8 "Automated clearance and billing of transiting goods" involves authorities, customs, carriers and freight forwarders operating at international transit points (e.g. ports). The objective was to speed up the transit of goods at international borders and to increase security levels.

The common idea for the Pilot Scenarios was the automated processes in terms of automated notification, reporting, authorization and progress statuses. One of the main finding was that the Integrated Intelligent Cargo Framework offers a simple, secure, scalable and distributed solution for collaboration. The cargo-centric approach based on the Intelligent Cargo concepts combined with process-oriented systems based on a Service Oriented Architecture (SOA) promises a more efficient and effective way to exchange information across business domains. Even though the architecture in itself is simple, it still requires some patient work for the initial setup and tailoring of the services for clients and integration with the back-office systems when necessary. The more actors are included in the supply chain, the longer the setup takes. Experience shows that every additional actor adds to the complexity of the final setup. The complexity also depends on the number and complexity of the required services. The producer/distributor companies usually have a significant number of companies or partners involved in their supply chains. As introducing the EURIDICE system only makes sense if it is applied to all (or major) supply chains, this complexity needs to be taken into consideration for the full implementation.

The implementation of the systems faced several problems. In one case, smartphones were used as mobile agents. A certain amount of time has to be planned for debugging the solution. Thereby, the debugging did not only have to take place in the office but also "in the wild", meaning that appropriate technological debugging functionalities and solutions have to be provided when such a device is running in a truck. These kinds of eventualities have to be considered when developing or adapting a system that runs on smartphones or GPS-enabled devices.

In general, since the cargo has to communicate with the global network without human intervention, wireless Machine to Machine (M2M) technology was used as the connectivity technology. The Intelligent Cargo was connected to the global network either directly using long-range communication technologies, such as GSM, UMTS or CDMA, or indirectly using short-range networks based on Wi-Fi, BT or ZigBee and then connected to the global network through a specific gateway. Within the EURIDICE Project, Wireless connectivity is mainly related to Machine to Machine (M2M) connectivity. In fact, the EURIDICE Project took into consideration bidirectional Intelligent Cargo communication as well as Intelligent Cargo to EURIDICE back-end communication, keeping human operator intervention as low as possible. Generally speaking, M2M technology is not only used in cargo transportation, it is in fact a technology that is used in a wide area of applications focusing on information exchanges between devices without human operator intervention.

In most of the pilots, the users agreed that the pilot applications were easy to use and user-friendly, providing help and displaying information in an understandable way. The EURIDICE solution contributes to the reduction in manual data collection and handling of paperwork (less labour), but, above all, real-time information becomes available, such as, for example, the location and ETA of a truck or wagon. However, the users seemed sceptical of whether the pilot applications made them more efficient. In some cases, there were concerns about personal data privacy: truck drivers seemed to be nervous of the idea that the route followed by the truck is tracked at regular intervals. However, this was just a feeling they had since all the data were stored and processed in a secure environment. An idea to overcome the employees' concerns and preoccupations and thus improve the impact of such a system would be to involve the end-users from the beginning of the development process.

Concluding Discussion

The European Commission has already funded many logistics platform development projects. In the upcoming calls, however, there will still be funding for research in the field of platforms supporting Sustainable Surface Transport. The challenge is obvious: it is hard to develop a comprehensive platform that supports all kinds of logistics information flows. EURIDICE had eight business scenarios, each with different requirements. In general terms, track and tracing were required by all the pilot scenarios, and all the pilots then had pilot-specific requirements. These specific requirements are a developer's nightmare because there is only a limited amount of resources in one project to fulfil all needs. On the other hand, work done in other research and development projects is hard to use because of the limited information and specifications available. Some common standards are available for logistics information management, but most of the work should be done in the individual project.

For track and tracing, the markets offer many solutions. Cargo- and container-level identification technologies have been available for years, but industry-wide implementation is still missing. The use of passive RFID tags is sufficient for identification and localization purposes in many cases. To determine the environmental conditions, more advantages and more expensive RFID tags are required. Each business case has determined if the investment cost makes it profitable to use more expensive RFID tags. For communication and data transfer, there have also been many development activities, such as those that Lo (2012) listed [7]. The M2M market has a potential of billions of connected devices, and tens of millions are already connected. M2M market growth shows an impressive trend and is expected to expand further over the next years. Up to now, the M2M market has developed considerably, but, due to the lack of standardization, it is dominated by vertical and/or proprietary solutions. The M2M value chain is evolving from single-point wireless communication solutions, or single-client vertical solutions, to end-to-end provision of value-added services. The market growth is expected to lead to a constant reduction in the price of M2M devices, and what may look expensive today could become low-profile, cost-effective solutions in the near future.

The cost of implementation may still be the main barrier. Logistics companies are constantly talking about cost-effectiveness and hard competition in the field. Companies are willing to improve their processes, but all additional investments are not welcome. The investment in identification is not enough, companies should have systems to store, manage and improve data from identification technologies. A platform is needed for this purpose and that was the motivation for the EURIDICE concept and architecture. The EURIDICE concepts seem promising, although tight integration with operational systems is required instead of adding an extra system. The development of tooling to build the application ontology to make use of the Intelligent Cargo data model can lower the barrier to using the EURIDICE architecture. The development of basic building blocks (mash-ups) for webpages to display common logistic information is also recommended to increase the quality to build more responsive user interfaces.

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THE STATE OF RFID ADOPTION IN THE UK

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ABSTRACT

Many academic and industrial case and simulation studies have highlighted the benefits of RFID (radio frequency identification) to supply chain planning and execution. Consequently, a number of major companies across industries (including Wal-Mart, Tesco, Gap Inc., Marks & Spencer, Metro AG, Carrefour, Home Depot, British Aerospace, and many civilian and military establishments) have implemented pilot projects on bulk-level and item-level RFID-enabled tracking and tracing within their organizations and across their supply chains. But there are many barriers to the supply chain-wide adoption of RFID. Indeed, evidence shows that expectations of the implementation of RFID by supply chains aren't matched by reality. Between 2010 and 2011 we conducted an online survey of selected 100 UK companies, with size (as a factor of staff strength and annual sales turnover) and sectors varying across the business spectrum, on their take-up strategies for RFID. We obtained surprising results. The survey was conducted by the University of Lancashire at Preston in collaboration with GS1 UK and the RIFD Forum of the Chartered Institute of Logistics (CILT). The aim was to gauge the rate of adoption of RFID across industries and sectors. The selection of the companies was intended to yield a good mix of business sizes and industrial/business sectors. The sampling was, therefore, not statistically random. Also, so far the sampling has had only one wave: there hasn't been a repeat of the survey. One striking finding was that of the 75 companies that fully completed the online questionnaire, less than 40% have implemented or planned to implement RFID in the near term. Only five of the respondents have actually implemented RFID in their organizations, and only six plan to adopt it in the short term (within two to three years). The results of the survey show adoption rates in various industrial sectors. Up to 61% of the respondents did not have any near-term plan to adopt RFID. While it is difficult to argue that these results indeed defy predictions of the technology adoption models, they certainly contrast with the purported popularity and rapid adoption rate of the technology as reported in some sections of the professional, trade and academic literature. The results also show that the adoption obstacles included challenges in configuring and managing devices, deriving useful business analytics and intelligence from RFID events, the need for business process reengineering before or after the adoption of RFID, absence of uniform standards, the availability of a diversity of medium access control protocols, as well as challenges of linking RFID events with the enterprise back-end (ERP systems, warehouse management systems, etc.), the perceived cost of adoption (especially at the item level), lack of industry or customer mandates, the assumption that the available technologies have not yet matured, and the lingering (if often unfounded) privacy concerns.

Keywords RFID, auto-identification technologies, technology adoption model, survey.

1. INTRODUCTION

RFID (radio frequency identification) is a contactless technology that has the capacity to replace the traditional optical means of recognition and identification of objects and people (Hunt et al., 2007; Finkenzeller, 2010). For supply chain managers, the most interesting potential of RFID is to be found in ultrahigh-frequency (UHF) passive tags or transponders, which operate without on-board power source and have small footprint antennae. These are well suited to retail item tracking. The main cost blocks are the tags, the stationary or mobile readers, and the corresponding IT infrastructure for data filtering, transfer, dashboard reporting, and integration with existing backend ERP

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systems. The tag cost is a variable cost, while the installation of the readers and the adaptation of the IT infrastructure have both variable and fixed costs. Hence, for supply chain management tasks such as inventory decisions, service level enforcements, etc., the variable cost due to the tags is the principal determinant of the business case for adoption of the technology.

Since Wal-Mart issued its 2003 mandate to its top 100 suppliers concerning RFID tagging of products and the later mandates by the Pentagon to its suppliers, the technology of RFID has grown considerably both in terms of innovation, development and adoption (Chao et al., 2007; Gaukler et al., 2007; Irani et al., 2010;). To date, nine out of ten major global retailers, including Wal-Mart, Carrefour, Home Depot, Metro, Tesco, Kroger, and Costco, have trialled or plan to use RFID technology to build more expedient, efficient and leakage-proof retail environments and to enhance planning and operational efficiencies in warehouses so as to achieve reduced out-of-stock rates, better replenishment strategy, and cost-effective inventory management. Famous apparel retailers such as Prada, Gap, Benetton, Levis, and Gardeur, also have recognized the value and benefits of RFID technology (Lee and Ozer, 2007). The product profile of the apparel retail industry is associated with significant seasonal demand characteristics, a strong requirement for customization, rapid replenishment, tremendous competitive market pressure, and uncertainty in customer preferences and sales forecasts. These characteristics result in inventory inaccuracy (Wen et al., 2010). By specifically addressing the characteristics of apparel retailing, the bellwether retailers are depending on the application of RFID technology to leverage the advantage of real-time information for rapid and low-latency decision making, as well as for enhancing their supply chains. With RFID, goods have a better information transparency, effectively reducing the operational costs of store management (Miragliotta et al., 2009; Ngai et al., 2008, 2012).

Even with RFID, inventory visibility, tracking and traceability at the atomic or item level still pose major operational and technological challenges for retailers. Aberdeen Group's (2011) benchmark study reported that 70% of retailers lack the ability to track and trace item-level inventory throughout their supply chains (from raw materials to store shelf). Furthermore, 70% of retailers also lack visibility of item-level inventory with their suppliers in regard of on-hand, in-transit and other supply chain events. The study also demonstrated the value of leveraging store and supply chain inventory visibility and traceability solutions. For example, 50% of the retailers that have these competences are on average incurring less than 10,000 US dollars in out-of-stock opportunity costs.

Several authors (Jones et al., 2005; Attaran, 2007; Cannon et al., 2007; Chang et al., 2008; Delen et al., 2007; Doerr et al., 2006; Dutta et al., 2007; Gunasekaran and Bulent, 2007) have highlighted the needs for and benefits of RFID and related technologies to supply chain operators. Prompted by the reported benefits and the rapid adoption of RFID by the industry, we decided to conduct, in the first instance, a limited assessment of the actual rate of adoption of the technology in the UK. GS1 UK, which, among other activities, develops and publishes RFID standards was also interested in the research and suggested, from their corporate membership, potential respondents to the survey. The questionnaire, which is still available on the University of Central Lancashire's web site, covered several questions and issues concerning the adoption of RFID by the respondent firms, but only the adoption rates are presented in this paper. Respondent companies range from those with staff strength of 50 to those with employee numbers of over 5,000. The corresponding annual turnover range is 1 to 3,000 million UK pounds. One of the most remarkable outcomes of the study was that about 61% of the respondent firms had no timeline for adoption of RFID.

The reported survey was exploratory and the sampling was not even stratified. Because the companies were sampled systematically to give a good mix of industrial sectors and sizes, the sampling was not random and hence gives a rather weak foundation for rigorous statistical analysis on the specific question of the rate of adoption of RFID[3]. This has limited significant statistical analysis by conventional tools. The figure of 61% given above precluded any need for test of hypothesis concerning the significance of the ratio of adopters to non-adopters. We have a plan to extend and replicate the survey in 2013 in a more structured, randomized manner that will permit more rigorous statistical tests to be applied. In the absence of replication in a purely random or stratified random sampling, there is no valid way of obtaining an unbiased estimate of the variance of an estimate.

LITERATURE REVIEW

Several recent analytical, simulation and case studies have shown that RFID and related tracking and tracing technologies are capable of realizing both short and long-term benefits for multi-tiered, multi-enterprise, and multi-channel manufacturing and retail supply chains (Twist, 2005; Doerr et al., 2006; Hou and Huang, 2006; Tajima, 2007; Munoz and Clements, 2008; Tzeng et al., 2008; Miragliotta et al., 2009; Tavares and Thiago Augusto, 2010; Lee and Lee, 2012; Ngai et al., 2008, 2012; Pal et al., 2008; Vecchi and Brennan, 2009, 2010). The global nature and complexity of the new supply chain has resulted in longer lead times, extra work in progress and sensitive pipeline inventory, as well as the need to control downstream and upstream operations and logistics. The involvedness of the modern supply chain is a significant challenge to businesses around the world. Among other consequences, it has negatively impacted the cost of managing supply chains. It has been suggested that increased supply chain-wide visibility is one of the major ingredients for coping with the complexity, sensitivity and risks of the new supply chain. RFID and other tracking and tracing technologies (such as GPS, roaming wireless communication, and temperature, pressure, vibration, gravity sensors) are major tools for ensuring supply chain wide visibility (Sahin et al., 2007; Catarinucci et al., 2009; Amaral et al., 2011). The need for end-to-end visibility (linking raw materials procurement to purchase order process, production and shipping schedules of factories) is significantly intensified for firms that belong to global supply chains.

Beyond the manufacturing shop-floor and supply chain, RFID is used in many other industries to reduce shrinkages and stockouts, reduce material handling, increase system throughput, improve product and service quality, enhance information sharing, and for product lifecycle management (Speckman and Sweeny, 2006; Tajima, 2007; Ngai et al., 2009).

However, it has also been reported that despite the apparent advantages of RFID in terms of ROI (return on investment) for many firms, the uptake of the technology by the industry has been appreciably slower than predicted in the 1990s (Wu et al., 2006; Barratt and Choi, 2007). According to both the classical and the various extended technology acceptance models (Venkatesh and Davis, 2000; King and He, 2006; Legris et al., 2003), a common feature of mass-market technologies is that literature often exhibits uninhibited enthusiasm at the inception of a new technology; this is then followed by potentially inimical cynicism, which eventually thins into a more rational analysis as the trend fades. We believe that the same precedent applies to RFID. Evidently, while technologies have a core recognisable functionality, management style is often transient when (as it often does) it lacks material substance. Management custom endures because it is more of a techno-economic reality than a socio-psychological concept. However, management also helps establish the favourable provisos where techno-economic benefits terminate and socio-psychological keenness takes over. Without doubt, RFID is a technology that has already yielded some companies significant returns and holds great prospects for many more. However, it appears justified to express some doubt about the utility of RFID for all organizations, now and into the future. We are of the view that the earlier, and still prevailing, excitement for RFID calls for special judgment and caution.

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[3] However, the Likert scales on other measures of the study can, and have been, analysed statistically.

DESCRIPTION OF THE PROBLEM

The main aim of this paper, and of the research from which it emerged, was to determine the current rate of adoption of RFID by the UK industry. This was required to inform both the theory and practice of RFID in the UK and beyond. The results mediate the debate on the economic value of RFID, and on how the adoption of RFID supports or contests the well-known technology adoption models. The results were also expected to contribute to shaping the approaches to RFID research and development (especially by the semiconductor industry) and market predictions about RFID.

RESEARCH WORK

The research was a collaborative effort between the University of Central Lancashire and GS1 UK, an auto-identification standards and advocate body. The structure and content of the questionnaire was agreed between us and GS1 UK. The questionnaire is hosted on the website of our University. GS1 UK solicited the willingness of a selected representative cohort of their corporate members to participate in the research. It then directed those companies that expressed their readiness to participate in the survey to the online questionnaire. At the outset GS1 UK contacted 200 companies and obtained the willingness of 100 to participate in the research. The selection of the companies was intended to yield a good mix of business sizes and industrial/business sectors. The sampling was, therefore, not statistically random. Also, the sampling so far has had only one wave, as there hasn't been a repeat of the survey. Plans are, however, under way to repeat the survey and additionally conduct longitudinal case studies at a few of the organizations that completed the questionnaire. Out of the 100 companies that agreed to participate in the research, 75 actually completed the online questionnaire, a reasonably good response rate when compared with some previous similar surveys. The round of survey reported in this paper was limited to commercial organizations. The deliberately peculiar structure of the selection and the distinct nature of the results thus far haven't necessitated complex statistical testing for concepts like the normality of the sample, non-response bias, and posterior hypothesis testing on the outcome.

RESULTS AND ANALYSIS

The questionnaire asked many questions, all pertaining to the stage of RFID adoption by the companies, the organizations' internal knowledge and capacity to implement RFID, the business case/plan for the adoption of RFID, the largest sources of cost in the adoption of RFID, the most compelling reason to adopt RFID, the product data that was currently ready for RFID implementation, the timeline for the company-wide or supply chain-wide adoption of RFID, areas of most use of RFID in the company's business, the product level at which the company is considering RFID adoption or has adopted RFID, etc. The findings of the research so far are many, interesting and profound, the most striking being that a large number of the companies surveyed (slightly more than 61%), including global operators, have no current plans to roll out RFID across their businesses or adopt the technology after pilot studies (Table 1). Some have not even conducted pilots. This goes against the grain of popular perception and what is often cited in the literature (Ngai et al., 2008; Chang et al., 2008; Irani et al., 2010).

Figures 1 to 3 show the Likert scales for the main drivers of adoption of RFID by the respondent companies, the major hindrances to adoption (as viewed by respondents that haven't adopted RFID), and the degree of achieved or forecast benefits of RFID.

Table 2: Summary of implementation plans by respondent firms

Industry/sector	No. of participants	# no plan	# plan to implement	# at pilot stage	# fully implemented
General merchandizing	5	2	1	2	0
Logistics and allied	12	8	1	1	2
Manufacturing-industrial	6	4	2	0	0
Manufacturing-consumer	34	28	2	2	2
Healthcare	5	4	0	1	0
Others	13	11	1	0	1
Total	**75**	**46**	**7**	**6**	**5**
% of total		**61.33**	**9**	**8**	**6**

Figure 9: Key drivers for RFID adoption

DISCUSSION AND CONCLUSIONS

The research impact of our study is that it provides an outcome that was not entirely expected, in the sense that it disagrees significantly with many of the results found in the literature on RFID and with the general discernment of the adoption rate of RFID. The results contribute to debates on the economic value of RFID and may shape the approaches to RFID research and market predictions. RFID seems to be defying the well-known technology adoption curve. This has insightful repercussions for both theory and practice. The evident slow take-up rate for RFID has rather negative implications for the development and growth of, for example, the predicted concept of the 'Internet of things'.

The outcome of this survey also has some implications for standards organizations like GS1, EPCglobal, ISO, DASH7 Alliance, for supply chain managers, and especially for the semiconductor industry. It was predicted in the late 1990s through early 2000s that in the late 2000s RFID will revolutionize merchandizing and generate an annual economic contribution worth billions of dollars. Our research shows that the adoption curve for RFID is disappointingly not as steep as predicted. The survey also determined the reasons responsible for this situation. The survey is planned for extension in the coming months. Space limitation has precluded detailed discussions of other important findings of the survey.

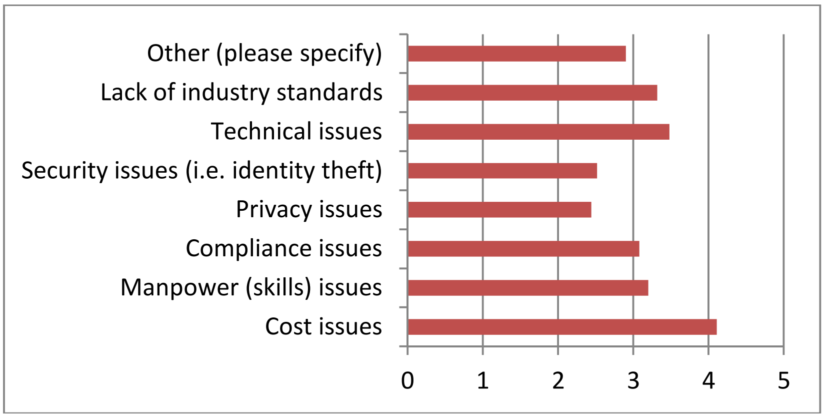

Figure 10: Major hindrances to RFID adoption

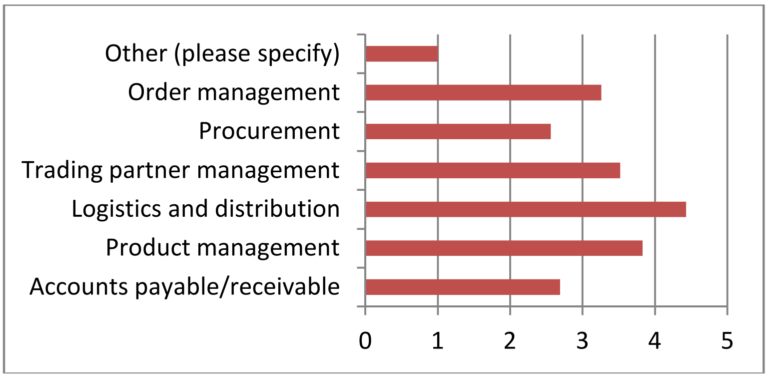

Figure 11: Respondent's business areas (to be) affected by RFID adoption

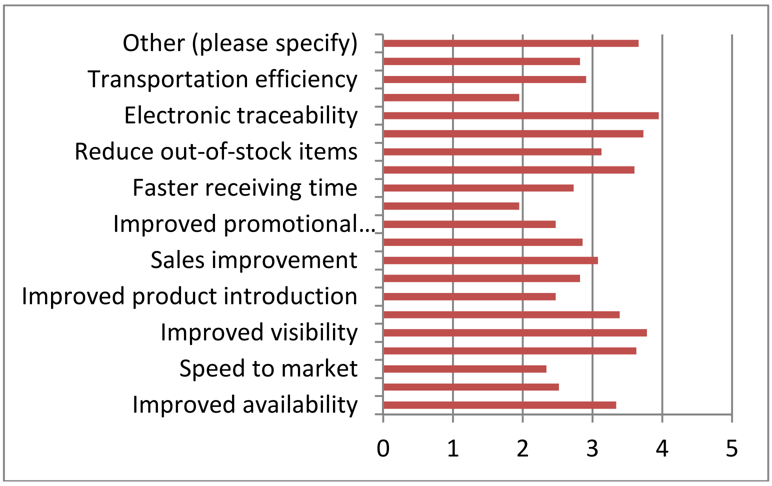

Figure 12: Actual or expected benefits of RFID

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INFORMATION SITE MAP (ISIMAP) – APPROACH FOR A BETTER MANAGEMENT OF LOGISTIC AD-HOC PROCESSES

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ABSTRACT

This conceptual paper describes current problems in providing information to address unplanned logistical processes (ad-hoc processes), and possible solutions to these problems. The approach focuses on overcoming of media disruptions and reduction of the complexity by means of an automatically determination of relevant information. Furthermore address the development based on mobile devices a better utilization of this information on work location. The technological focus of development is the systematic use of semantic technology, contextualization and the Augmented Reality technology (AR).

Initial situation and purpose of the research

The constant change in the industrial production demands a permanent realignment of the goal criteria and the change of the action fields within the factories. (Wirth, Schenk & Müller 2011) Requirements like energy and resource efficiency, flexibility and adaptability to modern manufacturing systems thereby inevitably lead to changing logistical requirements as well. (Müller 2011) A high time lag between the planning and execution moment with simultaneously high dynamics of the framework conditions, a high connectivity between the planning objects as wells as unreliable and incomplete planning information more and more lead to less satisfying results in terms of a pure deterministic pre-planning. (Schuh et al. 2006) The design principles for factories currently experience a change from a primarily deterministic pre-planning towards self-organizing systems. Drivers for this development are the increasing complexity and dynamics especially and increasingly presenting the challenge for the logistics due to its cross-sectional character. Notably, all the tasks appearing in an unplanned and non-standardized ad-hoc manner present a problem. As a rule, the addressees of those tasks are the clients (in the automobile industry these are the OEMs), suppliers or the own company management. The predominant part of those tasks consists of requests for information coped with by inquiries and inspection rounds and also of the short-term changes of already scheduled processed or correcting disruptions. The effort related to those resulting processes is estimated to 60% of the daily business. (Dickmann 2007) The fast and location-independent availability of the therefor necessary information is a crucial time factor as the responsible staff is characterized by a high level of mobility. Special challenges are the result of diverse media disruptions in the supply of information. Hence, printing out lists and overviews still appears on the agenda and the search for contact persons or other information carriers determines the daily work.

The efficient design of the ad-hoc processes requires an intelligent tapping, linking and bundling of more and more data. The nearly complete digitalization of almost all value creation processes along the lifecycle of an industrial plant led to an increase of the amount of data in the past few years. Regarding the intra-logistic systems there was an approximate increase by the factor 1000 solely in the past 10 years. (Günthner & ten Hompel 2010) Unusually, the necessary information are centrally available, partly have different formats and locally apply to a locally known meaning. There is no common understanding on the stored data. The resulting media disruptions prevent a cross-sectoral usage.

Hence, one future key ability for modern logistics will be the ability to respond to changes and therewith the ability to self-organize. New mechanisms of action have to be determined allowing self-organizing effects. This requires a conceptual revision of the latest logistical processes as well as their planning and decision models. The system approach presented in this paper aims at a systematic networking of the real and virtual world. A systematic networking of information with objects in the virtual world with those of the real world takes place. This renders new decision models for the planning and control of the logistics possible. For the better controllability of the complexity, a wealth of available information is automatically reduced to an adequate bundle of decision-relevant information. The conception as a mobile solution will guarantee a real support of the on-site work process in the logistics. The technological focus of development is the systematic use of semantic technology, contextualization and the Augmented Reality technology (AR).

Research approach

1. Optimization of ad-hoc processes in the logistics
2. Semantic technologies for networking the dispersed logistical information
3. Contextual design of decision-relevant information bundles
4. Augmented Reality (AR) for the visual linking of the virtual and real world

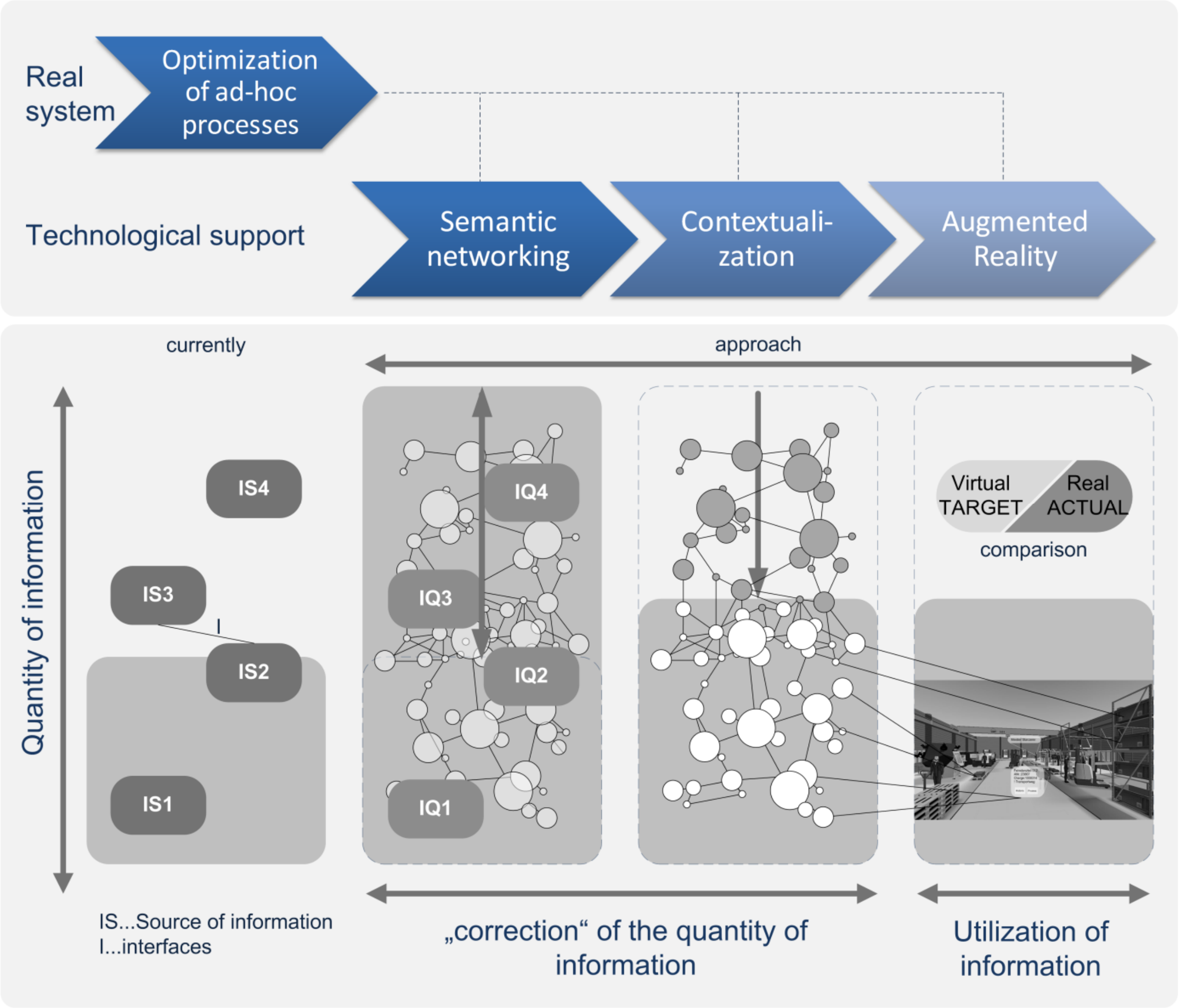

Figure 1: Approach of the research

1. Optimization of ad-hoc process in the logistical management

It shows that the fields of application of the classical advance planning more and more reduce. (Schuh et al. 2006) The latest challenges almost inevitably demand a paradigm shift towards self-organizing systems (cf. figure 2). The aim is to improve the ad-hoc processes in the logistical management based on self-organizing effects to be designed. This requires a conceptual revision of logistical processes, especially regarding the planning and decision models to be used.

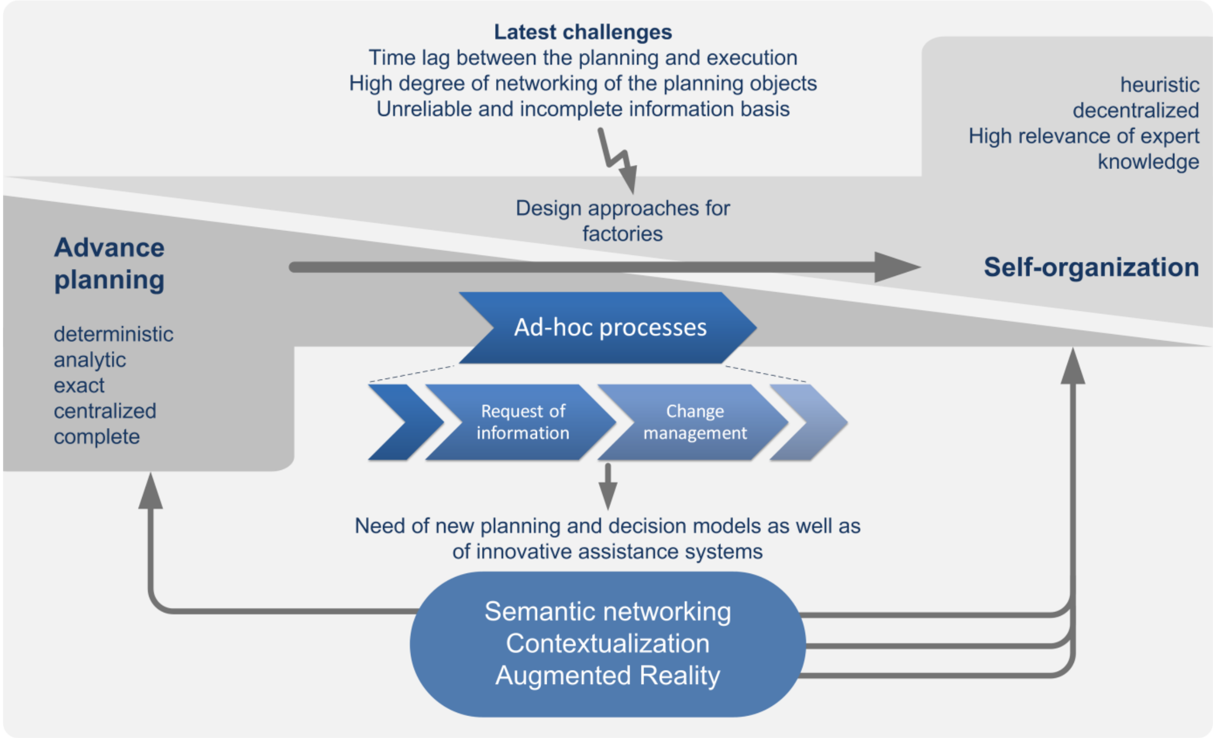

Figure 2: Approach for the optimization of ad-hoc processes in logistics

Optimizing ad-hoc processes requires a new balance between pre-planning and self-organization. Once the original planning is not useful anymore, both the system as well as the human being should be able to react in an ad-hoc and adequate manner. For instance, the system should automatically generate an ad-hoc work flow in case of changing framework conditions (change of versions of purchased parts) including all the necessary details of the processing. By means of an assistance system, the human being has to be qualified on perceiving changes of the framework conditions, deviations from the actual state (real) of the plan (virtual) and therewith influence its decision-making process. Therefor logistical processes especially facing challenges to a great extent have to be identified first and are summarized in figure 3. For those processes, the effects of awareness of deviations actual plan or automatized knowledge entries have to be examined. A necessary pre-condition for this are the advised technological developments: semantic linking of heterogeneous, dispersed information systems for the overcoming of media disruptions, contextualization and AR for commanding the complexity as well as the linking of the virtual and real world.

2. Semantic technologies for the networking of dispersed plant knowledge

Designing optimized ad-hoc processes presumes the overcoming of media disruptions and hence a stronger networking of the planning and operational knowledge. Semantic technologies support the networking of existing information sources (IQ) and enlarge the available quantity of information (cf. figure 1, column 2). The underlying data are then presented in the form of subject-predicate-object (S-P-O) and are interlinked in increasing graphs as exemplarily depicted in figure 3. Due to the simple structure, information can be easily added at a later date, without making a re-design of the data structures necessary. This renders a cooperative knowledge entry via different information systems possible. Figure 3 presents the example of the sources of this knowledge entry during the planning and operational phase.

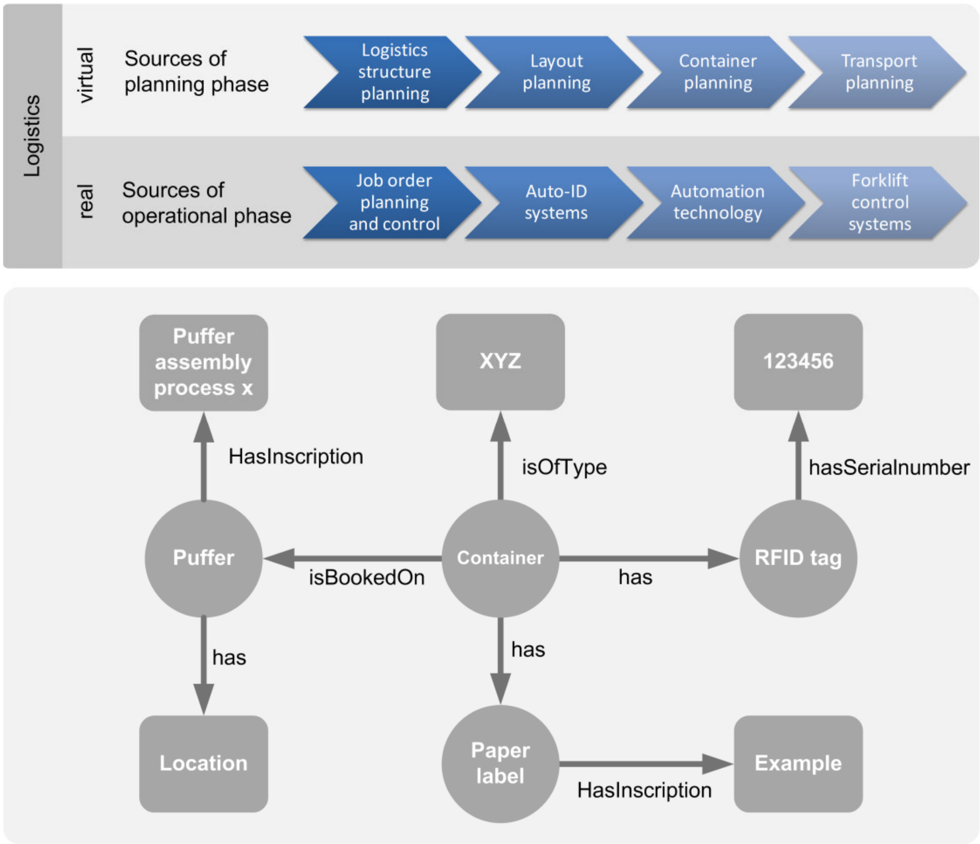

Figure 3: Plant processes and a resulting semantic graph

The resulting effects of the semantic networking are amongst others the automatic identification of different operational states, target deviations and random structure retrievals in terms of an increasing data structure.

Completely independently working on the data model is the advantage of the above S-P-O depiction. Every integrated information system maintains its own local data. Afterwards, they automatically take apart in the structure above, by means of parsing, and stored in a database optimized for semantic networks. However, a necessary pre-condition is the compliance with certain rules. Subjects, objects and predicates, like "isOfType" or "puffer" as abstract descriptions, have to be used in the same way; hence they require a common vocabulary. As this is not always possible, analogies have to be specified. Different termini can then be mapped together (cf. figure 4). Furthermore, logical rules can be determined for the therewith distinguished content. Therefor the development of a semantic description model for factories is necessary (cf. figure 4).

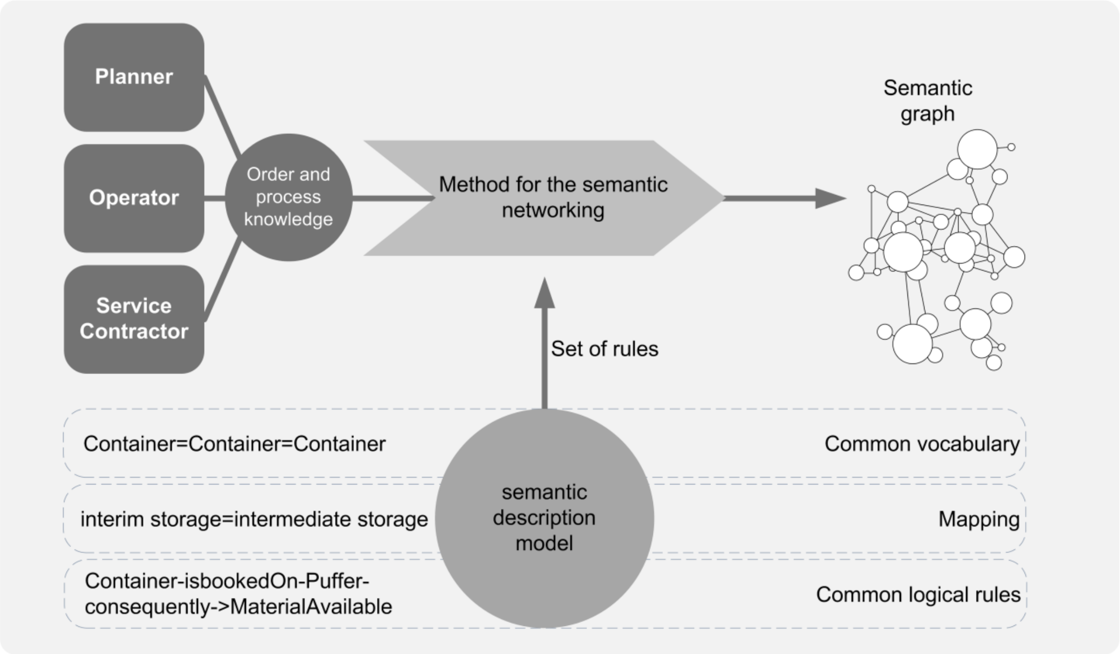

Figure 4: Description model

3. Context-based design of decision-relevant information bundles

Executing ad-hoc processes requires prompt and well-founded decisions. This can be achieved, if the executing person only has to process relevant information for an action or a decision. The explanations on initial situation have proven that exactly this processing capacity constitutes the actual bottleneck. Thus, the relevance or the application of the auxiliary conditions decides on the selection and representation of information. They can be interpreted as the context of an action or a decision. Now the goal is to automatically detect these contexts out of the current performance. The sources of these contexts hence can be found in the real as well as in the virtual world. The result is a reduction of the complexity due to intelligently minimizing the integrated quantities of information (cf. figure 1, column 3).

Contexts are implicitly exchanged during a conversation between human beings meaning without an explicit mention by the conversation partner. If two human beings stand in front of a locked door, the human actor when asked for the key will neither ask for the door nor for the type of key. This type of implicit context transfer is not possible in a man-machine-communication. The automatic enlargement of requests for information (I.-requests) by context information can however lead to comparable results. (Koch 2010) Reducing the quantity of information takes place by means of a targeted and automatized context enlargement of the I.-requests towards the information supply side. To visualize this, an example will be presented. In the context of a request for information, a logistician is looking for a component of the batch 1008314.

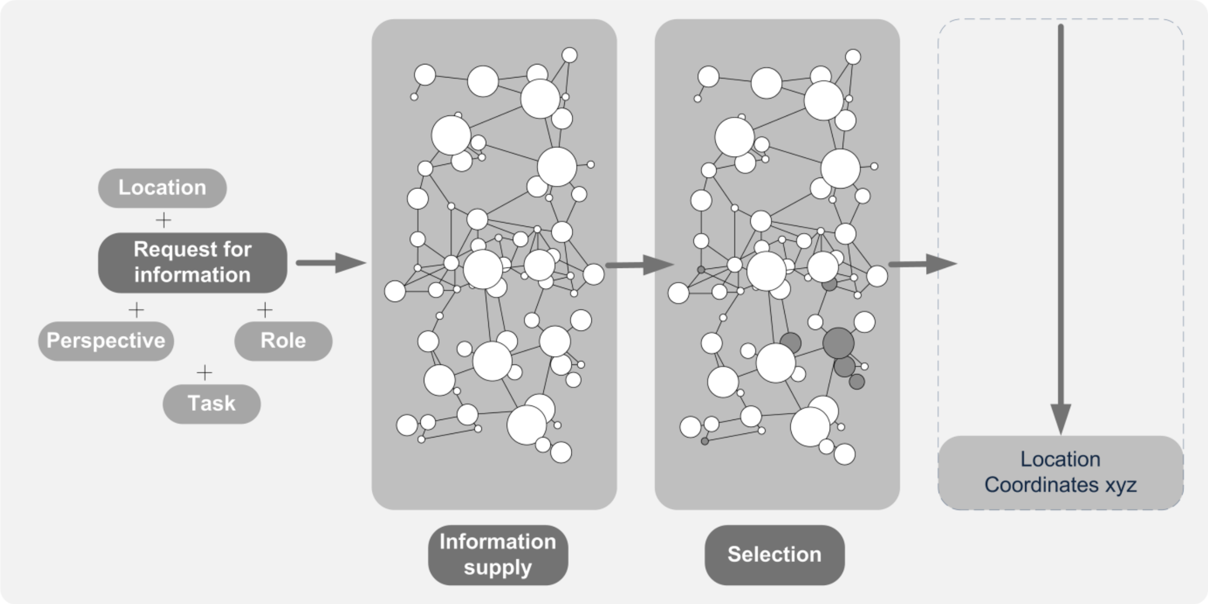

Figure 5: Context-based request for information

The example depicted in figure 5 presumes the integration of the presented context sources (column 1). Hence, the location and the perspective have to be determined by the user by means of sensors and will later be of importance for the demonstration by means of the AR. The contexts role and task emerge from the user login and the therewith associated rights as well as from the ongoing workflow.

In the context of this key subject, a context model is designed including the domain-specific contexts for the logistic ad-hoc processes and describing their effects. Table 1 gives an overview on the different context categories finding a use in the context enlargement of I.-requests.

User/Operator/Role	Time
Activity/task	Information/information sources
Social environment/environment	IT-environment/device characteristics
Location	Physical environment

Tabelle 1: Context sources

4. Augmented Reality (AR) for the visual linking of the virtual and real world

A very promising approach for commanding the complexity is linking the real perceivable world with the virtual world. If it succeeds to create a virtual target portrayal of an industrial plant by means of a cumulated knowledge entry, then an almost intuitively on-site judgment on the conformity of the actual state by means of a visual comparison with an AR is possible. So far, this visual linking of a real perception of a plant with its virtual model is missing.

This key subject, besides the model and method development, especially focusses on the technological development. Thus, mobile terminal devices as connecting links between the real and virtual world are in the center of attention. The new development addresses the objective to provide the information bundle, designed in the previous two key subjects, on-site and intuitively in order to support the decision-making process. Thereby, the problem-solving approach highly exceeds the simple mobile access to information systems by means of smart phones. Our vision is to create a virtual dynamic map of a factory making the development of an environmental model necessary. The elements of this model (3d layout, 3d models of the plants) compulsorily emerge from the planning phase of the production system and hence will be added to another usage. However, the map does not only include 3d-models. Every object relevant for the logistics (container, logistical resources) contains all information linked during the planning and operational phase. The environmental model represents the world known to the system as a preferably detailed equivalent to the real world. Developing a method for the overlapping of both worlds is used by the AR technology. By overlapping the camera pictures with computer-generated models and information, the AR offers an intuitive representation of information. Besides the visual comparison of the actual and the targeted consistency of groups real objects become hyperlinks. Hence, the resulting contribution to the knowledge management is guaranteed adequately providing planning knowledge (e. g. process instructions) as well as operational data (e. g. operational data collection).

With the help the new assistance system, the logistician can navigate within the map, retrieve decision-relevant At first the user positions himself/herself on the map. This happens via an optical coding provided in a raster. Thus, the coding have two functions. The user identifies the area surrounding him. The smart phone loads the respective parts of the environmental model deriving the exact position and the perspective of the user. Like in the introduced example, the position and the perspective simultaneously act as context sources for the intelligent retrieval of information. The crucial parameter now is the degree of congruence of the actual, real position and perspective with those calculated by the system. The perspective on the virtual and real world hence should be congruent. Following, by overlapping the real camera picture of the smart phone with a projection, the AR technology allows the projection of the correct position and perspective of the decision-relevant information (cf. figure 7). The representation of the required information of the mentioned example is depicted in figure 7.

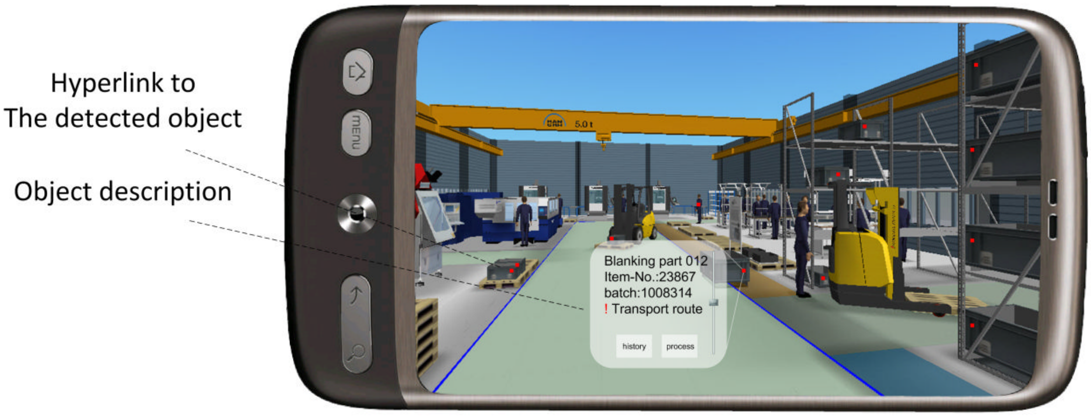

Figure 6: Example of the AR support in the logistics

Another important aspect for the user acceptance is that a permanent visual to an optical marker is not necessary. In terms of the loss of the marker out of the camera field, the position and perspective of the smart phone would generally be lost, whereby the AR depiction would not apply. The development of a movement model will allow the change of the perspective and the relative movement of the user and the mobile terminal device within the environmental model without losing the AR functionality. For its realization, the sensor data fusion and feature tracking are the latest approaches.

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MODELLING COMPLEX SUPPLY CHAIN SYSTEMS – A REVIEW

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ABSTRACT

Purpose: Supply chains are complex systems, therefore managing them becomes a laborious activity. In helping managers to make better supply chain decisions for planning, designing, evaluating, monitoring and controlling a supply chain system, modelling techniques can be employed. Jain and Benyoucef (2008) indicated that modelling and analysing complex supply chain systems is critical for performance evaluation and for comparing competing supply chains.

Modelling is considered a key aspect in understanding supply chain complexity as well as modelling plays a key role in evaluating supply chain behaviour that helps in supporting and guiding business process reengineering (Bhaskaran and Leung, 1997).

This paper aims to evaluate current models and modelling procedures used in complex supply chain analysis. This work synthesises key supply chain modelling procedures used in current literature with the aim to identify gaps in this area of research.

Approach: This evaluation is carried out by a thorough literature review, which highlights not only preferred methods used for modelling supply chain systems, but also their level of complexity and their practical applicability.

Findings: Findings from this review are summarised where a dedicated discussion indicating key problem areas in modelling supply chain systems has been provided.

Value: This investigation allows for an evaluation of the limitations in modelling complex supply chain systems and stresses the need for more research and more examples into this area as new advances to the area of modelling is still in demand. Models derived from practical applications have benefits by demonstrating the applicability of the techniques used, their limitations and issues linked to their implementation. There are also benefits to theoretical models as these will provide further understanding of the modelling theory of complex supply chain systems.

Therefore the value of this review is in identifying key problem areas from both theoretical and practical models and modelling procedures already used and stresses the need for further research into the modelling of supply chain systems.

INTRODUCTION

Supply chains are complex systems characterised by a large number of entities, a complex set of operations and many dynamic changes. Many definitions have been provided over the years on what forms a supply chain system, however issues such as their dimension, structure, complexity and dynamic behaviour are not fully captured or clearly understood.

Many authors agree that supply chains are complex systems which interlink with one another. From a traditional representation of supply chain systems such as the one indicated in Figure 1, we have the classical flow starting with the set of suppliers, where raw materials are then transported to manufacturing plants, where finished or semi-finished products will form the result of this process. They will then be transported to a warehouse or a distribution centre and following a distribution order they will then be transported to retailers or final customers.

Another key part, which has not been detailed here, is the reverse issue in the supply chain that comprises the returned, reused and recycled elements and forms closed loops in the system. Issues linked to the design of closed loop supply chain systems also generate complexity in the supply chain, however this aspect is not captured within this investigation.

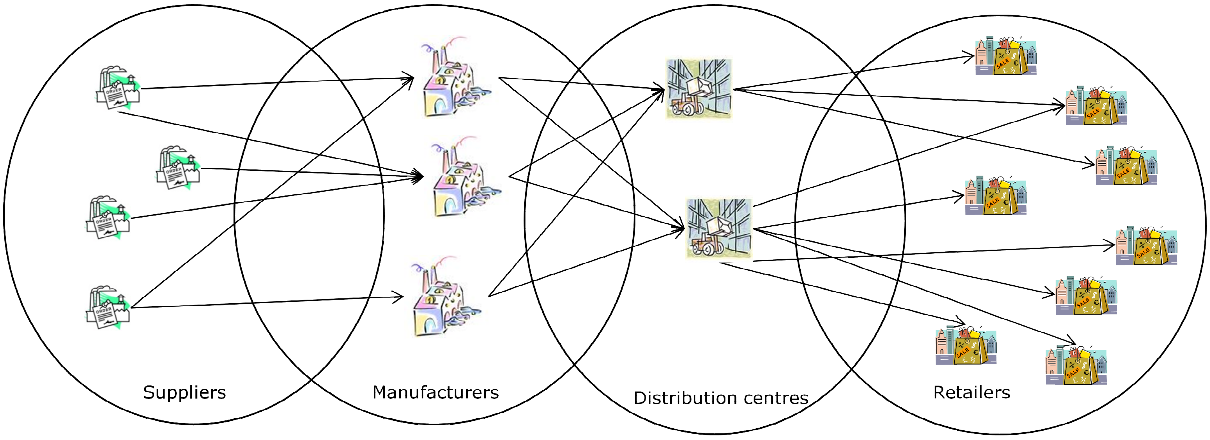

Figure 1. A supply chain system

For example the manufacturer of one supply chain could be the supplier of another chain, as well as the distribution centre of a chain can be the distribution centre of a different supply chain. The function of one entity in a supply chain can be the same to another supply chain, or it can change.

The number of entities in a chain can change continuously as the business evolves for example new products can generate new suppliers and at the same time open new opportunities for different markets therefore generate new customers in the chain. The behaviour of the supply chain changes continuously, at times where these cannot be predicted as well as their structure and design changes.

Another way to look at supply chains can follow the representation of a network and more than this the representation of interlinked supply chain systems as indicated in Figure 2. The representation provided in this figure is still simplistic where only the forward flow of products has been considered.

To be able to understand, design, redesign, measure, monitor and control supply chain system, modelling tools or techniques are considered to help in achieving any of these tasks.

The aim within this work is to evaluate how modelling tools have been currently used in practical applications in order to achieve any of these tasks. There are many modelling techniques used in different situations and for different aspects some of which will be highlighted here. Modelling tools such as linear programming, vehicle routing and scheduling, inventory control, centre of gravity, simulation and artificial intelligence tools are just some of the tools present in current literature. Some of these tools are used to provide a solution such as the best planning route to deliver to a set of customers or collect products from a set of suppliers which minimises the overall transportation cost by using the shortest distance travelled. Other techniques will allocate resources which again based on a set constraints will optimise one objective such as the total cost or distance travelled. Some of these tools are probably used only once in support to the decision making process, where others such as forecasting are used on a regular base.

It is also relevant to mention that there are no modelling tools which capture all aspects of a complex supply chain system therefore this evaluation also aims to understand to what extent models interact with one another.

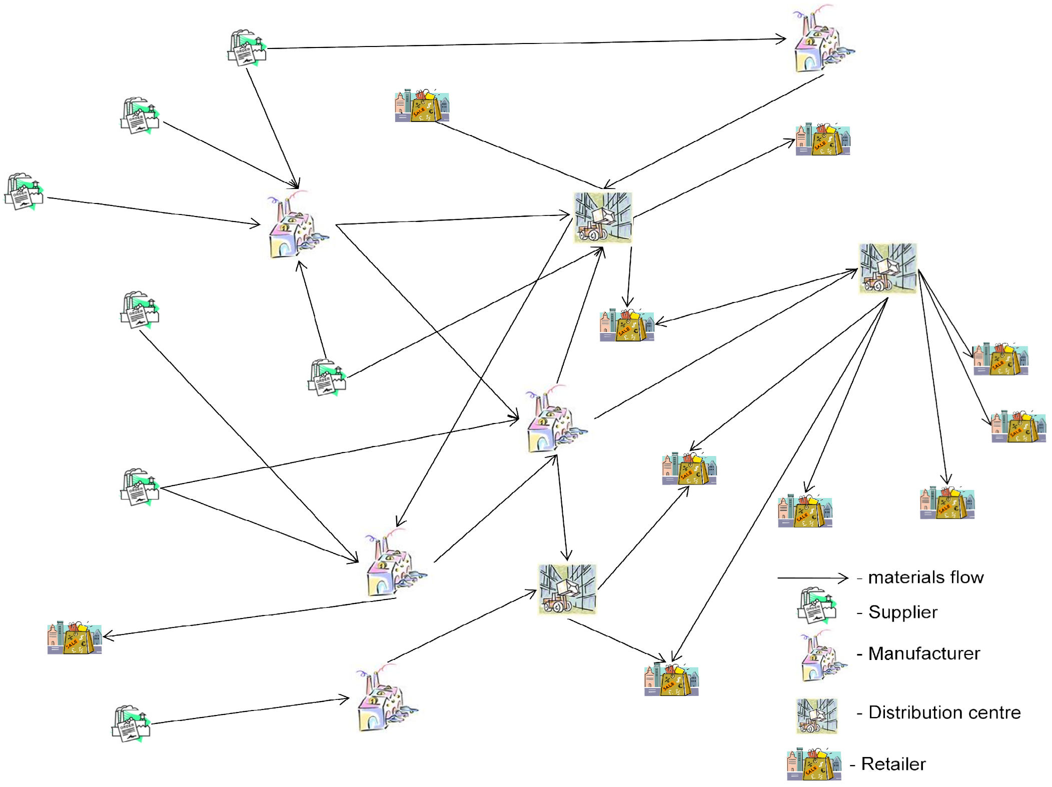

Figure 2. A network of supply chain systems

SUPPLY CHAIN COMPLEXITY

The be able to reach more markets, businesses are expanding their activities continuously by adding new products, new operations, different transportation links, therefore adding new complexity in the supply chain. What are the implications of added complexity in a supply chain becomes one relevant issue to be investigated.

Over the years many researchers (see for example Wilding 1998, Bandinelli et al. 2006, Choi and Krause 2006, Wycisk et al. 2008, Hofer and Knemeyer 2009, Bozarth et al. 2009, Baldwin et al. 2010, and Manuj and Sahin 2011) have looked at different aspects of supply chain complexity as well as what generates complexity in a supply chain system.

Many aspects can generate complexity in a supply chain system such as the number of suppliers, their location, changes in their selection, the number of facilities used to store products, their characteristics, the number of customers, the links used between each part in the chain and others.

In a study by Choi and Krause (2006) looking at the supply base theory, they have identified elements such as the number of suppliers, the level of variation in their characteristics and the level to which they interrelate as contributing to the complexity of the supply chain.

Supply chain complexity was seen from two different angles by Bozarth et al. (2009) such as detailed complexity and dynamic complexity. The detailed complexity is characterised here by the number of components where the dynamic complexity is characterised by the unpredictability of a system’s response to a given set of inputs. They observed in their study that elements which contribute to the dynamic complexity of the chain have a greater impact on the system performance than the elements which generate detailed complexity.

MODELS AND MODELLING TECHNIQUES USED IN SUPPLY CHAIN SYSTEMS

It is relevant to investigate to what extent current models and modelling techniques are able to capture the aspect of complexity in supply chains.

Based on models provided in the literature, different classifications of models have been considered over the years starting with Beamon (1998) who classified models in deterministic analytical models, stochastic analytical models, economic models and simulation models. Min and Zhou (2002) classified models in deterministic, stochastic, hybrid and IT driven models. Other relevant study is from Blackhurst et al. (2005) where the classification of models is captured in three distinct categories: optimisation models, network based models and simulation models. Kabak and Ulengin (2011) provided another classification of models which incorporates the following six categories: deterministic single objective, deterministic multiple objectives, stochastic models, hybrid (deterministic and stochastic), information technology driven models and fuzzy set theory models. Most of the categories considered here appear in the previous classifications, still the fuzzy set theory part is part of the artificial intelligent theory.

Deterministic, analytical or optimisation models with single or multiple objectives are using equations to form the model. These models are mainly trying to provide an optimum answer based on a number of constraints. However the number of constraints considered within a model tends to add more complexity, this does not imply that the supply chain complexity issue is fully tackled or it is captured in its entirety.

Providing an optimum solution to a set problem, is able to give an indication of the way in which resources, allocations, locations should be considered to arrive to a minimum or maximum value for a set objective. However, these conditions could change over a period of time, therefore the previously provided solution might no longer be in line with the new business changes. Still, this does not imply that these models are unusable in practice as models using these techniques have been applied in practical applications with significant results. Linear programming type models have been used in different formats with objectives to maximise profit or minimise cost (see for example Spitter et al., 2005, Stadtler, 2007, Ma and Suo, 2006). Van Dam et at. (2009) compared an equations based model with an agent based model of an oil refinery supply chain. En equation based model was also developed by Das and Sengupta (2010) for a supply chain network model. Another complex representation of a supply chain network was provided in Selema et al. (2010) using a mix integer linear programming model for a four echelon supply chain structure.

In Min and Zhou (2002) the hybrid type models are those which incorporate both deterministic as well as stochastic elements such as simulations and inventory control models. Other models such as the vendor management systems (VMS) models, the enterprise resource planning (ERP) models and the geographic information systems (GIS) models are coming under the IT type models.

Simulation models (see for example Venkateswaran and Son 2004, Appelqvist et al. 2004, Aslanertik, 2005, Longo and Mirabelli, 2008) tend to capture the flow of activities within a supply chain and be able to indicate problem areas in a predefined supply chain system. However, they will not be able to indicate if the overall output of the developed model can provide the optimum solution in any given situation.

Artificial intelligence type models do not only incorporate fuzzy set theory models as included in the category of models developed by Kabak and Ulengin (2011) where others can also be incorporated here. Some relevant examples which incorporate fussy set theory are seen in Gunasekaran et al. (2006), Mahnam et al. (2009) and Kabak and Ulengin (2011). Other artificial intelligent type models such as neural network, genetic algorithms (Han and Damrongwongsiri, 2005) and intelligent agents (van der Zee and van der Vorst, 2005) are also used to model different aspects within supply chain systems.

Some of these models and theirs characteristics have been captured in Table 1. It can also be observed here that some of the examples considered do have industrial applications, where others are only developed from a theoretical stand point. Models able to capture real case study or use data from real industrial applications will have the advantage of capturing real situations, where the objectives set within these models will have the ability of imitating company's or the supply chain's objectives.

Still, theoretical models have their advantages as well as they aim to support the development of theories and allows for scenario evaluations and model validation. When using a theoretical model, the size of a supply chain can be expanded beyond the boundaries set by a real case study.

Table 1. Examples of models and their characteristics

Author (year)	**Model/ Technique used**	**Supply Chain characteristics**	**Type of study**	**Software package used**
Venkateswaran and Son (2004)	Simulation model	Three echelons supply chain	Experimental model	ARENA discrete event simulation
Appelqvist et al. (2004)	Simulation model	Supply chain	Experimental model for an aerospace model	Simulation model developed between Patria and Delfoi Ltd.
Gunnarsson et al. (2004)	Heuristic optimisation model	Supply chain of two level facility location problem	Applied example for a forest fuel supply chain	AMPL/CPLEX
Blackhurst et al. (2005)	Non optimisation network model using Petri Nets	Supply Chain Network	Industrial example with data used from Rockwell Collins	Not specified
Turner and Williams (2005)	Simulation model	Complex supply chain	Experimental model of a car manufacturer	Visual Basic
van der Zee and van der Vorst (2005)	Agent based simulation model	Three echelons supply chain	A case study example of an actual supply chain chilled salads	Object-oriented simulation package eM-Plant^{TM} and ARENA simulation
Han and Damrongwongsiri (2005)	Mathematical model with Genetic algorithm	Two echelons multiple sourcing SC	Numerical example	Not specified
Stadtler (2007)	Single objective optimisation	Dyadic supply chain	Numerical example	Xpress-MP optimiser
Mahnam et al. (2009)	Hybrid simulation optimisation and particle swarm	Supply Chain Network	Theoretical and numerical example	MATLAB 7

	algorithm with bi-objective approach			
van Dam et al. (2009)	Equation based model and Agent based model	Direct flow supply chain	Experimental study of a oil refinery supply chain	Excel, Matlab/Simulink and Repast agent simulation toolkit
Das and Sengupta (2010)	Single objective optimisation model	Supply Chain Network	Numerical application	Lingo 09
Selema et al. (2010)	Single objective optimisation model	Supply Chain Network (four echelons structure)	Industrial application	GAMS/CPLEX
Kabak and Ulengin (2011)	Possibilistic linear programming optimisation model using fuzzy set theory	Supply Chain Network	Industrial application to Mercedes-Benz Turk	GAMS/CPLEX

CONCLUSION

This evaluation clearly indicated that there is no preferred model, or technique applied in previous research to model supply chain systems. Models have advanced over the years, still a limited number of models show the integration of more them one objective.

Different set of software packages have been considered for analysing supply chains, still optimisation type software appears to be predominant so far.

The number of supply chain models used in industrial applications appears limited, where further investigations should consider more industrial applications.

The attempt to model a supply chain system with added complexity is still very limited, where further work is to be carried out in this area.

Building a supply chain model which has the ability to capture a complex supply chain system proves to be a very challenging if not yet achievable task. Still, there is the argument that it is relevant to have the opportunity to model and evaluate the “whole” supply chain to be able to understand how one change in one part of the supply chain can have an effect to another part in the supply chain. So far, models were not capable of capturing this aspect where it would be relevant to investigate if by splitting the analysis into modular design could provide an understanding for the whole system.

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THE DESIGN OF FRESHNESS GAUGE FOR COLD CHAIN

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1. INTRODUCTION

Perishable food loses its quality continuously from harvest to consumption. In bad environment, the amount of loss might be considerable and quality deterioration has bad influence on the sales of the products. In worse cases, improper storage of perishable food may cause food poisoning and personal injury. For such reasons, it is important to preserve reliable environmental condition during entire logistics process.

Recently, many researchers have studied and drawn new technologies for perishable food in cold chain system. Especially, researches on the application of Radio Frequency Identification (RFID) and Wireless Sensor Network (WSN) technology to cold chain system is getting attention (Aung et al., 2011). RFID technology identifies each individual product automatically and WSN technology collects environmental information in real-time base. Both technologies work without wires and if artificial satellites or communication technologies are combined, the two technologies can cover very wide areas across countries. With an aid of the technologies, making ubiquitous monitoring system is possible in cold chain system.

Besides, it will be useful for all parties in the cold chain to know the portion of degraded products because they can plan and operate their logistics system more flexibly using such information. In this paper, we present algorithm for indicating quality of cold chain products such as vegetables and fruits. The algorithm works on real-time base with the aid of WSN technology. In next section, WSN technology and shelf life of food will be explained and some related researches will be introduced. In section 3, we designed an algorithm of an indicator which measures quality of fresh food and show how it works. We call the indicator as Freshness Gauge (F/G). Two examples of the F/G will be presented in section 4. More and advanced research topic is discussed in the conclusion.

2. COLD CHAIN TECHNOLOGY

Wireless sensor network technology

Wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, humidity, motion or pollutants and to cooperatively pass their data through the network to a main location (WIKIPEDIA, 2011). WSN technology is used in many industries such as factory, home automation, consumer electronics, military, agriculture and health. And a very large unit volume application of WSN is expected to be asset tracking and supply chain management (Callaway, 2003).

The conventional way to check propriety of storage temperature is to use a Time Temperature Indicators (TTIs) and temperature data loggers. TTIs are attached to products and stored with the products. Once surrounding temperature deviate from threshold temperature, the colour of the devices is changed and it implies that the product may not be preserved in a good way during logistics process (Roh et al., 2008). Temperature data loggers record temperature data during logistics process. But containers or packages should be opened first in order to read the temperature recorded, so temperature cannot be checked unless the devices arrive in the final destination (Abad et al., 2009). The conventional devices cannot give real-time temperature information to the members of cold chain system. But WSN technology can do it and members of cold chain system can prevent products from being stored in improper environment using the information.

Various researches on the application of RFID and WSN technology have been carried out in cold chain industry. Abad et al. (2009) developed RFID smart tag combined with light, temperature, humidity sensors and tested its performance in an intercontinental fresh fish cold chain system. Shi et al. (2010) studied decision-making model for distribution strategies in cold chain system. RFID, sensor and wireless communication technologies was used to formulate the model. Jedermann (2009) used RFID temperature logger to analyze the temperature in refrigeration trucks. Lang et al. (2011) built decentralized WSN system which features cognitive concept. In the WSN system, sensors not only collect environmental data but also operate data processing and decision making. Santa et al. (2012) equipped cargo truck with Trailer Control Unit (TCU) which consists of temperature, humidity and light sensors and RFID reader. For an application, they monitored temperature, humidity and illumination of a cargo truck which transports juice from Spain to Netherland. Montanari (2008) compared Eulerian method and Lagrangian method for the construction of cold chain monitoring system. Sensors are not movable in Eulerian method and sensors of Lagrangian method are able to be moved because the sensors are embedded in RFID active tag. Boquete et al. (2010) developed a WSN system for manufacturing of wine and tested the system in a winery for a few months.

Shelf life and quality of food

A shelf life is called stability time or acceptability time. During shelf lie, a product keeps its life with acceptable quality and based on the shelf life, 'expiration date' and 'sell by data' are settled. Company which make and sell food products should exactly assess the shelf life of the products. Table 1 shows example definitions of shelf life. As in the table, PSL is longer than JND and HQL. In case of fruits and vegetables, PSL is three times longer than HQL generally.

Name	***Definition***
Just Noticeable Difference (JND)	Period until sensory difference is found between an objective product and a contrastive fresh product.
Practical Storage Life (PSL)	Period until customers are able to consume objective product generally.
High Quality Life (HQL)	Period until 70% of inspectors find difference between objective products and contrastive products in three point assay test.

Table 1: Kinds of shelf life (Park et al., 2012)

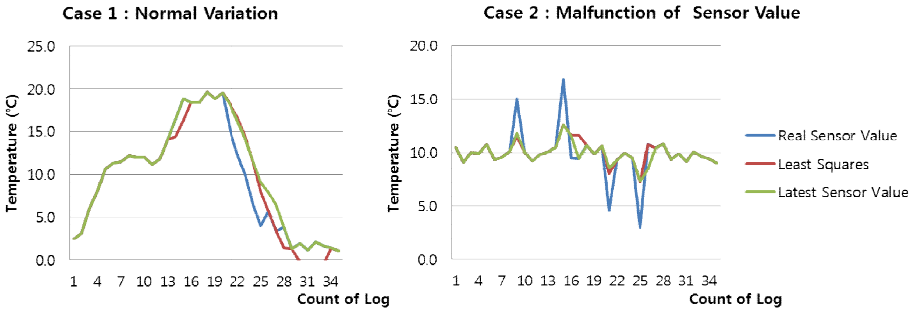
Index components are often used to determine a shelf life. Index components include microbial index like number of germs, physicochemical index like vitamin C and sensory index like appearance, taste, smell and texture etc. Examinations are executed to know how much the indexes change in various environmental conditions. A change of microbial and physicochemical indexes is measured by chemical reaction kinetic model. Chemical kinetics is the study of the speed with which a chemical reaction occurs and the factors that affect the speed (Blauch 2009). A shelf life was determined by a correlation with three indexes (Park et al., 2012; Roh et al., 2008).

There are researches on the quality and shelf life of food. Lang et al. (2010) applied a shelf life algorithm into their decentralized WSN system to know whether the goods are in proper condition or not. Broekmeulen and Donselaar (2009) studied inventory replenishment model for perishable products which have shelf life. Wang et al. (2012) designed an RFID-based quality evaluation system to monitor a whole supply chain of wine. For aging process and transportation of wine, environmental data are collected by sensors and the data are used to evaluate a quality of wine. K-nearest neighbours' algorithm and simple artificial neural networks' technique were used to calculate the quality of wine. Shi et al. (2010) considered product value loss in developing the distribution strategy for perishable food. The less value products have, the closer destination is selected in their model. Predictive microbiology model was adopted to predict the value loss of food. Plainsirichai and Turner (2010) studied correlation between ambient temperature and ripening of fruit. They found that the temperature of banana in the first few hours of ripening has a big effect on the change of banana colour.

3. DESIGNING FRESHNESS GAUGE ALGORITHM

Compensation of Sensor Value

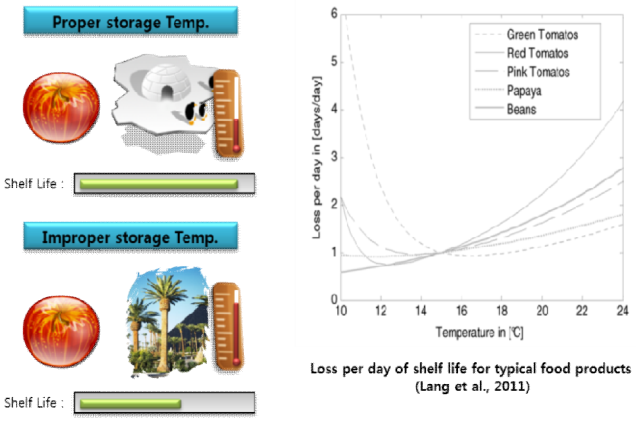
Because the F/G is based on the sensor data, the reliability of sensor values is important. Temporal and radical change of sensor value which may be caused by malfunction of sensors or the opening of refrigerator gate can give bad influence to the accuracy of F/G. There are two methods to increase the reliability of sensor data: one which uses some successive past data; and another which uses only the latest value to expect future value. The first uses the least squares method to grasp the trend of temperature. When the real sensor data is collected, the data is compared with the expected data. If the gap between the two values is small, the real data is used to calculate F/G. Otherwise the combination of two values is used. Normal case and abnormal case were used to evaluate the performance of the two methods. Throughout many tests, we found that the two methods had similar performance. Figure 1 shows the comparison of two methods.



Difference Method of Least Squares : 37.1 Method of Latest Sensor Value : 26.4	Difference Method of Least Squares : 19.8 Method of Latest Sensor Value : 20.2

Figure 1: Comparison of two methods

Freshness gauge algorithm



Loss per day of shelf life for typical food products (Lang et al., 2011)

Figure 2: Concept of freshness gauge

Figure 2 explains the concept of F/G algorithm. As the graph shows, the deterioration of quality occurred dynamically due to the storage temperature and this means that a shelf life also changes depending on the ambient temperature. For example, the apples stored in hot place would have high loss rate of quality and shorter shelf life than the apples stored in cold place. The concept of F/G algorithm is to subtract the quality loss from the finest quality whenever a sensor forwards temperature data. The amount of quality loss is determined by a variable shelf life and by reporting interval of sensor.

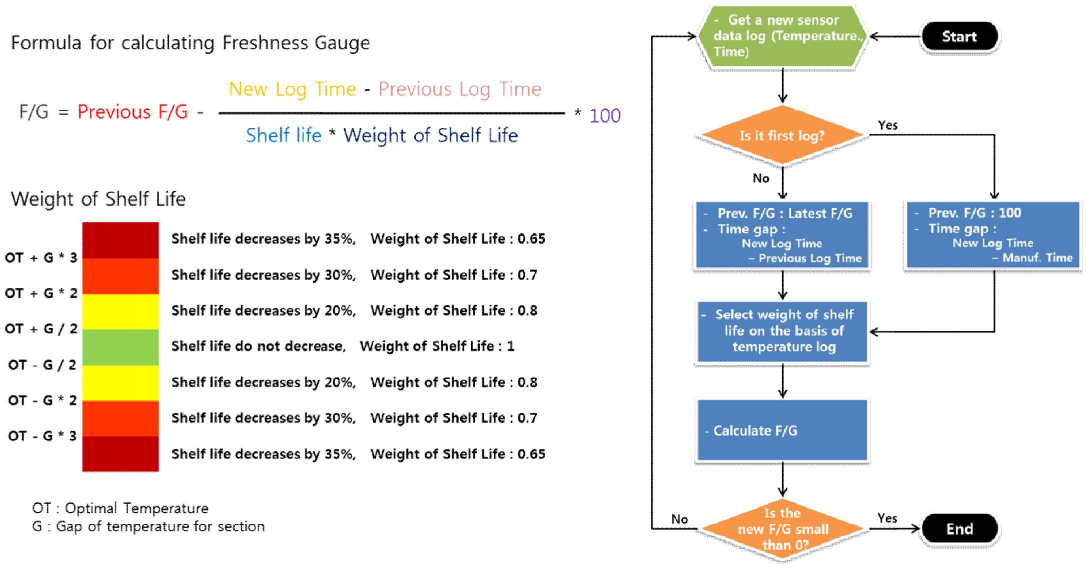


Figure 3: Calculation of freshness gauge

Figure 3 shows the formula and process of calculating F/G. The process starts from getting sensor data which includes item id, temperature value and log time. Secondly, the algorithm checks whether a previous F/G exists in a F/G log list or not. If the previous F/G does not exist, the algorithm regards the previous F/G as 100 (%). Third, the algorithm determines a weight of shelf life. A weight of shelf life is a value that shortens a shelf life of optimum condition in accordance with the temperature. Fourth, F/G is calculated by a formula as in Figure 3. If the calculated values are equal to 0 or lower than 0, the next process is not operated and the item should be discarded. Fifth, when sensor data is collected again, the current F/G becomes previous F/G and the same process is repeated. As the formula indicates, the quality loss is determined by 'new log time', 'previous log time', 'shelf life', 'weight of shelf life'. 'shelf life' in the formula is the shelf life which is assessed under the situation that the item is preserved at optimum condition. When the item is stored in optimum condition, the quality loss is small and only determined by elapse of time. But as the storage condition becomes inferior, 'weight of shelf life' and the numerator gets lower, consequently quality loss gets higher.

Evaluating weight of shelf life

Temperature (℃)	***Assumed Q_{10}***	***Relative velocity of deterioration***	***Relative shelf-life***
0	-	1.0	100
10	3.0	3.0	33
20	2.5	7.5	13
30	2.0	15.0	7
40	1.5	22.5	4

Table 2: Effect of temperature on rate of deterioration (Saltveit, 2002)

Because the weight of shelf life is a core for calculating F/G, evaluating the value is essential. We have estimated relative shelf life to evaluate the factor. Respiration rate is used to measure relative shelf life. Plants such as fruit and vegetables do respiration. Keeping high respiration rate means the product is on high velocity of deterioration and its relative shelf life is short. Generally, as temperature increases, the respiration rate becomes high. Table 2 shows the example of correlations with temperature, relative rate of deterioration and relative shelf life. Respiration rate is related with density of CO_2 (emitting CO_2 is essential for the process of respiration: $C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 12H_2O + 6CO_2$).

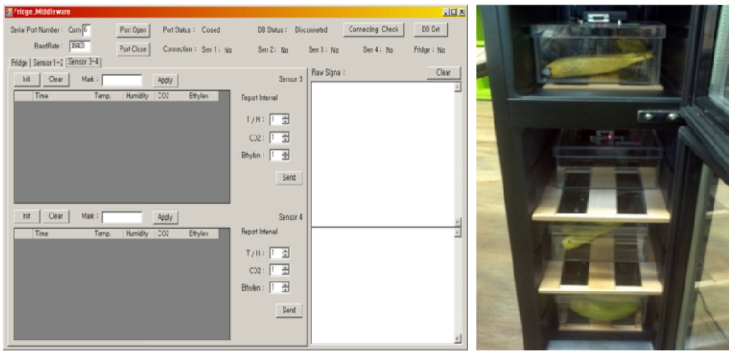
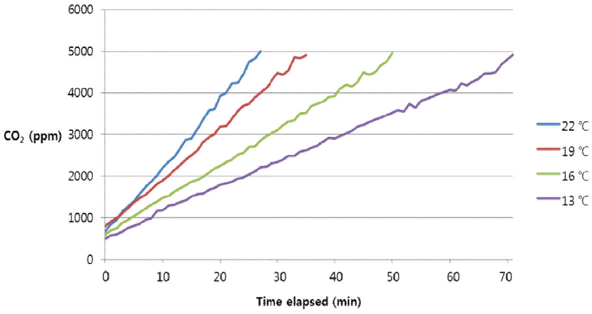


Figure 4: Wireless sensor device developed to evaluate shelf life

Figure 4 shows a small WSN system developed to test the respiration rate of real product. In the figure, the left is a console application and the right figure shows the sensors and a chamber for test. The sensors perceive temperature, humidity and density of CO_2. The chamber senses temperature and preserves refrigerated rooms with the same condition constantly. Sensed data are forwarded to console application wirelessly at selected interval. The console application gets data and shows those to a display and imports the data into database.

In this paper, banana was chosen as an object for test. 3℃ was selected as temperature gap of each section for setting weight of shelf life. If the temperature gap is set with smaller difference, more sophisticated calculation may be possible but it would be very difficult to make temperature condition for test and take longer time for test. Emission rates of CO_2 was checked at 13 ℃, 16 ℃, 19 ℃ and 22 ℃. Tolerance of ±1 ℃ was permitted to keep storage temperature during the test. The interval of data reported was set as a 1 minute.



Temperature	Rate of CO_2 emission (ppm/min)
13 ℃	58.98
16 ℃	84.48
19 ℃	121.19
22 ℃	161.47

Figure 5: Rate of CO_2 emission of bananas

Figure 5 shows a result of the experiment. Some data and its period of the early stage were ignored for more exact analysis. The slope of lines on the graph indicate respiration rate of banana. The values of the right table were calculated by regression analysis. The result shows that the banana stored at warm condition has high respiration rate.

Section of temperature	***Average rate of CO_2 emission (ppm/min)***	***Relative shelf life (%)***	***Weight of shelf life***
13 ℃ ~ 16 ℃	(58.98 + 84.48) / 2 = 71.73	100	1

16 ℃ ~ 19 ℃	(84.48 + 121.19) / 2 = 102.84	69.75	0.70
19 ℃ ~ 22 ℃	(121.19 + 161.47) / 2 = 141.33	50.75	0.51

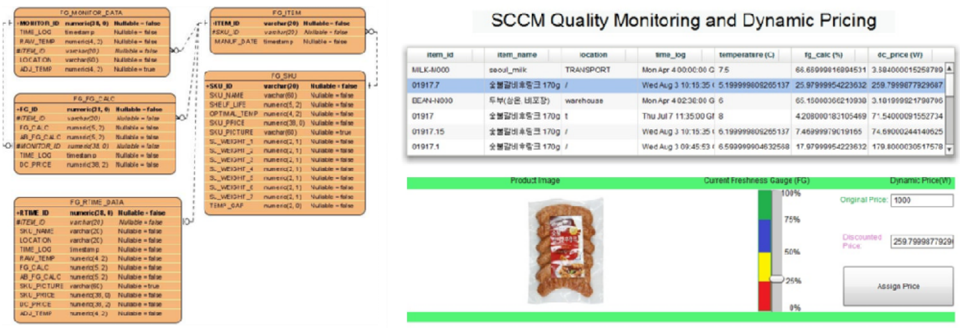
Table 3: Evaluation of shelf life

Table 3 explains how to get the weight of shelf life. Using respiration rate, we calculated the average respiration rate of each sector. We consider that the relative shelf life of 13 ℃ ~ 16 ℃ section is equal to 100 % because 13 ℃ ~ 16 ℃ is optimum condition of bananas (http://www.engineeringtoolbox.com/). It is also possible to estimate other relative shelf lives because respiration rate and relative shelf life are in inverse proportion ratio.

4. APPLICATION OF FREHSNESS GAUGE

Freshness gauge monitoring system

We developed a pilot application to monitor F/G in cold chain. The web based software can show real-time information such as the name of Stock Keeping Unit (SKU), current location, temperature, F/G and dynamic price of each item. Dynamic price is changeable price (Price could be decreased as F/G becomes reduced). Using the dynamic price, sellers can prevent from losing chances of sales for some product which has low F/G.



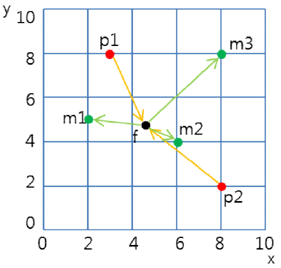
SCCM Quality Monitoring and Dynamic Pricing

item_id	item_name	location	time_log	temperature (C)	fg_calc (%)	dc_price (W)
MILK-N000	seoul_milk	TRANSPORT	Mon Apr 4 00:00:00 G	7.5	66.68999816894531	3.384000015258789
01917.7	숯불갈비후랑크 170g	/	Wed Aug 3 10:15:35 (	5.199999809265137	25.97999954223632	259.7999877929687
BEAN-N000	두부(상온, 비포장)	warehouse	Mon Apr 4 02:30:00 G	6	65.15000066210938	3.181999921798706
01917	숯불갈비후랑크 170g	t	Thu Jul 7 11:35:00 GI	8	4.208000183105469	71.5400009155273 4
01917.15	숯불갈비후랑크 170g	/	Wed Aug 3 10:15:35 (	6.199999809265137	7.46999979019165	74.69000244140625
01917.1	숯불갈비후랑크 170g	/	Wed Aug 3 09:45:53 (	6.599999904632568	17.97999954223632	179.8000030517578

Figure 6: Database schema and user interface of freshness gauge monitoring system

Figure 6 show database scheme and user interface of the application. Oracle and Flex was used to develop the system. Every time the database gets new sensor data by certain time interval, temperature, item id and location, the triggers produce adjusted temperature and new F/G automatically.

Selecting target temperature for storage



Point(i)	Volume(V_i)	Trans. Rate(R_i)	Coord.	
			x_i	y_i
p1	2,000	0.05	3	8
p2	3,000	0.05	8	2
m1	2,500	0.075	2	5
m2	1,000	0.075	6	4
m3	1,500	0.075	8	8

Min TC = $\sum_i V_i R_i d_i$

Where

TC = Total transportation cost

V_i = Volume at point i

R_i = Transportation rate to point i

d_i = distance to point i from the facility to be located

Figure 7: Concept of exact centre-of-gravity approach (Ballou, 2003)

In this section we show how to find proper target temperature and humidity for storage of various products which share same sealed room and refrigerating machine. And the products have different optimum temperatures and humidity. We applied an exact centre-of-gravity approach to solve the problem as in Figure 7 (Ballou, 2003). In our problem, the bigger gap of storage condition between item and target condition occurred, the bigger loss of product quality is generated. Our customized objective is minimize loss of product value as in equation 1.

$$\text{Min TL} = \sum_i[\{(C_i * ew_1) + (RG_i * ew_2) + (AG_i * ew_3)\} * \sqrt{(x_i - a)^2 + (y_i * hw - b * hw)^2}]$$

Where

TL = Total value Loss

C_i = Cost of item i (relative value)

RG_i = F/G of item i (relative value)

AG_i = Reversed absolute F/G of item i (relative value)

$ew_{1,2,3}$ = Importance of C_i, RG_i and AG_i ($ew_1 + ew_2 + ew_3 = 1$)

a = Target temperature

b = Target humidity

x_i = Optimal temperature of item i

y_i = Optimal humidity of item i

hw = weight of humidity ($hw \leq 1$)

(1)

Each item to be stored has unique value ($C_i * ew_1 + RG_i * ew_2 + AG_i * ew_3$) and as the value becomes higher, the target condition (a, b) moves to the optimum condition of the item (x_i, y_i). The value consists of cost of item (C_i), F/G (RG_i) and reversed absolute F/G (AG_i). The absolute F/G means a remaining shelf life. Because the most important factor for affecting postharvest life of vegetable and chemical reaction rate is temperature (Park, 2012; Saltveit, 2002), the weight of humidity (hw) was used to weaken the influence of humidity to emphasis the influence of temperature on the quality of food.

5. CONCLUSION

In this paper we presented a method for checking quality of perishable food. Storage temperature, variable shelf life of food and wireless sensor technology are applied to calculate the F/G. A freshness gauge monitoring system and a method for selecting storage temperature were developed for application of the F/G. The concept can be widely applied to other industries, if a target product has shelf life and the its shelf life is sensitive to temperature. For the improvement of the freshness gauge, other environmental factors like humidity and density of specific gases can be taken into account. Since the shelf life can be different according to products and environments, further researches on estimating shelf life are necessary.

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QUEUING BASED β RELIABILITY MAXIMAL COVERING LOCATION MODEL FOR EMERGENCY SERVICE VEHICLE

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ABSTRACT: By introducing queuing theory knowledge, an emergency service vehicle location model with service level guaranteed has been established, which relaxed the vehicle busy fraction independent assumption and modeled directly on the vehicle busy fraction, also a descriptive modelM1 and a mixed-integer linear model M2 are proposed respectively. At last, according to the property of queuing theory, an algorithm for no restrict on the service vehicle number in single site has been devised, computing results indicate that even for large scale instance, the algorithm can quickly find a satisfactory solution.

KEYWORDS: emergency service, covering location, queuing model, reliability

INTRODUCTION

In real life, the location of emergency service facility has a wide range of applications, such as the siting of police patrol car, fire station rescue vehicle, hospital ambulance and so on. Early applications mainly use the covering model to determine the location and quantity of the emergency service facility site. That is, as long as the service facilities can provide service for the demand point within a predefined time or distance standard. For example, Toregas at al[1] studied the emergency facility set covering problem in the early time, John and Morton[2] investigated two type emergency siren covering location problems. There are some drawbacks with the set covering problem in application, usually it will build excessive facilities, thus beyond the possible budget constraint. Thereafter, Church and ReVelle[3] proposed the maximal covering model, which not requiring to cover all demand points, rather covering as many demands as possible under the limited resources.

In some cases, the distance between demand point and facility is within the given service radius, in accord with the covering model, the demand point should be covered. However, it doesn't consider such a situation: when a demand point calls for service to the nearest service facility, the latter is just busy serving another customer within its service radius, in this case, the newly generated demand either waits in the queue or gets lost and turn to other service facility, both above cases are not in the consideration of general covering models.

Various uncertainty factors in real life make it difficult to accurately forecast all the possible future scenarios. Such as in the location of ambulance, it's hard to accurately determine the location of demand point and the demand quantities within the service area; as the roads and weather conditions is different, the travel time of the ambulance is often uncertain. So it's necessary to build the proper model to deal with the uncertainty in the reality.

In the possibility location models, queuing location model is an important aspect.A critical parameter in the queuing model is the server busy fraction, which is hard to estimate before the facility location is determined. Daskin[4] assumes that all the vehicles have the same busy fractions in the system scope, while ReVelle and Hogan [5]make the estimation in the regional level. Although estimation based on the region is more approximately to the real case than that of based on system level, the busy fraction of the both above is not directly modeled for the server and also needs to make the assumption that whether the servers are busy or not are independent of each other. Larson[6,7] proposed two versions super cubic queuing model to compute the vehicle busy fractions, which provide different method to study the queuing location problem.

LITERATURE REVIEW

Among the facility location models, the maximal covering model proposed by Church and ReVelle[2] is an important kind, it has been applied into the practice successfully and widely to the emergency service facility location. A variety of variations of the basic maximal covering model come out, Schilling[8] et al. divide the covering location model into set covering and maximal covering and make a review about the two types. Recently, Farahani[9] et al. make a comprehensive review about the covering related articles after nearly 20 years from Schilling. The above two reviews involve most part of covering location problem, interested reader can refer to the literatures.

The parameters in early location literatures are deterministic.For location problem under uncertainty, Snyder studied this kind of problems and decision-making under uncertainty. Boffey[11] et al. reviewed that the server is immobile and the system has capacity constraint queuing problem. Based on the deterministic p-median problem and by expansion of the parameters and constraints in the basic model, he gradually evolves it into other non-deterministic location problem.

Daskin[4] firstly introduced uncertainties in the maximal covering problem and also made a lot of simplifications about the problem assumptions. For example, the servers' busy fractions are independent of each other and equal, also independent of the location and workload. Later, ReVelle and Hogan[12] proposed covering location problem that has guaranteed reliability level and maximize vehicle availability, using the system-level and regional-level vehicle busy fractions to study the instance city respectively.

Considering the possible congestion situation, Marianov and ReVelle [13,14] directly use the queuing model to study the emergency vehicle location problem, they both relax the assumption that whether each server is busy or not is independent of each other, maximizing the reliability with assured demand quantity, paper[14] also deal with the arriving time at the different nodes are random.

Berman andDrezner [15] consider the demand and service time are random type network location problem, the demand points and facility points are only at the nodes of the network, their objective functions are to minimize the sum of travel time and average waiting time at servers, therefore belonging to the queuing-median location problem. Baron [17] et al. studied the general stochastic location problem that has stochastic demand and waiting time constraint, in their model, the demand quantity, arrival and service processes are subject to general distribution and the potential location of facilities are unknown with capacity constraints, at the same time, arrival time and service levels also have some requisitions, and finally construct the decomposition algorithm for solving the problem.

An important issue involved when solving the queuing location model is to determine the server busy fraction, however, in order to satisfy the predefined service level constraints, it is required that the server busy fraction which is dependent on the facility location is known in advance. Therefore, the literature either assumes that the busy fraction for all servers are known in advance [4], or based on system level or regional level to estimate them [5,12,13,14], some literatures use iteration or other improving methods to approximately estimate busy fraction of the server [18,19].

For above reasons, this paper relaxed the server independent assumption and modeling directly on the server busy fraction, established emergency service vehicles queuing location model that has a guaranteed service level β, finally an algorithm has been devised according to the nature of the queuing theory and an instance to test the validity of the algorithm. In the following sections it will no longer distinguish between these two concepts of the servers and emergency service vehicles.

MODEL FORMULATION

Before modeling, first briefly introduce the reliability location model based on local busy fraction estimation proposed by ReVelle and Hogan in paper [5]. In traditional coverage model, as long as the demand point is within the coverage radius of the facility, any demand will be met; this provision implies that at any moment, the facility can respond to all requirements. However, this assumption is very strict and often not realistic in the location of emergency service facilities.Therefore, taking into account the above facts and based on the paper [5], later paper [12] proposed the location model that maximizes the demand that have ensured available service.

It is a great improvement in assumption from assuming equal system wide busy fraction to local area busy fraction. However, the study of the above paper is based on the system level or regional level to estimate the busy fraction. This article below will directly model on the server busy fraction, so we need neither to assume equal system busy fraction as the system-based estimation do nor to assume outer side demand can cancel each other as the regional-based estimation do. Finally due to the application of queuing theory, there's no need to assume that the servers are busy or not are independent of each other. It is important that this model can also directly deal with servers in different areas together service the same demand point scenario.

Because the number of emergency demands generated per unit time generally obey the Poisson distribution, such as the number of calls that a city 120 platform received, the quantities that urban traffic accidents occurred in a day and so on. So it is assumed that the demand quantity in demand point i obey the Poisson distribution with parameter λ_i, without loss of generality, also assumed the time that server processing unit demand follows the exponential distribution with parameter μ.For any potential facility j, donate the demand point set within service radius S asM_j,then $M_j = \{i | d_{ij} \leq S\}$. For some demand point i, it may lie in the cross area of several different facility service radius, in this case, any facility within the service radius can provide service for demand point i. If assume the demand can be service separately and donate the demand quality assignedto facility j from point ias x_{ij}, then the demand quality generated per unit time in the service area of facility j is $r_j = \sum_{i \in M_j} x_{ij}$.In fact, it's not required that the equation $\sum_j x_{ij} = \lambda_i$ always holds, in this case, the demand of point i is partially met.

For demand points that can't be served immediately, it can apply the FCFS (First Come, First Service) principle to add the demand into the queue or assume it getting lost, for example servicing by the other facility in the near area. For emergency service, the latter is more reasonable, so it assumes no queuing is allowed. If donate the server number of facility j as y_j, then it can get the $M \ M \ y_j \ y_j$ queuing system. In terms of queuing theory, the traffic intensity of service point j is $\rho_j = r_j \ (y_j \mu)$, if donate the possibility that k servers are busy as P_k and $\alpha_j = r_j \ \mu$, then $P_0 = (\sum_{r=0}^{y_j} \alpha_j{}^r \ r!)^{-1}$, $P_k = \alpha_j{}^k \ k! \cdot P_0$. For given service level β, any demand can get the corresponding level service requiring that the possibility that at least one server is idle should not less than β, that is $1 - P_{y_j} \geq \beta$. If letting 0-1 variable y_{jk} donate facility j is at least covered by k servers when equal 1,otherwise 0, and the maximal number servers at each facility areb_j, then $y_j = \sum_{k=1}^{b_j} y_{jk}$. If maximizing the demand qualities that are ensured by the service level in unit time, the following mathematical model M_1 can be built:

$$M_1: \qquad \text{Max} = \sum_j \sum_i x_{ij} z_j \qquad (0.1)$$

$$\text{s.t.} \qquad \sum_{j \in N_i} x_{ij} \leq \lambda_i, \qquad \forall\, i \in I \qquad (0.2)$$

$$\sum_{j \notin N_i} x_{ij} = 0, \qquad \forall\, i \in I \qquad (0.3)$$

$$\sum_{i \in M_j} x_{ij} \leq y_{j1}, \qquad \forall\, j \in J \qquad (0.4)$$

$$\sum_j y_j \leq C, \qquad (0.5)$$

$$\sum_{k=1}^{b_j} y_{jk} = y_j, \qquad \forall\, j \in J$$

(0.6)

$$y_{jk} \le y_{j(k-1)}, \qquad \forall\, j \in J, k = 2,3 \ldots b_j$$

(0.7)

$$z_j \left(1 - P_{y_j}\right) \ge z_j \beta, \forall\, j \in J$$

(0.8)

$$0 \le x_{ij} \le \lambda_i \qquad \forall\, i \in I, j \in J$$

(0.9)

$$z_j, y_{jk} \in \{0,1\} \qquad \forall\, j \in J, k = 1,2 \ldots b_j$$

(0.10)

x_{ij} is the demand quality of demand point i assigned to facility j; $z_j = 1$ indicates that facility j reaches the given service level, or otherwise; $y_{jk} = 1$ indicates facility j is allocated at least k servers, or otherwise; the remaining symbols as mentioned above. Formula (0.2) and (0.3) require that the demand is assigned to the facility within service radius; formula (0.4) requires only facility is built so that it can provide service; formula (0.5) is the total servers quantity that allowed to be allocated; formula (0.6)and (0.7) indicate that only facility is allocated at least k-1 servers, it can possibly be allocated k servers and the quantity of server equals the number of the logical condition that whether the facility is allocated k servers(k=1,2,…,b_j) or not;formula (0.8) tells that only service facility can provide the given level service for the periphery demand, this part of demands are count into the objective function; formula (0.9) and (0.10) are the domain of the variables.

Observing the formulas (0.1) and (0.8) in the objective function, it indicates that this is a nonlinear programming model and meanwhile in formula (0.8) the subscript appear in the summation symbol, so the problem can't be solved by any mathematical optimization method or programming software. But it can be solved by intelligent algorithm, such as genetic algorithms, evolutionary algorithms, etc.

Although it is difficult to solve the model M_1, it provides us with a descriptive model that direct modeling for server busy fraction. In the objective function (1.1) and constraint (1.8), if letting β=0, then all $z_j = 1$ satisfy the constraint (1.8), so the problem is equivalent to the maximum coverage problem that not considering whether the server is busy or not. When $\beta \neq 0$ is true, only the covering quantity of facility j that satisfy the constraint $1 - P_{y_j} \ge \beta$ is include in the objective function, so in order to maximize the objective function, it should cover demand as much as possible (making x_{ij} as large as possible) and also to make the server busy fraction not great than $1 - \beta$(making as much $z_j = 1$ as possible). Based on the above analysis, if it can guarantee that demand assigned to a facility won't makes the server busy rate in that facility more than $1 - \beta$, then the demand allocated by this method will be included in the objective function.

The P_{y_j} is the possibility that all y_j servers are busy, so it is also the system calling loss rate. In order to make $1 - P_{y_j} \ge \beta$, that is $P_{y_j} \le 1 - \beta$, On the one hand, it can increase the number of servers, on the other hand it can also reduce the demand for service. Because the demands can be partially met, for any positive integer k servers, it can always find a corresponding demand making $P_k = 1 - \beta$ exactly, this is also the maximal demand quantity served by the k servers in the given service level. If donate$\mathrm{MAX}_k$the maximal demand quantity that making $P_k = 1 - \beta$, also maximize the demand quantities that are ensured by the service level in the unit time, a second model M_2 can be got:

M_2:

$$\mathrm{Max} = \sum_i \sum_j x_{ij} \quad (0.11)$$

s.t.

$$\sum_{j \in N_i} x_{ij} \le \lambda_i, \qquad \forall i \in I$$

(0.12)

$$\sum_{j \notin N_i} x_{ij} = 0, \qquad \forall i \in I$$

(0.13)

$$\sum_{i\in M_j} x_{ij} \le \sum_{k=1}^{b_j}\left(y_{jk}\cdot MAX_k\right), \forall j \in J \quad (0.14)$$

$$\sum_{k=1}^{b_j} y_{jk} = Y_j, \qquad \forall j \in J \quad (0.15)$$

$$\sum_j \sum_{k=1}^{b_j}\left(y_{jk}\cdot k\right) \le C, \qquad \forall j \in J \quad (0.16)$$

$$0 \le x_{ij} \le \lambda_i, \qquad \forall i \in I, j \in J \quad (0.17)$$

$$Y_j, y_{jk} \in \{0,1\}, \qquad \forall j \in J, k = 1..b_j \quad (0.18)$$

$$Y_j = \begin{cases} 1, & \text{building the jth facility;} \\ 0, & \text{otherwise} \qquad ; \end{cases}$$

$$y_{jk} = \begin{cases} 1, & \text{allocating k servers in facility j;} \\ 0, & \text{otherwise} \qquad ; \end{cases}$$

Formula (2.2) and (2.3) specify the manner and scope of the demand distribution; formula (2.4) limits the maximum demand that can be served by each facility; formula (2.5) requires only facility j is established, servers can be allocated to it and only one distribution manner can be used; formula (2.6) requires the sum of all the facility server should not exceed the total available number of servers; formula (2.7) and (2.8) are the corresponding variables' range constraints. Because formula (2.4) ensures the service for all demand is not less than the given service level, so the objective function (2.1) simplifies to maximize the feasible demand distribution.

Model M_2 is a mixed integer linear programming problem, compared to model M_1, it is relatively easy to solve. It can be solved by the general linear programming method combined with branch and bound or cutting plane method or directly solved by the optimization software. In the following sections, this paper will design a greedy algorithm when the server number has no limit in single facility according to the nature of the queuing theory.

ALGORITHM DESIGNATION AND SOLUTION

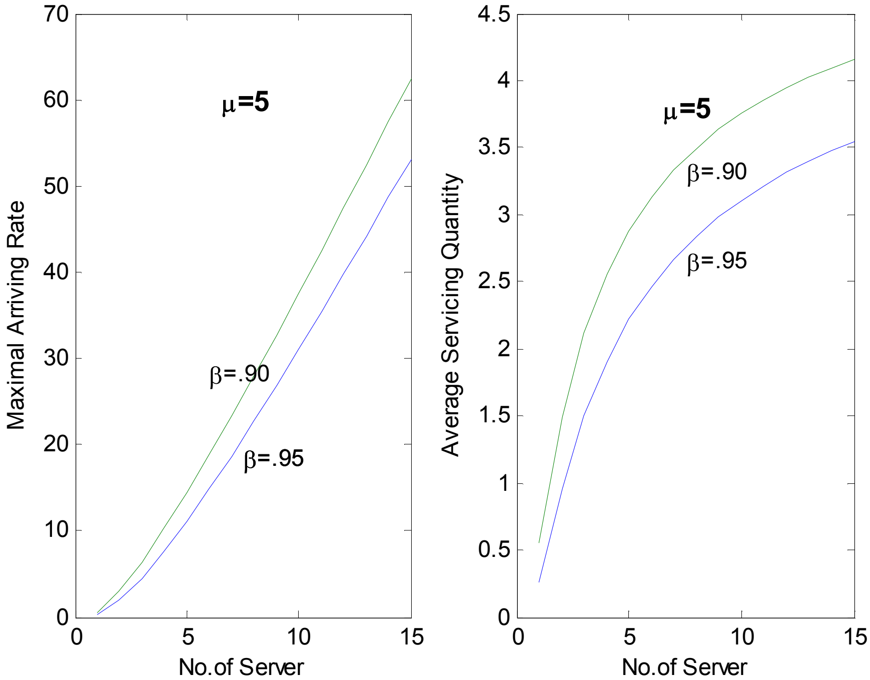
Algorithm designation

First consider such a situation, for a fixed coverage amounts, if there are two or more different coverage, in order to achieve a specific service level, one of these methods needs less number of servers or use the same number of servers, it can provide a higher level of service, then the amount of coverage achieved by this method must be closer to the optimal value. P_{y_j} is the possibility that all y_j servers are busy, so it is the system calling loss rate, what we need to do is to find a cover method: given the same covering amount or resources, it has less calling loss rate so that the demand can be include in the objective function. Here is a property based on the $M\ M\ k\ k$ queuing system:

Property 1:if arriving rate is λ, the serving rate of single server is μ,the server number is k $(k \ge 2)$,then the k servers serving together system $M\ M\ k\ k$ has less calling loss rate than that of the k independent systems$M\ M\ 1\ 1$.

For the proof of property 1, see appendix, by this property, it should get all the demand together for service so that ensure less calling loss rate(the bigger $1-P_k$).Based on the property 1, for the same demand quantity,centralized processing can get a higher level of service than the decentralized processing. Figure 1 indicates when $\mu = 5$, $\beta = 90\%$and $\beta = 95\%$, the relationship between maximal covering amount and server number,also the relationship between average covering amount of every server and server number.

Graph-1



Obviously, from the left figure it can be found that when the server number is fixed, the higher service level β, the less demand quantity the system can service; when service level β is fixed, the more server number, the more demand quantity the system can service. It can be found from the right figure that no matter how high is the service level, as long as the server number is increasing, the average demand quantity that a server can service is increasing, which described as property 1.

Based on the property 1, this paper will propose a greedy algorithm for solving the problem. As the algorithm is built on the property 1, that is centralized services can produce better results under the same condition, so in the following algorithm it assumes that no server number limit on single facility. The above assumption, on the one hand, simplify the processing, on the other hand, when the number of servers of the facility are limited to a lower level, this may be a potential obstacle for property 1 to make its effect. For the sake of convenience, here propose the following concepts:

Maximum assignment covering quantity: the maximum assignment covering quantity of facility j is the sum of all demand quantity that within service radius and allocated to it, donate MACQ;

Actual covering quantity: the actual covering quantity of facility j is the covering quantity that realized actually;

Redundancy covering quantity: the redundancy covering quantity of facility j is the maximum assignment covering quantity minus the actual covering quantity, that is RCQ=MACQ-ACQ;

Marginal contribution quantity: the marginal contribution quantity of the last server of facility j is the actual covering quantity minus the maximum covering quantity when the current server number decline 1, if donate the server number as N, then $\mathrm{MCQ} = \mathrm{ACQ} - \mathrm{MAXN} - 1$;

Adding upper bound: the adding upper bound of facility j the maximum covering quantity of current server number minus the actual covering quantity, that is $\mathrm{AUB} = \mathrm{MAX}_{\mathrm{N}} - \mathrm{AC}$, N is the server of facility j.

The following is the concrete steps to implement the algorithm:

Init: Initialization parameters of the potential facility, including the maximal assignment covering quantity, actual covering quantity, redundancy covering quantity, marginal contribution quantity and the adding upper bound.

Phase 1:
Step 1: Judging whether the number of servers that can be used currently is zero, or the covering quantity that potential facility can cover is zero, if yes, stop;

Step2: Calculating the maximum assignment covering quantity of the non-allocated potential facility and select the one that is the biggest donating$\mathrm{F_k}$;

Step 3: Labeling facility $\mathrm{F_k}$ has been established and assign a specified number of servers to it, set the demand within the radius of facility $\mathrm{F_k}$ to zero at the same time, update the number of servers that can be used and the relevant parameters of the facility, return to Step1.

Phase 2:
Step 1: Select the final facility $\mathrm{F_n}$ generated in Phase1, determine whether the redundancy covering quantity is zero or not, if yes, stop; Otherwise, select the facility $\mathrm{F_i}$ whose marginal contribution quantity is minimal in the previous n-1 facilities, set k = 1;

Step 2: Select the facility $\mathrm{F_{i+k}}$ that offset k places with facility $\mathrm{F_i}$, if $\mathrm{F_i}$ has intersect points with $\mathrm{F_{i+k}}$ and the maximum transferable demand is not zero, then transfer this part of demand, and update the parameters of the facility;

Step 3: Determine whether the marginal contribution quantity of facility Fi is zero or not or $\mathrm{F_{i+k}}$ is the same as $\mathrm{F_n}$, if yes, turn to Step4; Otherwise, let k = k +1, return to Step2

Step 4: If the marginal contribution quantity of facility $\mathrm{F_i}$ is less than the demand quantity increased by the newly added server in the facility $\mathrm{F_n}$, move the last server of facility $\mathrm{F_i}$ to $\mathrm{F_n}$, update the parameters of the facility, return to Step1 ; otherwise stop.

COMPUTING INSTANCE

In order to verify the model and the efficiency of the algorithm, we assume that there are N demand points in the plane and every demand point can be treat as the potential facility. The demand parameter of every demand point per unit time $\lambda_i$follows the integer uniform distribution U(1,10); the vertical and horizontal coordinates of the demand points follow the integer uniform distribution U(1,100). Assume all the servers' service rate μ = 5, the service radius S is a standard deviation of the distance between all demand points(Table-2:σ-5, Table-3:σ-10), the total server number is equal to the number of demand points N, the service level $\beta = 90\%$. The following are the solutions of N at different values generated by the above algorithm and compared with the exact solutions obtained by the Lingo program (or feasible solution), shown as table-2 and table-3:

Table-2

No. of demand point N	No. of server C	Covering radius R	Estimate solution		Lingo exact solution		error%	Upper bound
			Location No.	Optimal value	Location No.	Optimal value		
50	50	21.823	5	190.136	5	190.136	0.000%	—
80	80	19.972	6	326.335	6	326.703	0.113%	—
100	100	20.395	6	427.966	6	428.660*	0.162%	432.134
120	120	19.662	5	530.000	5	539.637	1.786%	—
150	150	20.115	7	671.315	7	671.684*	0.055%	678.639
180	180	19.479	9	801.755	8	810.391*	1.066%	823.076
200	200	20.258	6	945.800	6	950.586*	0.503%	957.484

1. Covering radius is one standard deviation of the distance of every demand point minus 5;
2. The column marked by * indicates that Lingo procedure can't give out the exact solution within

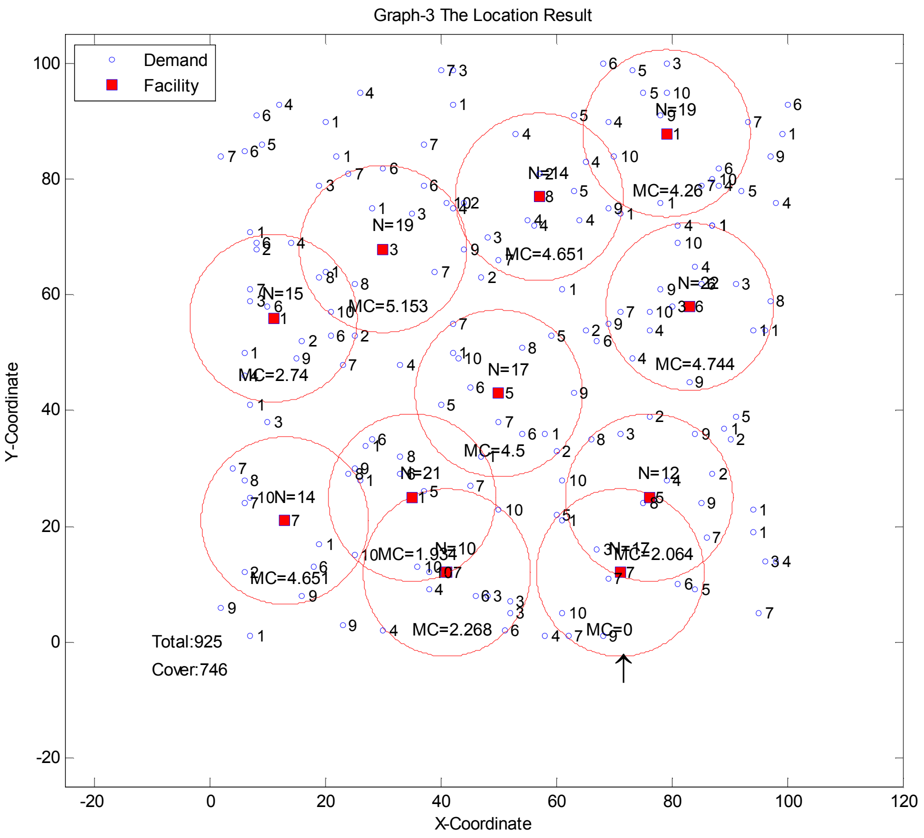
2 hours and provide the upper bound of the objective function.

Table-3

No. of demand point N	No. of server C	Covering radius R	Estimate solution		Lingo exact solution		error%	Upper bound
			Location No.	Location No.	Location No.	Optimal value		
50	50	14.710	6	175.570	6	176.778	0.683%	—
80	80	14.977	7	304.370	7	304.370	0.000%	—
100	100	15.395	8	399.958	8	400.426	0.117%	—
120	120	14.662	8	500.443	8	500.604	0.032%	—
150	150	14.143	10	625.914	10	626.681*	0.122%	630.191
180	180	14.479	11	746.000	11	761.998	2.099%	—
200	200	15.256	10	888.645	10	887.369*	—	895.839

1. Covering radius is one standard deviation of the distance of every demand point minus 10;
2. The column marked by * indicates that Lingo procedure can't give out the exact solution within 2 hours and provide the upper bound of the objective function.

It can be found in Table-2 and Table-3, the solutions of the proposed algorithm and the Lingo program are basically the same in terms of location numbers but one case(Table-2, N=80). So from the perspective of the location number, the final result indicates that by choosing less facility sites and centralizing servers for service, it can get a better location result, which is consistent with property 1. It can be found that by comparing Table-2 and Table-3 the larger the service radius, the less facility site need to be built and therefor covering more demand quantity, which is consistent with our intuitive feeling.
In the solution quality, the error between the proposed algorithm and exact algorithm is within 2%, the biggest error is the instance N = 120 in Table-2 and N = 180 in Table-3. Further analysis shows that the objective function can be further improved slightly in the instance N=180 in Table-3. Figure 3 below shows the final location result and the marginal contribution quantity of the last server in instance N=180 in Table-3. Observe the arrow marked facility in low right corner, its MC = 0, for some facilities the MC are about 2, at the same time the demand points in the peripheral regional are not to cover , such as the upper left corner.



The reason why in the low right corner the facility's MC=0 is when moving the demand to other facility, even if saving a single server in the original location, but the redundancy quantity of the other established facility is zero, thus they can't accept the extra one server (because the objective function does not increase). In addition, the improving algorithm of the second phase is also only used between the established facilities, so the net saving facilities have not been moved to the demand points that are not covered. This is the second case not considered in the algorithm designation, using the proposed algorithm that have not implemented and recomputed the instance N=180 in Table-3, the objective function can reach 751.399, the error is reduced by 1.391%. Recalculating all the other instances, the solution of minority instances can be further improved, but in a very small degree. In the reality, improving the objective function a little at the cost of building a new facility, most decision-makers will not accept this kind of improvement solution.

Finally, the algorithm of this paper has more advantage in the run time. Even for N = 200, it needs less than 1 second to solve the problem by programming in Matlab whereas when N>=100, for majority of the instances it will cost the Lingo procedure more than 2 hours to solve the mixed integer linear programming model M2. Therefore, the algorithm can provide a reasonable lower bound estimate for large-scale problems quickly.

CONCLUSION

In the emergency service vehicles location problem, it is not rare that the demand point request for service and the server is temporarily unavailable in reality, and therefore consider location problem that have guaranteed service level is needed by the real life. Applying queuing theory model to study the emergency service vehicle location problem, there is no need to assume that each server is busy or not is independent of each other, Different from the method used by the previous literatures, this paper directly model on the server busy so it is more accurate than using the system wide or regional area server busy rate. The model M1 provides a descriptive framework for solving the problem, the relationship between service level and the calling loss rate in the queuing system enable us to transform model M1 to easily solved model M2. An important property in queuing theory provides the important basis for designing the algorithm to solve model M2, but it is only applicable for the unlimited server number case and the algorithm needs further improvement. For the case that there are strict limit on the server number, the advantage of property 1 may be greatly impaired, so the manner of demand distribution is more similar with the maximum coverage problem. Therefor effective algorithm for the general problem should be designed in the future.

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SECTION 6 – ENVIRONMENTAL SUSTAINABILITY AND GREEN LOGISTICS

BUILDING A NATIONAL ACTION PLAN FOR IMPROVING THE ENERGY EFFICIENCY AND REDUCING THE CO$_2$ EMISSIONS OF ROAD FREIGHT TRANSPORT

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1. INTRODUCTION

The new Transport White Paper of European Union has set a target to reduce carbon dioxide emissions of transportation by 60% by 2050 compared to 1990 emissions level (COM/2011/0144). Same kinds of targets as set in EU's White Paper, have been also set earlier, for example in the Energy Service Directive (2006/32/EC) and in Climate Change Goals and Action Plans (COM/2008/0030; COM/2008/0017). Road freight transport is responsible for 24 percent of CO$_2$ emissions from road transport in Finland (LIPASTO 2011). Therefore there is a growing need to find solutions to reduce the CO$_2$ emissions, and improve the energy efficiency. As a response to these targets, ministries and transport associations in Finland entered into an energy efficiency agreement for freight transport and logistics in 2008. This agreement aims at 9% improvement in energy efficiency over the period 2008-2016 (Motiva 2008). The aim in the energy efficiency agreement is that 60% of transport companies be covered by the agreement in year 2016 (Motiva 2008). The Ministry of Transport and Communications has also made a political climate program, which seeks 15% reduction in greenhouse gas emissions by 2020 compared to 2005 emissions level (MINTC 2009).

In order to promote the energy efficiency agreement, a multi-stakeholder steering group has been established and this research was funded to gather useful information on the issue. The research consisted of four work packages: statistical analysis, haulier survey, Delphi study and workshops. The objectives of the workshops were (1) to identify the obstacles of improving the energy efficiency of road freight transport, (2) to identify possible measures for overcoming these obstacles and (3) to give recommendations on the measures which can be used to promote reaching of the targets.

2. METHODOLOGY

Workshops belong to the participatory research methods which use facilitated group processes to deal with actual problems concerning the group (Vidal 2006). Participatory methods are more likely to produce normative than analytic results, i.e. they can be used to produce general strategies rather than specific plans (Glenn 2009). Several types of workshops have been developed to deal with varying aims of the process and number of participants; these include for example future workshop, perspective workshop, future search conference and scenario workshop (CIPAST 2012). The workshops of this study followed the phases of future workshop with a few modifications. The future workshop usually involves 15-25 people who are directly involved with the theme of the workshop and can affect the future of the theme (CIPAST 2012). In this study the workshops were organised to bring together the most important stakeholders of the road freight transport sector. Representatives from 26 organisations were invited to each workshop. These organisations included:

- 3 ministries
- 3 government agencies
- 4 freight transport associations
- 1 research organisation
- 1 consultant

- 4 freight transport companies
- 2 heavy duty vehicle importers
- 8 companies from various branches of industry and trade

15 participants attended the first workshop in February 2011. At least one participant from each stakeholder group, except research organisation, was present. The second workshop in May 2011 was attended by 8 participants and seven of them had also participated the first workshop. The participants from the consultant and industry and trade companies were not present in the second workshop. 10 participants attended the third workshop in November 2011 and three of them had not participated the previous workshops. Six experts participated every workshop and contributed greatly to the process.

The future workshop consists of five phases which usually take place during one or two days (Vidal 2006), but in our study took place in three separate workshops in February, May and November 2011. The five phases are (Vidal 2006):

- preparation (invitations, facilities, timetable)
- critique (critical and open discussion of the current situation)
- fantasy (free visioning of the future and ideas for achieving the future)
- implementation (critical evaluation of ideas and development of strategy)
- follow-up (reporting and dissemination of results)

The workshops of this study followed these five phases. Each half-day workshop was designed to answer one of the three research objectives and the workshops comprised a continuing process to build a national action plan for improving the energy efficiency and reducing the CO_2 emissions of road freight transport. In the first workshop (critique phase) the current situation of the energy efficiency of road freight transport in Finland was critically discussed in order to identify the obstacles of improvement. In the second workshop (fantasy phase) possible measures for overcoming these obstacles were identified. In the third workshop (implementation phase) these measures were evaluated and a strategy was developed. The results of the workshops were reported (follow-up) in a research report in January 2012 (Liimatainen et al. 2012). The findings of the three workshops are explained in detail in the following chapters.

Each workshop lasted four hours and included a presentation about the results of other work packages of the research project. A presentation about the research results and measures taken in the United Kingdom was also held in every workshop. Most importantly, each workshop contained a discussion session and these discussions formed a continuous process which aimed at producing an action plan for improving the energy efficiency and reducing the CO_2 emissions during the period of 2012-2016. In the first two workshops the discussion consisted of four parts. Firstly the experts considered the themes by themselves. Secondly the topic was discussed in small groups of 4-5 persons with one researcher facilitating and taking notes of the small group discussion. Thirdly the findings of each small group were gathered and discussed openly among all participants. Finally a voting was organised to rate the findings of the discussion. The third workshop was different as the discussion was done openly among all participants and no small group discussions nor voting was performed.

3. FIRST WORKSHOP - IDENTIFYING THE OBSTACLES

The discussions in the first workshop focused on the following themes:

- What are the strengths of the Finnish road freight transport sector considering the energy efficiency?
- What are the most important trends and drivers which will affect the energy efficiency of road freight transport in the next 5-10 years?
- What are the most important obstacles for improving the energy efficiency?

The participants first considered these themes by themselves and made notes, after that discussed their views in groups of five experts. A member of the research team followed the discussion in each group and wrote the key findings to a flip chart. Each group then presented their findings and these were discussed upon by all participants. Finally there was a voting on the severity of the obstacles identified in the last theme and on the possibilities for removing these obstacles.

The following strengths were identified in the discussion:

- utilisation of long and heavy vehicles
- collaboration and networks of hauliers
- strong tradition in ecodriving training
- cooperation between the government and the key stakeholders of the sector.

In the next 5-10 years the most important trends and drivers of the energy efficiency and CO_2 reduction were seen to include:

- rise in the price of fuel
- EU regulation and policy objectives
- national policies
- foreign transport companies increasing the competition in the market
- economic development on different sectors of the economy
- technological development of vehicles and ITS

Several obstacles for improving the energy efficiency of road freight transport were identified in the first workshop. The identified obstacles were listed on flip charts for voting. Each expert was given five red stickers and five green stickers to put on the charts next to the obstacles. Several stickers could be assigned to same obstacle and not every sticker was required to be used. The experts were asked to indicate a severe and important obstacle with the red sticker. Green sticker indicated an obstacle which should be acted on, i.e. it would be possible to remove the obstacle. Results of the voting are presented in **Figure 1**.

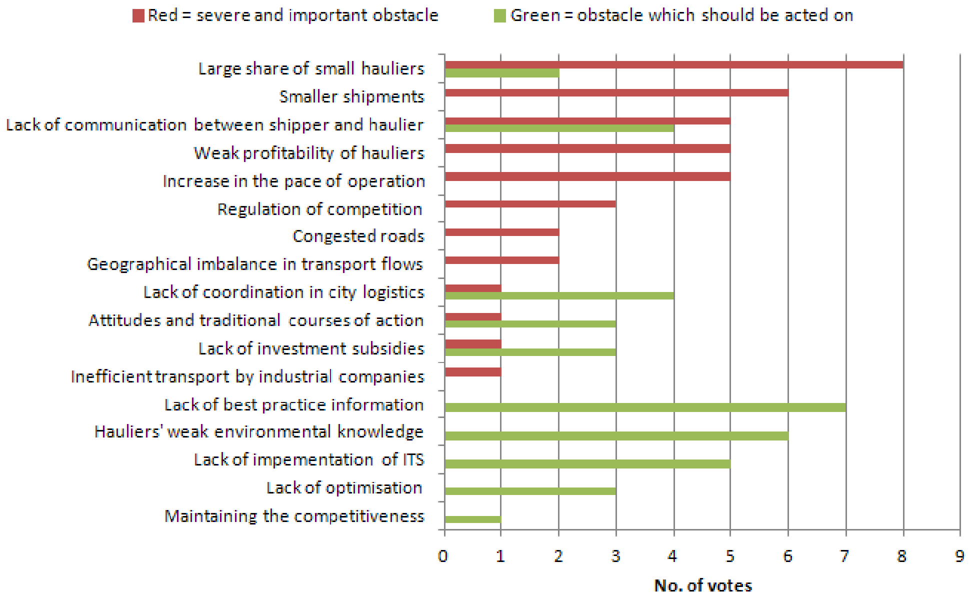

Figure 1. Votes on the obstacles

Some of the obstacles were rather similar or relate to a larger problem area, so the obstacles were grouped into the following seven problem areas.

- Hauliers' lack of environmental knowledge and best practices (1 red, 19 green votes)

    - lack of optimisation
    - hauliers' weak environmental knowledge
    - lack of best practice information
    - attitudes and traditional course of action
- Lack of coordination in city logistics (1 red, 4 green votes)
- Lack of implementation of ITS (0 red, 5 green votes)
- Financial problems (14 red, 6 green votes)
    - large share of small hauliers
    - weak profitability of hauliers
    - lack of investment subsidies
    - maintaining the competitiveness
- Infrastructure and geography (4 red, 0 green votes)
    - geographical imbalance of transport flows
    - congested roads
- Shippers' lack of environmental consideration (12 red, 0 green votes)
    - inefficient transport by industrial companies
    - increase in the pace of operation
    - smaller shipments
- Lack of communication between shipper and haulier (5 red, 4 green votes)

It seems clear according to the votes that shippers' lack of environmental consideration and financial problems that are related to the small average size of hauliers are the most severe obstacles for improving the energy efficiency and reducing the carbon dioxide emissions of road freight operations. These obstacles also seem to be difficult to act on. Measures to address the hauliers' lack of environmental knowledge and best practices, on the other hand, seem easy to be found, but these obstacles are not seen very severe. These problem areas identified in the first workshop formed the basis for identifying various measures to overcome these obstacles in the second workshop.

4. SECOND WORKSHOP - IDENTIFYING ENERGY EFFICIENCY MEASURES

In the second workshop the experts were given papers showing the eight problem areas identified in the first workshop. The experts were then asked to consider the problem areas by themselves and suggest measures which could be taken to overcome the obstacles. Also the potential effects, possible difficulties, costs, benefits and responsible organizations were asked to be evaluated of each measure. However, the experts did not have enough time to evaluate these details accurately, so they indicated mainly just the responsible organisations. After the individual consideration the measures were discussed in small groups and then openly with all attendees. Finally the measures were listed on flip charts and each expert was given five stickers. The experts were asked to indicate the most important measures with the stickers and divide the stickers to at least three measures.

There were three measures suggested to overcome the hauliers' lack of environmental knowledge and best practices:

- collecting and sharing benchmarking data (3 votes)
- education about various energy efficiency measures and their costs and benefits (3 votes)
- active communication about the energy efficiency measures to the hauliers (2 votes).

Measures to improve the efficiency of city logistics were seen important in the voting:

- development of collaborative consolidation centres for urban distribution (4 votes)
- use of environmentally friendly vehicles (2 votes)
- optimisation of routing (1 vote)
- consolidation of the material flows of municipalities (1 vote)

Road freight transport is seen to gradually implement more and more intelligent transport systems and services (ITS). However, this development could and should be accelerated:

- electronic consignments should be promoted (3 votes)
- information management should be developed to fully utilise the data (1 vote)

Financial problems, especially among small hauliers, were seen in the first workshop as severe obstacle for improving energy efficiency. These problems could be addressed by:

- investment grants, loans or tax subsidies for hauliers (4 votes)
- information and education for hauliers to make investment appraisals (2 votes)

Geographical imbalance of goods flows and congested roads were identified in the first workshop as obstacles for improving the energy efficiency. However, no measures for changing the geographical imbalance were considered viable in the second workshop. Congestion on the other hand was seen to be a minor problem in Finland and only affects the main roads around the capital city Helsinki during the rush hours. Reducing the car traffic on these roads was seen important (2 votes). This could be done by implementing congestion charges in Helsinki. Another way to avoid congestion is to increase off-peak and night time deliveries in the congested areas (0 votes).

Shippers' lack of environmental consideration in their logistics was seen in the first workshop as a very severe problem area but also very hard to act on. The same was highlighted in the second workshop. Energy efficiency criteria should be used when the state or municipalities purchase freight transport services (4 votes). Other measures suggested in the workshop included:

- awareness campaign for consumers (0 votes)
- promoting carbon labelling (0 votes)
- developing online freight exchange services (0 votes)
- regional consolidation centres and agreements of cooperation (0 votes)

The final problem area identified in the first workshop was the lack of communication between the shipper and the haulier. Lack of communication about environmental issues may well be due to the fact that there is lack of knowledge on both sides. The experts in the second workshop saw that the large logistics service providers play an important role in raising the awareness about the environmental issues of logistics (3 votes). It was also suggested that new forums of cooperation should be established to bring together shippers and hauliers to discuss environmental issues (0 votes).

5. THIRD WORKSHOP - ENERGY EFFICIENCY ACTION PLAN

Findings from the two workshops and also other parts of the research were used to write a draft of an action plan for improving the energy efficiency and reducing the CO_2 emissions of road freight transport in Finland in 2012-2016. This draft was sent to the attendees of the third workshop one week before the event. The draft was discussed upon in the workshop and each proposal was dealt with an open discussion. Based on the comments from the experts in the third workshop the action plan was finalised and is presented here. The action plan is organised to address three problem areas with seven action packages.

5.1 Improving the energy efficiency agreement

Action package 1: Marketing the energy efficiency agreement for freight transport and logistics and related communication and education activities

A marketing plan should be developed for the energy efficiency agreement for freight transport and logistics. Necessary resources should also be reserved for marketing to ensure that the agreement is promoted in all important events of the transport sector. In addition to the events, marketing should be done via theme issues and regular articles in trade press. Further publicity would be attracted in the marketing events by granting a

"Freight energy efficiency innovation" prize to a haulier who has been highly successful in implementing energy efficiency actions.

The national energy efficiency monitoring system, PIHI, provides a good platform for developing useful tools for the companies who participate in the energy efficiency agreement and thus use the PIHI-system. One tool which should be developed is an application which allows the hauliers to estimate the costs and effects of energy efficiency actions with their existing fleet. PIHI-system should also be developed to contain practical guides and best practice case studies similarly to the British Freight Best Practice programme. FBP was very successful in providing useful information to hauliers and helped them to save fuel (AECOM 2010; Databuild 2007).

Education of energy efficiency should be developed into a one-day course which could be included in the periodic driver training. The course should include not only ecodriving, but also other aspects of saving fuel. Advice on measuring the transport performance and fuel consumption as well as calculating the carbon footprint of transport operations should also be an important part of the course.

Action package 2: Producing and communicating benchmarking information

Information on the energy efficiency and carbon dioxide emissions of road freight transport should be produced and communicated in a more systematic manner than it currently is. This information should also be made available for the hauliers via PIHI-system so that hauliers can benchmark their performance against sectoral averages. Branch-level information should also be communicated to the shippers who participate in the sectoral energy efficiency agreements so that they can evaluate the performance of their hauliers. Sectoral Transport Key Performance Indicator studies should also be done in Finland similarly to the ones done in Britain (McKinnon 2009). These studies would give more detailed sectoral benchmarking information than the analysis based on the Good Transport by Road Statistics (GTRS). A question about fuel consumption should also be included in the GTRS questionnaire. The hauliers could indicate the actual fuel consumption of each trip that they report or they could give an estimate on the total fuel consumption during the survey dates or the average fuel consumption of the lorry.

Action package 3: Investment grant for hauliers

Many energy efficiency actions require investments that the small hauliers cannot make. An investment grant scheme should be developed to help hauliers make these investments. Investment grants should only be available for hauliers who participate in the energy efficiency agreement. These hauliers could get free energy efficiency audit and then apply for grants to invest in new vehicles or improvements of the existing vehicles and also to implement ITS. Research is necessary in order to determine which actions are eligible for the grant. Manufacturers of vehicles, parts and add-ons should give their product to be tested by an independent research institution which verifies the effects of the energy efficiency action. Investment grants may only be given to verified actions and only verified actions could be advertised in the PIHI-system.

5.2 Energy efficiency in purchasing transport services

Action package 4: Including energy efficiency criteria in the transport service purchases by state and municipalities

State and municipalities should require certain minimum level of energy efficiency from the hauliers when purchasing transport services. For example, the haulier must participate in the energy efficiency agreement and must be able to verify it by showing the energy efficiency certificate which can be printed from the PIHI-system. State and municipalities should also ask what energy efficiency actions the hauliers have implemented and prefer active hauliers. Monitoring the level of energy efficiency of the operations is also important. Government agencies should give guidance on how these issues should be done. Municipalities have their own energy efficiency agreements and the energy efficiency of purchased transport services should be mentioned in this agreement.

Action package 5: Including energy efficiency information into the sectoral energy efficiency agreements

In addition to the energy efficiency agreements for transport and municipalities, there are also agreements for industry, energy sector, private service sector, property and building sector, oil sector and farms (Motiva 2012). Guidance on how to take the energy efficiency into consideration when purchasing transport services should be included in the energy efficiency agreements of all these sectors. Similarly to the public procurement the shippers should require that the haulier is participating in the energy efficiency agreement and verifies this with the energy efficiency certificate. Shippers should also require continuous reporting of the energy efficiency of the transport operations they purchase. PIHI-system could be developed to enable the shippers to see the sectoral benchmarking information so that they could evaluate the energy efficiency of their logistics service provider.

Action package 6: Improving the communication between shippers and hauliers

Communication and cooperation between the shippers and hauliers is vital for improving energy efficiency and reducing CO_2 emissions. Company-level communication with a common goal of improving the efficiency and reducing the costs of road freight operations is the most important form of communication. The largest logistics service providers have a key role in improving the communication, because they can influence the shippers and their sub-contract hauliers. It is difficult to affect the company-level communication through policy measures. However, policy measures can encourage companies to this kind of communication by facilitating with the trade associations forums for communication. There is an example of successful cooperation and communication forum in Sweden where the Network for Transport and the Environment (NTM 2012) brings together the shippers, logistics service providers, researchers and government agencies. NTM has also done excellent work in developing calculation methods of the environmental effects of transport services. Such a forum could be developed in Finland as well.

5.3 City logistics

Action package 7: Improving the city logistics

The largest cities should consolidate their own freight movements and thus show an example to other actors. Cities may control their logistics on their own or they may outsource it to a logistics service provider, as e.g. Stockholm has done with good results (Schencker 2006). The cities can also promote consolidation of companies’ freight movements in urban areas by establishing a consolidation forum. The key members of such forum are the large logistics service providers, retailers, hotels and restaurants. Cities can also perform survey to determine the freight transport demand and opportunities for consolidation. Based on this survey the city can encourage the companies to cooperate and consolidate their freight. Cities can also encourage hauliers to use environmentally friendlier vehicles by using low emission zones or by decreasing parking fees or congestion charges. Future city logistics can be planned in advance by requiring a delivery and servicing plan (DSP) for new buildings as has been done in London. London is also a good example of how the construction logistics can be organised with construction logistics plans (CLP) and a consolidation centre (TfL 2011).

6. CONCLUSIONS

Three major problem areas were identified in the workshops: (1) lack of knowledge and best practices of energy efficiency within logistics service providers, (2) inadequate environmental consideration by industry and trade in purchasing logistics services and (3) lack of coordination of urban logistics. In order to overcome these issues, seven action packages are proposed and their benefits, challenges and responsibilities were analysed. There is an on-going initiative to promote energy efficiency through sectoral energy efficiency agreements in Finland and many proposed actions aim to improve these agreements. International best practices were also used in the action plan. In the proposed action plan cooperation and division of responsibilities between various stakeholders of the road freight sector are emphasized.

The study showed that the multi-stakeholder workshops are a practical tool for identifying the obstacles and measures for improving the energy efficiency and reducing the CO_2 emissions of road freight transport. The workshops provided an excellent forum for discussion between various stakeholders of the road freight sector. Workshops summoned the key actors and thus enabled networking and sharing of knowledge. Active involvement in the process also enabled a deep commitment to the resulting national energy efficiency action plan.

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REVENUE MANAGEMENT FOR MULTIPLE PRODUCT RECOVERY OPTIONS IN THE MOBILE PHONE RECYCLING INDUSTRY: A SIMULATION MODEL

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ABSTRACT

Pricing and revenue management is one of the most critical themes of quantitative models for reverse logistics since this subject is a niche research area and the fifth phase (prices and markets) of the evolution of closed loop supply chain research. Hence, this paper aims to formulate a simulation model to investigate the revenue management impact of a multiple recovery options system affected by the model's parameters and the results from a questionnaire survey. The triangulation approach, more specifically the multilevel model is employed to achieve the research objective. Namely, this study uses mixed research methods combining a case study in the recycled mobile phone sector, a questionnaire survey, and a simulation model as research strategy. This research work based on the use of the proposed simulation model covers some of the previous research gaps as follows: multiple recovery options operations, multiple periods, the element of uncertainty in terms of return quantity and reprocessing time and product substitution policy. The results of this paper have a direct contribution to support current pricing and revenue management research but more importantly, the results from the models have potential to support decision making in the recovery operations and reverse logistics sector to the industry.

1. INTRODUCTION

In today's competitive world, many firms in various sectors might not be able to sustain their competitive advantage or even stay in business if they do not have appropriate value-added recovery systems and make profitability from returns due to the large volumes of reverse logistics activities. For example, in the UK the return of goods in the retail sector amounted an average of £ 5.75 billion (Bernon & Cullen, 2007). Customer returns incur acquisition costs and take-back operations costs that are considered as a sunk cost by many companies. In addition, due to take-back legislations, in the European Union (EU) and a demonstration of corporate citizenship, firms have been encountering a variety of return types from customers such as B2C commercial returns, warranty returns, service returns, end-of-use returns, and end-of-life returns (De Brito and Dekker, 2004). On the other hand, pricing and revenue management have become a crucial issue concerning profitability for several recovery players who consider returns as potential profit source. Particularly, in the mobile phone recycling industry, various companies have made a decision to enter the end-of-use or end-of-life mobile phone recycling business since they can make a profit from a recovery mobile phone. Souza (2009) highlighted that the volume of the current global market for recovered mobile phones is $240 million.

Hence, this research work investigates pricing and revenue management in reverse logistics, particularly with regard to multiple recovery options. This subject is considered as one of the most critical themes of quantitative models for reverse logistics, since such issues are considered as a niche research area and the fifth phase (prices and markets) of the evolution of closed loop supply chain research (Guide Jr. and Van Wassenhove, 2009). Moreover, Mitra (2007) and Sasikumara and Kannan (2008) argued that there is a need for more investigation on pricing and revenue management in reverse logistics since it has not been extensively addressed in the academic literature to date. The remainder sections of this paper cover: literature review, the research methodology, simulation model, result and sensitive analysis and conclusions.

2. LITERATURE REVIEW

Guide Jr. and Van Wassenhove (2001) proposed a framework for economic value analysis of the potential profitability of product recovery based on product acquisition management. Moreover, authors also classified types of product recovery system for acquiring used product from end users for reuse into two major systems: the waste stream system and the market-driven system. Based on the framework presented by Guide Jr. and Van Wassenhove (2001), nine articles were found related to research in pricing and revenue management for recovered products during the period 2003-2009 (Guide Jr. et al., 2003; Bakal and Akcali, 2006; Vorasayan and Ryan, 2006; Mitra, 2007; Qu and Williams, 2008; Chanintrakul et al., 2009a & 2009b; Liang et al., 2009; and Xiang et al., 2009). These papers proposed a number of pricing models applied in different industrial and product sectors such as recovery of mobile phones (Guide Jr. et al., 2003; Mitra, 2007; Chanintrakul et al., 2009b), remanufactured parts of the end-of-life vehicles (ELVs) (Bakal and Akcali, 2006; Qu and Williams, 2008), and recovery of personal computers (Vorasayan and Ryan, 2006; Chanintrakul et al., 2009a).

By evaluating these pricing models, that a variety of model types were proposed such as an econometric model (Guide Jr. et al., 2003), a stochastic model (Bakal and Akcali, 2006; Liang et al., 2009), a queueing network model (Vorasayan and Ryan, 2006), a nonlinear programming model (Mitra, 2007; Qu and Williams, 2008; Chanintrakul et al., 2009a & 2009b), and a stochastic dynamic programming model (Xiang et al., 2009). Nearly all of the proposed models (Guide Jr. et al., 2003; Bakal and Akcali, 2006; Mitra, 2007; Qu and Williams, 2008; Chanintrakul et al., 2009b; Liang et al., 2009; Xiang et al., 2009) apply to the market-driven system. Moreover, most of the papers (Guide Jr. et al., 2003; Bakal and Akcali, 2006; Vorasayan and Ryan, 2006; Mitra, 2007; Chanintrakul et al., 2009a & 2009b; Xiang et al., 2009) incorporated a single time period into their models. Significantly, only Mitra (2007) and Chanintrakul et al. (2009a) took capacity limitation into account, and none of the papers considered product life cycle issues. In terms of objective function, all papers utilised profit maximization as a single objective.

Moreover, only three articles addressed the element of uncertainty i.e. recovery yield uncertainty (Bakal and Akcali, 2006), selling price uncertainty (Liang et al., 2009), and recovery yield uncertainty and demand uncertainty (Xiang et al., 2009). On the topic of reverse logistics frameworks, Thierry et al. (1995) and De Brito and Dekker (2004) argued that there are two main types of recovery depending on quality of returned items: direct recovery (i.e. reuse, resale, and redistribution) and reprocessing recovery (i.e. repair, refurbishing, remanufacturing, retrieval/cannibalisation, recycling, and incineration). Furthermore, multiple recovery options of returned items have been used in real world situations, particularly in the electrical and electronic equipment industry (Thierry et al., 1995; Fleischmann et al., 2004; Bloemhof-Ruwaard et al., 2004; Bernon and Cullen, 2007). In light of the recovery issue, most papers explored only one recovery option (Vorasayan and Ryan, 2006; Guide Jr. et al., 2003; Liang et al., 2009; and Xiang et al., 2009; Qu and Williams, 2008) or two recovery options (Bakal and Akcali, 2006; Mitra, 2007). Only Chanintrakul et al. (2009a and 2009b) addressed multiple recovery options.

After reviewing the academic literature on pricing and revenue management research in the field of reverse logistics, it has been decided that the setting of this research work is different from the setting of the previous studies in the following considerations: first, most of the proposed models considered only one recovery option or two recovery options. On the other hand, this paper investigates multiple recovery options operations (i.e. direct resale, repair, refurbishment and recycling), which are employed in the mobile phone recycling industry. Second, in the previous research, the element of uncertainty including recovery yield uncertainty, selling price uncertainty, and recovery yield uncertainty and demand uncertainty were considered. On the other hand, this study involves the element of uncertainty in terms of return quantity and reprocessing time by assuming return rate is exponentially distributed, and reprocessing time is normally distributed. Third, most of the articles proposed models with a single time period while this research work considers multiple time periods. Fourth, none of the proposed models considered a product substitution policy whereas in this simulation model, this policy is taken into account as one of the most important assumptions.

3. RESEARCH METHODOLOGY

The methodology employed in this research work is the triangulation approach, more specifically the multilevel model adopted from Creswell and Plano Clark (2007). In other words, this study uses the mixed research methods comprising of case study, questionnaire survey, and simulation model. This research begins at level one collecting data from the case study subject that is a top European mobile phone recycling corporation. Next, at level two, the questionnaire survey is developed from the case study. Finally, at level three, required data collected from two sources including the results from the case study are employed to formulate the simulation model and the outputs from the questionnaire survey are used to carry out 'what-if' assessments.

3.1 Case Study

BBC News (2010) reported that the estimated number of discarded mobile phones is 85 million phones across the UK. Moreover, the survey results of 853 people indicated that 68% of the samples had kept one or more old phones that they did not use. Government-backed Consumer Focus mentioned that these handsets could be sold, recycled or sent to charity. Hence, currently, there are dozens of online mobile phone recycling companies take this opportunity to make a profit from the unwanted phones by offering cash for old handsets to owners (BBC News, 2012). The company participating in this study was founded in England in 2001 by a group of experienced professionals. Since the beginning of 2002, the firm has become one of the top European mobile phone recycling corporations and has expanded its operations from the UK into Continental Europe. Moreover, the company also has cooperation agreements with leading national and international partners. Currently, the mobile phone recycling firm recovers more than one million mobile phones comprising between 3,000 to 5,000 models each year.

The company's end-of-use mobile phone recovery procedures are as follows; firstly, the company collects old mobile phones from its suppliers. Next, the mobile phones are graded, sorted, and tested and the firm classifies them in terms of their quality and age. Next, there are multiple recovery options operations. The firm sends them for direct recovery (direct resell) or process recovery (repair, refurbishment, and recycling) depending on the items' quality. Finally, the firm redistributes and resells them to a secondary market. However, the company operates these reverse logistics activities either in-house or/and by utilizing a third party. Figure 1 demonstrates the recovery process of the firm. Focusing on suppliers, the business has collected used handsets from a variety of suppliers and from several countries throughout Europe such as the UK, the Netherlands, and Germany. Regarding to suppliers' categories, the company classifies its suppliers into two main groups: the offline suppliers (including business partners, charity partners and small and medium enterprises) and the online suppliers (end users). The firm offers higher acquisition prices with an incentive for the off-line suppliers. In terms of collection procedure, the firm has employed two primary schemes to collect used mobile phones from its suppliers as follows; the first method is that end users send old mobile phones directly to the company via freepost envelope and the second method is that the company will arrange a courier to collect a bulk of old mobile phones from the suppliers.

In terms of classification of the received mobile phones, the phones are graded, sorted, and tested by a technician. The phones are classified into three main technology classes;

high-end, mid-range, and low-end and into four main quality classes; A+, A, B, and R. After that, the company recovers these mobile phones by utilising four recovery options as follows; direct resell for A+ grade mobile phones (functional phones), repair and refurbishment for A grade and B grade mobile phones (non-functional phones), and recycling for R-grade mobile phones. After the recovery process, the firm ships the recovered handsets to secondary markets fortnightly because acquisition prices of old mobile phones and selling prices of recovered mobile phones fluctuate considerably. The major secondary market of the firm is represented by developing nations, especially in Asia, Africa, and Eastern Europe since people in these countries cannot afford new-technology mobile phones.

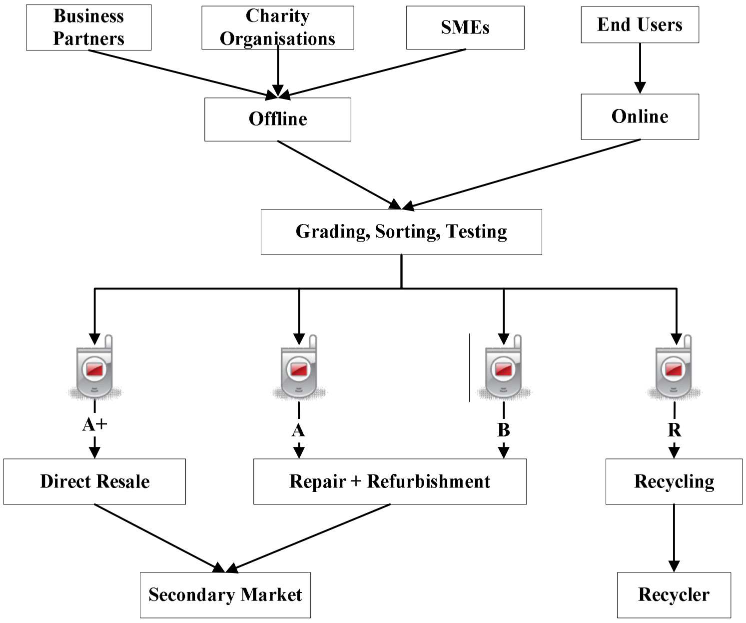

Figure 1: The recovery process of the firm

3.2 Questionnaire Survey

The questionnaire survey is developed from the handset recycling business in order to look for behaviours and opinions of respondents with regard to this industry. Students and staff from a university located in northeast England were considered as 'the population' in this research due to budget restrictions, time constraints, and more-quickly-available results. Furthermore, the results from an annual survey conducted by Endsleigh Insurance of 1,000 students and young people about to start university reported that of their most important possessions the top three items were laptops, mobile phones, and clothes (BBC News, 2008). Hence, students and staff at the University were taken as 'the population' in this research. The current figure of the total population of the university surveyed is approximately 22,500. Based on the formula proposed by De Vaus (1996), the actual sample size should be 378 cases at the 95% confidence level. This research used the delivery and collection questionnaire technique as the questionnaire administration method. The total number of possible respondents was 500 and the response rate of this study was 84.00%. Two main statistics techniques have been used in this research including descriptive statistics and one-way ANOVA technique. The data analysis outputs include the frequency with which a mobile phone is changed, respondents' mobile phone types, things that people did with their old handsets, and the selling price ranges of old mobile phones. More importantly, it was found that the business should use new strategy implementation: a higher offer price as an order-winner with which to persuade potential customers to trade-in their old phones to its website.

4. SIMULATION MODEL

4.1 Model’s assumptions

This section provides the assumptions for the model which are listed below:

- There is no misclassification that leads to defect.
- Yields of all reprocessed products are perfect.
- There is a limit to recovery capacity due to recovery processing time.
- No fixed costs, no travel time and monopoly market.
- The demands of direct resold mobile phones and repaired and refurbished mobile phones are dependent because the company sells the recovered mobile phones at the same price, and there is not much difference in their quality.
- The model is for a multi-period time scale and is not dependent on the product life cycle.
- All received mobile phones have the same handling costs.
- The characteristics of workstations of each recovery type are identical.
- Return rates are exponentially distributed, and repair and refurbishing processing time is normally distributed.
- Due to the ease of traceability, this study assumes that the reprocessing layout is cellular manufacturing.

4.2 Model formulation

This research work uses the SIMUL8 simulation software package to formulate the simulation model. Model construction is in accordance with the recovery process of the firm presented in Figure 1 and the model is illustrated in Figure 2. The performance measurement of the system is the total profit as shown in equation 1.

Total profit = Income − Acquisition Cost − Handling Costs − Recovery Cost − Transportation cost Eq. (1)

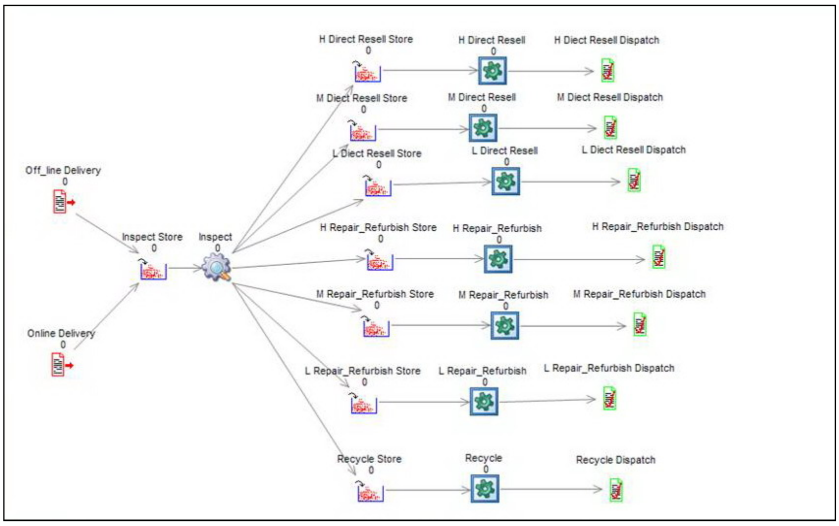

Figure 2: The simulation model

5. RESULT AND SENSITIVE ANAYLYSIS

The return rate of received mobile phones from each reverse channel, all the reprocessing time and other parameters are estimated, based on the data from the structured interview, since the firm could not provide all required data for the analysis due to commercial reasons. This model performs on a fortnightly basis. The result based on the number of received mobile phones from both channels shows that the recommended number of runs is seven using a confidence interval of 95%. The study used five random number sets to deal with more uncertainty. The initial outputs of the model are presented in Table 1. The outputs show that the total profit is £305,050.98.

Next, the sensitive analysis is conducted. This analysis includes six scenarios as follows: labour cost changes, recovering time changes, selling price changes, recovery efficiency changes, percentage changes of mobile phone types and new strategy implementation: higher offer price. The first, second, third, and fourth scenarios are affected by the model's parameters; on the other hand, the fifth and sixth scenarios are based on the results from the questionnaire survey.

Simulation Object		**Output**
Off-line Delivery	unit	63,572.43
Online Delivery	unit	20,956.00
Inspect	unit	83,557.29
H Direct Resale Dispatch	unit	5,655.43
M Direct Resale Dispatch	unit	13,148.57
L Direct Resale Dispatch	unit	18,858.86
H Repair and Refurbish Dispatch	unit	2,661.00
M Repair and Refurbish Dispatch	unit	6,668.00
L Repair and Refurbish Dispatch	unit	9,339.14
Recycle Dispatch	unit	12,535.71
Simulation Total	Total Costs (£)	962,449.74
Simulation Total	Total Revenue (£)	1,267,500.71
Simulation Total	Total Profit (£)	305,050.98

Table 1: The initial outputs of the simulation model

5.1 Labour cost changes

It has been decided to alter the labour cost in order to forecast possible fluctuations and impacts on profit. Based on the results of the experiment, when decreasing the cost by £1 and when increasing the cost by £1 and £2, it is found the total profit has increased by 5.41%, decreased by 5.41%, and decreased by 10.81%, respectively, compared with the outputs from Table 1.

5.2 Recovering time changes

During analysis, changes were introduced to the inspecting time and the repairing and refurbishing time. Hence, the outputs indicated that the repairing and refurbishing time changes have more impact on the total profit than the inspecting time changes have. For example, when decreasing the repairing and refurbishing time by 10 %, normally distributed with mean of 0.27 hour and standard deviation of 0.068, it is found that the total profit has increased by 13.12 % compared with the results from Table 1.

5.3 Selling price changes

To allow the measurement of the impact on profit margins, it was decided to alter the selling prices of high-end, mid-range, and low-end mobile phones by decreasing the prices by 10% and by increasing the prices by 10% and 20%. It is found that the selling price changes of high-end handsets have the most significant influence on the total profit. This implies that the firm has to apply caution when making the decision to alter the selling prices of high-end handsets.

5.4 Recovery efficiency changes

This experiment introduced changes to the recovery efficiency of the inspecting workstations and the repairing and refurbishing workstations. It was assumed that the recovery efficiency is 95% and 90%. The outputs shows that the recovery efficiency changes of the repairing and refurbishing work centres have more influence on the total profit than the recovery efficiency changes of the inspecting work centres have. This means that the recycling firm has to take the recovery efficiency of the repairing and refurbishing workstations into account when forecasting and calculating costs.

5.5 Percentage changes of mobile phone types

When analysing the results from the questionnaire survey, it is found that the current percentage of used high-end, mid-range and low-end mobile phone types are 27.68, 57.28 and 15.04 %, respectively. Hence, these figures are used as potential received handset types to carry out 'what-if' assessments in this study. The results show that the total profit has increased by 11.42 % compared with the outputs from Table 1. Therefore, it is suggested that the company needs to adjust the number of repairing and refurbishing work centres as required by the new proportion of handset classes.

5.6 New strategy implementation: higher offer price

According to the results from the questionnaire survey, the 'what-if' assessments are carried out in order to investigate how this strategy would impact on the firm's total profit. It is decided to increase the offer prices of mid-range and high-end handsets (A and B grade handsets) which need to be repaired and refurbished because the offer prices of these mobile phone types are very low and the firm has high profit margin from these handset classes. When increasing the offer prices, it is assumed that the number of received mobile phones will increase; as a result, there is a need to increase the number of repairing and refurbishing workstations. The outputs from three scenarios have a positively significant impact on the total profit.

6. CONCLUSIONS

This paper presents a simulation model in order to cope with the element of uncertainty in terms of return quantity and reprocessing time. These simulation models are formulated based on the real case study of the mobile recycling business. The objective of this model is to investigate the revenue management impact of multiple recovery options systems affected by the model's parameters and the results from the questionnaire survey. The sensitive analysis conducted by carrying out "what-if" assessments includes six scenarios i.e. labour cost changes, recovering time changes, selling price changes, recovery efficiency changes, percentage changes of mobile phone types and new strategy implementation: higher offer price.

Furthermore, the review of the academic literature presents that the previous studies have paid little attention to this research area since there are only a limited number of papers exploring pricing and marketing decision of recovered products. Hence, the results of the research contribute to support current pricing and revenue management research and also future researchers will be able to expand these models. More importantly, the simulation model and its outputs would provide relevant decision-making support for the recycled handset sector. Limitations of this paper are related to data availability that the simulation model and the parameters are formulated and estimated from the structured interviews and limited secondary data. Moreover, the model uses only one performance measurement that is total profit. In addition, this study does not take the separating distance between facilities into account (there is no travel time) and considers only in-house, on-shore operations. Furthermore, the model only takes the element of uncertainty in terms of return quantity and reprocessing time into account using a cell layout. Thus, future studies that use simulation models should consider travel time, the integration of profitability and sustainability (by using the performance measurement of total profit and carbon footprint) and further investigate the element of uncertainty in terms of return, demand, recovery yield, reprocessing time, or/and selling price, onshore versus offshore outsourcing decisions, and other manufacturing layouts.

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A MULTI-OBJECTIVE APPROACH TO SUPPLY CHAIN VISIBILITY AND RISK

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ABSTRACT

This paper investigates the twin effects of supply chain visibility (SCV) and supply chain risk (SCR) on supply chain performance, using a fuzzy multi-objective decision making (FMODM) approach to model SCV and SCR from a strategic perspective. The FMODM model incorporates three objectives, namely, SCV maximization, SCR minimization, and cost minimization under the constraints of budgeting, customer demand, production capacity, and supply availability. This initial study of SCV and SCR on supply chain performance can be employed to fine-tune supply chain design in which risk and visibility are becoming important levers to help manage the appropriate supply chain performance. A numerical example is used to demonstrate the applicability of the model. Our results suggest that decision makers are prone to mitigating SCR first rather than enhance SCV.

Keywords: Supply chain visibility, Supply chain risk, Multi-objective decision making

Introduction

The recent flooding in Thailand and the March 11 earthquake, tsunami and nuclear reactor crises in Japan affected two global supply chains – electronics and automotive. Asia is already a major contributor to these supply chains with many manufacturers, contractors and supply bases located in many countries in this part of the world. More than 7000 parts suppliers service the automotive industry of the top ten vehicle manufacturers alone. Japan is a source of key electronic and automotive components and feeds the global supply chain, from supply locations such as China, Vietnam, Thailand, and India to destinations in North America (Rajasekera 2011). Nearly every firm making any of the most demanding consumer products needs Japanese components because of its intrinsic product quality and technological edge. The disruption caused by the March 11 event has been felt in these industries, especially when the impact on the supply chain of these two industries is exacerbated by the recent flooding in Thailand. The role of the parts supplies in Japan and Thailand is critical for the global supply chain of large vehicle manufacturers such as Toyota who for instance is served by a significant tier one supplier Denso (which supplies 50% of its production to Toyota), who in turn is served by Marcon Denso, a tier two single source supplier who for cost reasons draws its labour force from the cheaper rural areas in Japan near where the tsunami struck. Already, Krebs (2011) reports on the impact of the risk of a delay of a Marcon Denso part to Toyota, who recently reported a decline of 77% in earnings. Indeed, most of the smaller suppliers to Japanese automotive and electronic suppliers are single source. The risk of their production being affected by natural or unnatural disasters, will lead to undesired postponed shipments resulting in the already evident disruptions of downstream companies in the global supply chain (Jüttner, 2005).

No doubt, the unforeseen natural disasters mentioned earlier have caused disruptions in the global supply chain, leading to undesired results or consequences (Harland et al., 2003). Zsidisin (2002) defines this form of 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.

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As mentioned, events affecting one supply chain entity or process will interrupt the operations of other supply chain members either directly or indirectly and in more ways than one. Supply chain disruptions have become a critical issue for many companies. In the literature, Zsidisin (2002) has 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 the research on the sources of potential supply risk is also provided by Zsidisin (2003) and Zhang et al. (2010b). From the literature, it becomes apparent that a main consideration in supply chain risk (SCR) management is the visibility of the risk. For instance, visibility in the supply chain can yield benefits in operations efficiency (e.g. Smaros et al. 2003) and more effective supply chain planning (Petersen et al., 2005). While we acknowledge that SCR is wide ranging, we limit our scope of SCR in this paper to supply risk given the recent development of events in this area.

Separately, Harland et al. (2003) report that in the supply chains examined, less than half of the risk is visible to the focal firm. Thus, a key question arising from these two Asian experiences and the extant literature that begs an answer is how to choose the parts supplier so as to minimize the supply risk / disruption due to the supply chain and how to invoke as high a visibility as possible without exceeding the production or total budget.

Indeed, the study of supply chain visibility (SCV) has drawn much recent interest from both researchers and practitioners in supply chain management (Barlett et al., 2007). According to Enslow (2006), about 79% of the large companies surveyed globally cited the lack of SCV as their top concern. Further, 90% of the responding supply chains asserted that their existing supply chain technology is incapable of providing timely information to prepare budget and cash flow plans for the finance department. In spite of its emerging importance, SCV has been defined by various authors without a consensus definition. Goh et al. (2009) have defined SCV as "the capability of a supply chain actor 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". While some work on visibility has been undertaken, this area is still nascent (see e.g. Smaros et al., 2003). Zhang et al. (2010a) have also reported that global logistics operators clearly seemed to benefit from the visibility of the end-to-end supply chain. Thus, there is a need to better understand the joint issues of risk and visibility particularly in the context of multiple objectives. As such, it warrants further study, especially when combined with other aspects of supply chain management such as risk, complexity, or disruptions.

This paper makes the following contribution. We consider specifically in the context of a selection of a parts supplier who has to meet a tri-objective of cost, risk and visibility for the downstream supply chain. This problem is new to the field and is practical in the light of the recent spate of events affecting the automotive and electronics supply chains globally.

Model Development for SCV and SCR

A mathematical model is developed incorporating SCV and SCR so that the appropriate suppliers can be identified. The model includes three objectives of visibility maximization, risk minimization, and cost minimization. The model formulation is described as follows.

Index sets:

i: Index of parts

j: Index of suppliers

Decision Variables:

Q_{ij} : Quantity of part *i* provided by supplier *j*.

$$Y_{ij} = \begin{cases} 1 & \text{if part } i \text{ is supplied by supplier } j \\ 0 & \text{otherwise} \end{cases}$$

Parameters:

B_i : Budget available to enhance SCV for part *i*.

C_j : Production capacity of supplier *j*.

CR_{ij} : Cost of reducing supply risk for part *i* from supplier *j*.

CV_{ij} : Cost of enhancing SCV to current level for part *i* from supplier *j*.

D_i : Demand for part *i*.

m_{ij} : Minimum order quantity for part *i* required by supplier *j*.

P_{ij} : Purchase price for part *i* supplied by supplier *j*.

IR_{ij} : Impact (financial loss) caused by supply risk for part *i* from supplier *j*.

R_{ij} : Supply risk for part *i* from supplier *j*.

R_i : Maximum allowable supply risk for part *i*.

V_{ij} : Supply chain visibility incurred if part *i* is supplied by supplier *j*.

V_i : Minimum amount of visibility needed for part *i*.

Model:

$$\text{Max visibility} = \sum_i \sum_j V_{ij} Y_{ij} \qquad (1)$$

$$\text{Min risk} = \sum_i \sum_j R_{ij} Y_{ij} \qquad (2)$$

$$\text{Min cost} = \sum_i \sum_j V_{ij} CV_{ij} Y_{ij} + \sum_i \sum_j R_{ij} CR_{ij} Y_{ij} + \sum_i \sum_j IR_{ij} Y_{ij} + \sum_i \sum_j P_{ij} Q_{ij} \qquad (3)$$

Subject to:

$$\sum_j V_{ij} CV_{ij} \leq B_i \qquad \text{for each } i \qquad (4)$$

$$\sum_j V_{ij} Y_{ij} \geq V_i \qquad \text{for each } i \qquad (5)$$

$$\sum_j Q_{ij} = D_i \qquad \text{for each } i \qquad (6)$$

$$\sum_i Q_{ij} \leq C_j Y_{ij} \qquad \text{for each } j \qquad (7)$$

$$\sum_j R_{ij} Y_{ij} \leq R_i \qquad \text{for each } i \qquad (8)$$

$$Q_{ij} \geq m_{ij} Y_{ij} \qquad \text{for each } i, j \qquad (9)$$

$$Q_{ij} \leq N Y_{ij} \qquad \text{for each } i, j \qquad (10)$$

Since the information regarding the vendor selection problem is fuzzy in nature, the original model is transformed to an FMOP model. 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.

$$\text{Max visibility } Z_1(x) \cong \sum_i \sum_j \tilde{V}_{ij} Y_{ij} \qquad (11)$$

$$\text{Min risk } Z_3(x) \cong \sum_i \sum_j \tilde{R}_{ij} Y_{ij} \qquad (12)$$

$$\text{Min cost } Z_2(x) \cong \sum_i \sum_j \tilde{V}_{ij} CV_{ij} Y_{ij} + \sum_i \sum_j \tilde{R}_{ij} CR_{ij} Y_{ij} + \sum_i \sum_j IR_{ij} Y_{ij} + \sum_i \sum_j P_{ij} Q_{ij} \qquad (13)$$

Subject to:

$$\sum_j \tilde{V}_{ij} CV_{ij} Y_{ij} \tilde{\leq} B_i \qquad \text{for each } i \qquad (14)$$

$$\sum_j \tilde{V}_{ij} Y_{ij} \tilde{\geq} V_i \qquad \text{for each } i \qquad (15)$$

$$\sum_j \tilde{R}_{ij} Y_{ij} \tilde{\leq} R_i \qquad \text{for each } i \qquad (16)$$

Solution algorithm for modified FMOP model

To solve for the modified FMOP model, the solution algorithm is described as follows:

(1) Construct the model based on the available information on SCV and SCR. The demand and capacity constraints for different parts and suppliers are established.

(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. Since SCV and SCR are modeled as triangular fuzzy numbers (*L, M, U*), the upper and lower bound solutions can be solved by implementing the following crisp models.

Maximization objective functions:

$$U_1 = Max \sum_i \sum_j (V_{ij})^U Y_{ij} \tag{17}$$

$$U_2 = Max \sum_i \sum_j (R_{ij})^U Y_{ij} \tag{18}$$

$$U_3 = Max \sum_i \sum_j (V_{ij})^U CV_{ij} Y_{ij} + \sum_i \sum_j (R_{ij})^U CR_{ij} Y_{ij} + \sum_i \sum_j IR_{ij} Y_{ij} + \sum_i \sum_j P_{ij} Q_{ij} \tag{19}$$

Subject to:

$$\sum_j (V_{ij})^L CV_{ij} Y_{ij} \le B_i \qquad \text{for each } i \tag{20}$$

$$\sum_j (V_{ij})^U Y_{ij} \ge V_i \qquad \text{for each } i \tag{21}$$

$$\sum_j (R_{ij})^L Y_{ij} \le R_i \qquad \text{for each } i \tag{22}$$

Minimization objective functions:

$$L_1 = Min \sum_i \sum_j (V_{ij})^L Y_{ij} \tag{23}$$

$$L_2 = Min \sum_i \sum_j (R_{ij})^L Y_{ij} \tag{24}$$

$$L_3 = Min \sum_i \sum_j (V_{ij})^L CV_{ij} Y_{ij} + \sum_i \sum_j (R_{ij})^L CR_{ij} Y_{ij} + \sum_i \sum_j IR_{ij} Y_{ij} + \sum_i \sum_j P_{ij} Q_{ij} \tag{25}$$

Subject to:

$$\sum_j (V_{ij})^U CV_{ij} Y_{ij} \le B_i \qquad \text{for each } i \tag{26}$$

$$\sum_j (V_{ij})^L Y_{ij} \ge V_i \qquad \text{for each } i \tag{27}$$

$$\sum_j (R_{ij})^U Y_{ij} \le R_i \qquad \text{for each } i \tag{28}$$

(3) Find the respective membership functions for all objective functions.

Eqn (31) and Eqn (32) give the membership functions $\mu_i(x_i)$ for the fuzzy maximization and minimization objective functions respectively where L_1, L_2, and L_3 denote the lower bounds for the three fuzzy objective functions, and U_1, U_2, and U_3 are the upper bounds.

$$\mu_i\left(Z_i(x)\right) = \begin{cases} 1 & \text{if } Z_i(x) \ge U_i \\ \dfrac{Z_i(x) - L_i}{U_i - L_i} & \text{if } L_i \le Z_i(x) \le U_i \\ 0 & \text{if } Z_i(x) \le L_i \end{cases} \tag{29}$$

$$\mu_i\left(Z_i(x)\right) = \begin{cases} 1 & \text{if } Z_i(x) \le L_i \\ \dfrac{U_i - Z_i(x)}{U_i - L_i} & \text{if } L_i \le Z_i(x) \le U_i \\ 0 & \text{if } Z_i(x) \ge U_i \end{cases} \tag{30}$$

(4) Defuzzicate the fuzzy constraints by a weighted average approach using a beta probability function.

(5) Reformulate and solve the FMOP model as a crisp single objective model by using the results obtained from Steps 2 to 4.

A weighted crisp single objective model comprising *K* objectives is used to solve the

FMOP model, where λ_k is the achievement level of the k^{th} objective (Amid et al. 2006).

$$\text{Max } \sum_{k=1}^{K} w_k \lambda_k \tag{31}$$

Subject to

$$\lambda_k \le \mu_k \left(Z_k \left(x \right) \right) \qquad k = 1,2,\ldots,K \tag{32}$$

$$\sum_j \left[(\frac{1}{6}) V_{ij}^{p} CV_{ij} Y_{ij} + (\frac{4}{6}) V_{ij}^{m} CV_{ij} Y_{ij} + (\frac{1}{6}) V_{ij}^{o} CV_{ij} Y_{ij} \right] \le B_i \text{ for each } i \tag{33}$$

$$\sum_j \left[(\frac{1}{6}) V_{ij}^{p} Y_{ij} + (\frac{4}{6}) V_{ij}^{m} Y_{ij} + (\frac{1}{6}) V_{ij}^{o} Y_{ij} \right] \ge V_i \qquad \text{for each } i \tag{34}$$

$$\sum_j \left[(\frac{1}{6}) R_{ij}^{p} Y_{ij} + (\frac{4}{6}) R_{ij}^{m} Y_{ij} + (\frac{1}{6}) R_{ij}^{o} Y_{ij} \right] \le R_i \qquad \text{for each } i \tag{35}$$

$$\lambda_k \in \left[0,1 \right] , \quad k = 1,2,\ldots,K \tag{36}$$

$$\sum_{k=1}^{K} w_k = 1 , \quad w_k \ge 0 \tag{37}$$

Numerical example

A car maker determines the quantities of three different car lock systems (CLS1, CLS2, CLS3) to buy so that multiple objectives (i.e., visibility maximization, risk minimization, and cost minimization) are achieved. The lock systems are needed for the assembly lines of the compact, medium-priced, and luxury car models respectively. In a given planning period, the monthly demand quantities of the lock systems are 60,000, 45,000 and 35,000 respectively. Three suppliers with various production capacities offer different prices for the lock systems (Table 1). The monthly production capacity for the suppliers is 70,000, 80,000, and 90,000, with a minimum order quantity of 5,000, 6,000, and 7,000 respectively.

Table 1: Pricing ($) for car lock systems from different suppliers

Part *i*	Supplier 1	Supplier 2	Supplier 3
CLS1	30	28	27
CLS2	41	39	37
CLS3	53	51	48

To enhance SCV, the car maker has set aside various budgets of $100,000, $120,000, and $150,000 for the three suppliers respectively, based on their geographical locations and information processing capabilities. To model SCV and SCR, fuzzy theory is used due to the uncertain nature. Following Manuj and Mentzer (2008) who define supply risk (SCR) as the expected impact the buyer may incur, the probability form for the SCR can be modeled as a scale of three different probability levels (low, medium, high). For each level, the incurred impact is modeled as its monetary value. Table 2 presents the risk profile.

Table 2: Risk profile for different suppliers

Supplier	Probability of risk	Impact due to risk
1	0.05	$1,000,000
2	0.25	$300,000
3	0.60	$200,000

The selection of different suppliers may incur various degrees of supply risk due to the supplier’s capacity, capability, proximity, and natural environment. The possible risks for each part supplied by a different supplier are represented by triangular fuzzy numbers (Table 3). A fair amount of cost is incurred if supply risk is to be reduced to a lower level either through more production flexibility, using more secured transport modes, or designing a substituted part. In this example, $50,000 is assumed to reduce the risk down to the next level. As for each different part, it can endure different risks since it is used for different car models that are sold to different markets and have different prices. The maximum allowable risk for each of the three lock systems is 6.5, 6.0, and 5.5 respectively.

As the three suppliers are in different geographical regions with various information processing capabilities, the cost needed to improve visibility to the current level is \$20,000 (i.e., CV_{ij}) for supplier 1, \$22,000 for supplier 2, and \$25,000 for supplier 3. The visibilities for each part purchased from different suppliers are modeled as a (low, medium, high) scale with a triangular fuzzy number (Table 4). For the buying process to be more efficient, a minimum amount of visibility is needed for each lock system. In this case, at least 1.5 is needed for CLS1, 2 for CLS2, and 2.5 for CLS3 respectively.

Table 3: Risk encountered for part *i* if purchased from supplier *j*

Part *i*	Supplier 1	Supplier 2	Supplier 3
CLS1	*(0.5, 1, 1.3)*	(1.2, 2, 2.5)	(2.4, 3, 3.5)
CLS2	(0.3, 0.8, 1.2)	(1.5, 2.1, 2.6)	(2.1, 2.8, 3.4)
CLS3	(0.4, 1.1, 1.6)	(1.7, 2.2, 2.7)	(2.4, 3.1, 3.7)

Note: (0.5, 1, 1.3) denotes triangular fuzzy number *(L, M, U)* where membership functions of L and U equal 0 and membership function of M is 1.

Table 4: Visibility incurred for part *i* if purchased from supplier *j*

Part *i*	Supplier 1	Supplier 2	Supplier 3
CLS1	*(2.4, 3.2, 3.8)*	(1.6, 2.3, 2.8)	(0.6, 1.1, 1.7)
CLS2	(2.3, 2.9, 3.4)	(1.4, 2.0, 2.5)	(0.7, 1.3, 1.8)
CLS3	(2.4, 3.3, 3.9)	(1.3, 1.9, 2.4)	(0.5, 1.1, 1.7)

Note: (2.4, 3.2, 3.8) denotes triangular fuzzy number *(L, M, U)* with membership functions of L and U equal 0, and M equal 1.

The solution of the model is processed as follows.

Step 1: Establish the FMOP based on the information described above.

Step 2: Solve as a single objective function model using Zimmermann's (1978) max-min approach for each objective function, where $\{x,y\}$ denotes $\{U_k, L_k\}$, yielding $(Z_1,Z_2,Z_3)= (\{35.9, 6.6\}, \{21.3, 7.6\}, \{7,519,400, 6,101,000\})$.

Step 3: Find the respective membership functions for the fuzzy objective functions. The membership functions are given by both the upper and lower bounds of step 2 (Table 5).

Table 5: Membership functions for fuzzy objective functions

	μ=0	μ=1	μ=0
Z_1	6.6	35.9	-
Z_2	-	7.6	21.3
Z_3	-	\$6,101,000	\$7,519,400

Step 4: Defuzzicate the fuzzy constraints using a beta probability distribution. The weight of the most likely is 4/6, and the weights of optimistic and pessimistic are both 1/6. The defuzzicated risk and visibility triangular numbers are shown in Tables 6 and 7.

Table 6: Defuzzication of triangular fuzzy numbers for SCR

Part *i*	Supplier 1	Supplier 2	Supplier 3
CLS1	0.96667	1.9500	2.9833
CLS2	0.7833	2.0833	2.7833
CLS3	1.0667	2.2000	3.0833

Table 7: Defuzzication of triangular fuzzy numbers for SCV

Part *i*	Supplier 1	Supplier 2	Supplier 3
CLS1	3.1667	2.2667	1.1167
CLS2	2.8833	1.9833	1.2833
CLS3	3.2500	1.8833	1.1000

Step 5: Reformulate and solve the modified FMOP model as a crisp single objective model using the results obtained from Steps 2 to 4. It is assumed that the decision preferences for the three objective functions are equally weighted (i.e., 1/3 for each objective). The results of the revised FMOP model are shown in Table 8.

Table 8: Results of revised FMOP model

Part i	Purchase quantity Q_{ij} from supplier j			Z values	Degree of achievement
	1	2	3		
CLS1	0	60,000	0	$Z_1 = 8.1433$	$\lambda_1 = 0.0527$
CLS2	45,000	0	0	$Z_2 = 8.0166$	$\lambda_2 = 0.9696$
CLS3	0	6,000	29,000	$Z_3 = 6{,}045{,}546$	$\lambda_3 = 1.0000$

The results demonstrate that the degree of achievement of the cost-minimization objective (λ_3) is greater than the achievement level of the other two objectives. This result agrees with the decision preference for the majority of firms. In addition, the achievement level of the risk-minimization level (λ_2) is relatively greater than that of the visibility-minimization objective. The reason may be that most decision makers are risk-averse and hence are prone to mitigating SCR rather than to enhance SCV. CLS3 (needed for the luxury model) has the least allowed risk since its associated products are sold for a higher price. Thus, supplier 1 is selected to provide CLS2 due to its high visibility and low risk. As for supplier 3, though it sells at a cheaper price, it is however exposed to a higher risk and incurs a higher impact, it is hence selected to provide CLS3. Supplier 2, on the other hand, offers a medium priced product while providing a medium level of SCV and is exposed to a medium level of SCR, is opted for supply two parts.

Conclusion

This paper has, through an FMOP model, attempted to model the twin effects of SCV and SCR on supply chain performance. Our results suggest that decision makers tend to favour mitigating SCR first and then enhance SCV. However, suppliers who can provide a balanced treatment of SCR and SCV can supply to a large portion of the marketplace.

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A GREEN LOGISTICS ABSORPTIVE CAPACITY MODEL FOR TRANSPORT AND LOGISTICS SECTOR

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INTRODUCTION

Organizations have been under pressure to accommodate the environemtal concerns into their operations over last decade. Over recent years there has been a concern that transport and logistics activities will result in a subsequent rise in carbon emissions and climate change (McGettigan *et al.*, 2005) . In response to such concerns, the transport and logistics industry (T&L) has been investing in using new practices and technologies in the movement towards more greener logistics (McKinnon, 2010). Some of these practices include switching to low emission fuel, reduction in percentage of truck kilometres run empty (Durbin *et al.*, 2003), and increasing the average weight-based load factor (Woodburn and Whiteing, 2010). However, Lenox and King (2004) argue that in most cases top management is either unclear or unconvinced how green practices can add value. Knowledge about sustainability best practices and regulations and the mechanism to transform this knowledge into competitive advantage is an essential capability to operate in the increasingly carbon constrained economy (Schultz and Williamson, 2005). Successful environmental initiatives require harnessing both internal knowledge processes and external knowledge exchange (Gluch *et al.*, 2009). Cohen and Levinthal (1990) argue that developing, nurturing and renewing absorptive capacity (AC) is critical to achieve this capability. Absorptive capacity refers to the ability of a firm to recognise the value of internal and external information, assimilate it, and transform it to commercial ends (Zahra and George, 2002). AC is also applicable in environmental context in which companies are seeking for more sustainable development. Pinkse *et al*. (2010) showed what role AC plays in implementing an environmental strategy.

Despite the above applications, although there are a few studies that investigate green logistics practices (Gonzalez-Benito and Gonzalez-Benito, 2006; Zhu et al., 2008; Lin and Ho, 2011), how logistics and transport firms acquire, assimilate, transform and exploit knowledge about green logistics and to what extent these practices influence their green logistics performance merits an empirical examination. To address this need, this paper adopts the theory of absorptive capacity to explore the absorptive capacity of the logistics and transport industry and its influence on green logistics performance.

THERORETICAL FRAMEWORK

Cohen and Levinthal (1990) argue that the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities. They called this capability as absorptive capability which is largely a function of the firm's level of prior related knowledge. Zahra and George (Zahra and George, 2002, p 188) posit that the absorptive capacity is 'a dynamic capability that influences the firm's ability to create and deploy the knowledge necessary to build other organizational capabilities'. They propose AC as a dynamic capability pertaining to knowledge creation and utilization that enhances a firm's ability to gain and sustain a competitive advantage. Zahra and George (2002) reconceptualised the AC construct and distinguished between a firm's potential and realized absorptive capacity. In their proposed model, they outlined the conditions when the firm's potential and realized capacities differentially influence the creation and sustenance of its competitive advantage. Todorova and Durisin (2007) argued that, knowledge transformation is not the step after knowledge assimilation but represents an alternative process linked to assimilation by multiple paths. Assimilation simply adds new knowledge to the existing knowledgebase but transformation creates new knowledge internally from a novel combination of the new and existing knowledge (Pinkse *et al.*, 2010).

Absorptive capacity is typically investigated to determine its impact on business innovation and performance (Cohen and Levinthal, 1990; Zahra and George, 2002). Absorptive capacity is path dependent, in that the extent to which a firm has accumulated a capacity for absorption in the past, influences the ability of the firm to do so in the future (Cohen and Levinthal, 1990). Thus absorptive capacity may be the source of developing other capabilities that could be difficult for competitors to develop in the short-term. Gluch et. al. (2009) argue that the theory of absorptive capacity can be useful in understanding environmental innovation, particularly since environmental issues require understanding of complex cross-disciplinary knowledge.

The dependent variable in this study is Green Logistics Performance. Economic performance has traditionally been the first priority for many organizations. However, environmental performance has become increasingly important (Zhu and Sarkis, 2007). *Green Logistics performance* refers to the effects of the organization's logistics operations on the environment (for example, consumption of fuel or generation of CO2 emissions) (Link and Naveh, 2006). The Resource-based view (RBV) scholars argue that if an organization possesses and exploits resources and capabilities that are both valuable and rare, it will be able to improve its performance (Eisenhardt and Martin, 2000; Newbert, 2008; Lockett *et al.*, 2009). In resource-based view, knowledge is one of the decisive elements for acquiring, transforming and integrating other resources. AC links external knowledge to the internal knowledge of a firm (Williander, 2007) and as such can be a source of a firm's superior business performance (Zahra and George, 2002). Zahra and George (2002) argue that exploitation capability is likely to influence the firm performance through product and process innovation. Camisón and Forés (2010) showed how absorptive capacity would affect performance and competitive advantage through the exploitation of external knowledge. Based on this, we argue that a firm's green logistic knowledge exploitation can influence its green logistics performance. Green logistics knowledge exploitation refers to a firm's environmental capability that is based on the routines to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations (Zahra and George, 2002). This leads to the following hypothesis.

> *Hypothesis 1: Logistics companies with greater levels of green logistics knowledge exploitation have better green logistics performance.*

Green logistics knowledge assimilation refers to the firm's routines and processes that allow it to analyse, process, interpret, and understand the environmental information obtained from external sources. In T&L context, green logistics knowledge assimilation can include an organization's training programs, plans to achieve environmental targets, and analytical tools to identify environmental impacts such as life cycle measurement (LCA) (Gluch *et al.*, 2009). *Green logistics knowledge transformation* on the other hand denotes a firm's capability to develop green practices that facilitate combining the existing and newly acquired or assimilated environmental knowledge.

Firms can possess a strong capability to identify new knowledge and a weaker exploitation capability, which causes them to fail to translate new knowledge into new products and processes (Baker, Miner, & Eesley, 2003). Therefore there is a need that organization has the capacity to develop and refine the internal routines that facilitate the transference and combination of previous knowledge with the newly acquired or assimilated knowledge and to incorporate acquired, assimilated and transformed knowledge into their logistics operations and routines in order to create new operations, competences, routines, goods and organizational forms (Camisón and Forés, 2010). This leads to the following hypotheses:

> *Hypothesis 2: there is a significant and positive association between the level of green logistics knowledge assimilation and level of green logistics knowledge exploitation.*
>
> *Hypothesis 3: there is a significant and positive association between the level of green logistics knowledge transformation and level of green logistics knowledge green exploitation.*

Firms' routines to identify external knowledge (acquisition) can be a predictor of firm's capabilities to analyse and understand the absorbed new knowledge (assimilation) or firms' capabilities (transformation) that 'through the process of bisociation help firms to develop new perceptual schema or changes to existing processes' (Zahra & George, 2002: 195). *Green logistics knowledge acquisition* refers to a firm's capability to identify and acquire externally generated environmental knowledge that is critical for green logistics practices. For example, in the transport and logistics industry (T&L) context it can be the existence of organizational routines to capture emerging environmental regulations. Based on this argument, the following is proposed:

> *Hypothesis 4: there is a significant and positive association between the level of green logistics knowledge acquisition and the level of green logistics knowledge assimilation.*
> *Hypothesis 5: there is a significant and positive association between the level of green logistics knowledge acquisition and the level of green logistics knowledge transformation.*

METHODOLOGY

Measurement Development

After a comprehensive review of the absorptive capacity and green performance literature we developed items to measure the green logistics best practices and knowledge for acquisition, assimilation, transformation, and exploitation. Table 1 represents the definitions and the items for the research constructs.

Data Collection

The database of Australian Transport and Logistics firms was obtained from ImpactList, a commercial company providing company details for research purposes. The T&L companies in Australia were chosen as the sanple frame for this study. For the purpose of this study, T&L refers to those companies whose primary role is transport and logistics. This includes both transport (air, rail, road, and water) and warehouse and distribution companies. The initial database consisted of 3080 company details. An email containing an explanation about the purpose of the study and a link to the online questionnaire was sent to the potential respondents. We received 325 questionnaires of which 46 questionnaires were removed from further analysis because of many items left blank. It resulted in 279 responses (9 percent response rate) as the basis for the analysis. The response rate is acceptable for email surveys (Dillman 2000).

RESULTS

Factor Analysis

The unidimesionalilty of the research instrument is examined to ensure that the research anlysis is reliable. Pricipal component analysis and relaribility tests are used to examine the internal and external validity of the research items. All but two items exceed the acceptable cutoff of 0.70 for unidimensionality (Nunnally and Bernstein, 1994). The factor loadings for items GLKAC1 in green logistics knowledge acquisition and item GLKAS1 in green logistics knowledge assimilation, are slightly lower (0.68 and 0.68 respectively) than the minimum accepted value of 0.7. We preferred to keep them so as not to weaken the definition of the respective constructs. Cronbach alpha coefficent was used to assess the reliablity of the scale. Cronbach alphas values are above the gernerally accpeted cutoff of 0.70 (Hair, 2010). Table 2 shows the results of psychometric properties of the research instrument.

Construct	Definition	Survey Items	Survey statement	References
Green Logistics knowledge acquisition (GLKAC)	Firm's capability to identify and acquire externally generated knowledge that is critical to its green logistics operations.	GLKAC1	Our company normally goes to other bodies (consultants, universities) to find out about fresh opportunities for introducing green logistics practices.	(Gluch *et al.*, 2009)
		GLKAC2	Our company has routines to acquire information on legislation on green logistics.	(Gluch *et al.*, 2009), (Nieto and Quevedo, 2005)
		GLKAC3	We communicate relevant environmental knowledge across all units of our firm.	(Nieto and Quevedo, 2005)
		GLKAC4	Our company carries out initial environmental reviews.	(Lichtenthaler, 2009)
		GLKAC5	Our company is aware of competitors green technologies/practices.	(Nieto and Quevedo, 2005)
Green Logistics knowledge assimilation(GLKAS)	Firm's routines and processes that allow it to analyse, process, interpret, and understand the information obtained from external sources.	GLKAS1	The employees in our company participate in environmental training programmes	(Nieto and Quevedo, 2005; Gluch *et al.*, 2009)
		GLKAS2	Our company has implemented life cycle analysis (LCA) as a mean to identify environmental impact from our operations.	(Gluch *et al.*, 2009)
		GLKAS3	We quickly analyse and interpret changing market demands for our technologies.	(Lichtenthaler, 2009)
		GLKAS4	New opportunities to serve our customers with existing technologies are quickly understood.	
		GLKAS5	Our company has regular meetings of department heads to discuss green logistical issues.	(Schmidt, 2010)
Green Logistics knowledge transformati on(GLKT)	Firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge.	GLKT1	We are successful in transforming technological knowledge into greener practices	(Gluch *et al.*, 2009)
		GLKT2	Our company is capable of sharing its expertise to develop new green practices.	
		GLKT3	We regularly match new technologies with ideas for greener practices.	(Lichtenthaler, 2009)
		GLKT4	We are effective in developing new knowledge or insights that have the potential to address environmental concerns	(Pavlou and El Sawy, 2006)
		GLKT5	We can successfully integrate our existing knowledge with the new information and knowledge acquired.	(Pavlou and El Sawy, 2006)
Green Logistics knowledge exploitation(GLKE)	Firm's capability that is based on the routines that allow firms to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations.	GLKE1	Our company utilizes environmental considerations in its strategic decisions	(Gluch *et al.*, 2009)
		GLKE2	Our company easily implements new knowledge and technologies in new green practices.	
		GLKE3	Our company applies new knowledge and technologies into its green practices.	(Lichtenthaler, 2009)
		GLKE4	Our company tries to change operations and practice in a way they are aligned with its environmental interests.	
		GLKE5	We can successfully exploit internal and external information and knowledge into concrete applications.	(Pavlou and El Sawy, 2006)
Green logistics Performance (GLP)	The effects of the organization's logistics operations on the environment	GLP1	Reduced overall environmental footprint	(Murphy and Poist, 1995; McIntyre *et al.*, 1998; Link and Naveh, 2006; Zhu and Sarkis, 2007; Darnall, 2009)
		GLP2	Reduced CO2 emission	
		GLP3	Improve an enterprise's environmental situation	
		GLP4	Reduced cost of environmental compliance	
		GLP5	Reduces Energy Consumption	
		GLP6	Improve green brand value	
		GLP7	Improve employee morale	
		GLP8	Compliance with government regulations	
		GLP9		

Table 1 Construct and suggested items

Hypothesis Testing

The above analysis suggests that the scale items used to measure the research constructs are reliable and valid indicators. The significance of relationships among constructs was examined using regression analysis. Each hypothesis was tested by reviewing the significance, magnitude, and direction of each parameter coefficient. Table 3 displays the results from the test of research hypotheses.

Factor	Item	Factor Loadings	Cronbach α
Green Logistics knowledge acquisition	GLKAC1	0.69	0.87
	GLKAC2	0.85	
	GLKAC3	0.75	
	GLKAC4	0.73	
	GLKAC5	0.71	
Green Logistics knowledge assimilation	GLKAS1	0.68	0.83
	GLKAS2	0.79	
	GLKAS3	0.78	
	GLKAS4	0.80	
	GLKAS5	0.77	
Green Logistics knowledge exploitation	GLKE2	0.88	0.88
	GLKE3	0.75	
	GLKE4	0.84	
	GLKE5	0.79	
Green Logistics knowledge transformation	GLKT2	0.92	0.86
	GLKT3	0.84	
	GLKT4	0.76	
	GLKT5	0.92	
Green Logistics performance	GLP1	0.77	0.93
	GLP2	0.71	
	GLP3	0.74	
	GLP4	0.76	
	GLP5	0.86	
	GLP6	0.76	
	GLP7	0.82	
	GLP8	0.75	
	GLP9	0.75	

Table 2 Psychometric properties of Research Instrument

Hypothesis	**Standardized coefficent**	**F-value**	**Significance Level**	**Result**
Hypothesis 1	0.51	99.78	< 0.001	Supported
Hypothesis 2	0.40	52.57	< 0.001	Supported
Hypothesis 3	0.40	52.30	< 0.001	Supported
Hypothesis 4	0.21	13.24	< 0.001	Supported
Hypothesis 5	0.26	20.64	< 0.001	Supported

Table 3 The Results of Hypothesis Testing

All hypotheses are supported at ρ <.001 indicating that significant positive relationships exist between the hypothesized paths. The independent varibale explains 26 percent of the variation in green logistic performance which is reasonable given that our analysis was based on cross sectional data.

DISCUSSION AND CONCLUSION

While in previous studies the focus of AC was on such internal and external knowledge as technological knowledge, managerial practices, HRM models and so forth in this study we focus on internal and external sources of green knowledge. This study is possibly the first empirical attempt to investigate the role of AC in green logistics performance. The measure for green AC model was developed through a comprehensive review of the literature and rigorous methods.

The proposed model provides empirical validation of the Todorova and Durisin's AC model within an environmental context and with green logistics performance. The results of this study show AC model is helpful in understanding the mechanisms through which logistics firms become greener.

Hypothesis 1 which claims that there is a positive relationship between green logistics knowledge exploitation and green logistics performance is supported. The path coefficient is 0.51 which is significant at ρ <0.001. The result indicates that enhancing green logistics knowledge exploitation may be a valid factor to increase green logistics performance. This can be achieved through changing the logistics operations and incorporating new knowledge into green practices in a way that can reduce CO2 emission, fuel consumption, or the cost of environmental compliance. The positive and significant effect of green logistics knowledge exploitation on green performance is consistent with Rothaermel and Hill's (2005) findings where ongoing investment in absorptive capacity, operationalized as R&D expenditures, leads to persistent performance differences and explained performance differences in firms. Hypothesis 2 is supported with the path coefficient of 0.40 (ρ<0.001 indicating those logistics companies with effective routines and processes to obtain knowledge from external sources would possess better capabilities to incorporate the assimilated information into their logistics operations. Also green logistics knowledge transformation is found to be significant predictor of green exploitation. The path coefficient for this linkage is 0.40 with ρ < 0.001 supporting hypothesis 3. Supporting H2 and H3 indicates that developing analytical routines and assessments are critical in greening logistics (Gluch *et al.*, 2009). These routines can be Life Cycle Assessment (LCA) or training staff about the environmental issues. Through this process, intellectual capital, that is capable of turning potential ideas into real ones, can be developed and accumulated (Gluch *et al.*, 2009). Both green logistics knowledge assimilation and Green Logistics knowledge transformation in turn, are the predictors of Green Logistics knowledge exploitation (leveraging existing green competencies) which in turn is predictor of green logistics performance.

Hypothesis 4 which indicates that green logistics knowledge acquisition (externally acquired environmental knowledge) has a direct and positive impact on green logistics knowledge assimilation (processes to analyze environmental information) was supported with the path coefficient of 0.21 (ρ<0.001). Green logistics knowledge assimilation routines such as environmental training programs, implementation of life cycle analysis in measuring the impact of logistics operations would enhance the chance that firms could successfully transform internal and external information and knowledge into green routines. Also green logistics knowledge acquisition is found to be a significant predictor for green logistics knowledge transformation (combining existing and newly acquired or assimilated environmental knowledge). This indicates that Hypothesis 5 is supported with the path coefficient of 0.26 with ρ<0.001. Supporting H4 and H5 is in line with previous research that emphasize that real systems are open and interact with their environment and that they can acquire new properties (Markus *et al.*, 2002). For applying green practices, companies need to open their knowledge gates to a variety of sources (Gluch *et al.*, 2009).

The psychometric requirements of the measurement instruments have been confirmed in this study so it can be used for future research in the areas of green logistics. This study identified mechanisms that are important for green practices and knowledge within the context of logistics and transport firms. Many researchers and practitioners agree that environmental responsibility plays an important role to the future of organizations. In this study, it was shown that addressing environmental concerns requires a process in which environmental information, through a wide range of channels and practices is acquired, assimilated, transformed and exploited. As a result, it was found that logical sequence of this process can lead to superior green logistics performance. The results imply that logistics and transport companies need to pay attention to developing their absorptive capacity, an issue that is not sufficiently recognized within an environmental context in previous studies. Practitioners must be aware of the role environmental management plays in near future. The findings of this study show that logistics companies need to improve their absorptive capacity if they want to increase their green logistics performance. In order for a logistics company to have higher level of green performance, they need to incorporate the environmental considerations into their strategic decisions and apply new environmental knowledge into new green practices.

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AGILITY IN HUMANITARIAN SUPPLY CHAINS

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ABSTRACT

Efficient Logistics and Supply Chain Management practices are now seen as vital to effective and rapid responses to emergency humanitarian events. In an environment which is extremely uncertain, humanitarian organisations need to be able to respond to high-impact events with unpredictable levels of resource. It has been suggested that concepts normally associated with commercial supply chains may be beneficial in aiding humanitarian organisations in becoming more responsive to changing condition. In particular, the concept of agility has been proposed due to its benefits in situations where demand is not constant. In this study the notion of agility and the benefits it holds for humanitarian organisations is explored. In order to gain up-to-date insights about the challenges and work being undertaken in relation to emergency humanitarian aid efforts, a qualitative research study utilising semi-structured interviews and questionnaires with logisticians and directors in Humanitarian Aid organisations was conducted. Based on the responses a better understanding of the value agility holds in a humanitarian context has been developed. Following an analysis of the findings, it is evident that while some organisations have installed the basics of an agile corporation, a number of barriers still exist which inhibit their ability to operate effectively in turbulent environments.

1. INTRODUCTION

Recent events suggest that natural disasters are increasing in frequency and that no nation/region is immune to this trend. While the majority of disasters have been in third world countries; Hurricane Katrina (2005), Australian floods (2010/2011) and the Tōhoku earthquake / tsunami (2011) all highlight that even first world countries are susceptible. Natural disasters are uncertain by their nature and it is therefore difficult for humanitarian aid (HA) agencies to be ready for them (Kovacs and Spens, 2007). Like natural disasters business can be unpredictable and volatile business environments require agile supply chains (Lin et al, 2006). Some authors have suggested that the application of agile principles may help humanitarian organisations to become more responsive to the disruptions and imbalances in both supply and demand (Oloruntoba and Gray, 2006; Scholten et al., 2010). However, in contrast Charles et al. (2010) argue "by constantly working in environments with high degrees of uncertainty, humanitarian organisations end up becoming specialists in the implementation of agile systems". As Tatham and Pettit (2010) explain "the application of commercial supply network management theory and practice has received limited consideration within humanitarian logistics literature to date". Therefore, a deeper investigation into the potential improvements in efficiency and effectiveness that commercial business concepts offer to humanitarian logistics is needed.

This paper discusses the shortcomings of HA logistics in response to natural disasters and provides an analysis of whether the concept of supply chain agility is appropriate in such turbulent environment. Further, it aims to highlight the logistics challenges involved in response to natural disasters and to analyse the appropriateness of commercial logistics/supply chain management concepts in humanitarian organisations. In order to gain up-to-date insights into emergency humanitarian aid logistics response a qualitative research study utilising semi-structured interviews and questionnaires with logisticians and directors in Humanitarian Aid organisations was conducted during 2011. The research included both semi-structured interviews and questionnaires with logisticians and directors from 10 HA organisations. The interviewees included NGO directors as well as logisticians at an operational level. The second-stage questionnaire consisted of twenty one open ended questions addressing general, operational and strategic activities within the organisation. The interviews generally lasted between 30 and 45 minutes.

2. LEAN OR AGILE?

Naylor et al (1999) define agility as "using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place". Christopher and Towill (2000) argue it is "a business-wide capability that embraces organisational structures, information systems, logistics processes and, in particular, mindsets". Although there is no single definition for supply chain agility, Charles et al. (2010) stress that 'from an academic point of view, supply chain agility is becoming a major field of research'. Power (2005) supports this and states that 'the requirement for organisations to become more responsive to the needs of customers, the changing conditions of competition and increasing levels of environmental turbulence is driving interest in the concept of 'agility''.

According to Power et al. (2001), agility evolved from flexible manufacturing systems, which captured the integration of the organisation's suppliers, business processes and customers as well as product use and disposal. Beresford et al. (2005) explain it is necessary to have excess capacity available within the supply chain in order to meet the changing requirements while reducing inventory to a minimum. By having this excess capacity it provides organisations with "flexibility in being able to respond to changes in the market, both in terms of demand and design". Christopher and Peck (2004) state that agility has many dimensions and a key to an agile response is to have agile partners along the supply chain. Power (2005) meanwhile asserts that "the notion of agility is therefore recognised to be holistic rather than functional and of strategic rather than tactical importance".

Christopher (2000) explains that, for a supply chain to be 'truly agile', it must have market sensitivity, as well as, process and network integration. In order to achieve an agile supply chain the focal organisation must share information and knowledge with its suppliers and customers across common systems. Power (2005) reveals 'an underlying assumption of this model is that of open relations between the supply chain participants, the sharing of information and the use of technology to create 'connectivity' i.e. the ability for organisations to share information in 'real time'.

An alternative supply chain strategy is 'lean thinking' which refers to creating a co-ordinated schedule with all chain segments operating at the same speed, thus minimising waste (Womack and Jones, 1996). Naylor et al. (1999) define leanness as "developing a value stream to eliminate all waste, including time, and to ensure a level schedule". It involves identifying what creates value and removing any activity that does not add value as perceived by the end customer. Beresford et al. (2005) suggest that although agility and lean are in some ways similar philosophies, there are nonetheless some differences between these two schools of thought'. Mason-Jones et al. (2000) argue that lean works best when demand is known and stable; conversely, agility is suited to turbulent and fluctuating demand. However, in some circumstances it is prudent to employ both strategies on either side of a de-coupling point to enable a total supply chain strategy.

While it may seem that lean and agile are paradoxical, in reality, many supply chains incorporate both lean and agile elements. Naylor et al. (1999) refer to this as 'leagility' and discuss a number of ways in which the two paradigms can be merged. The benefit of leagility according to Beresford et al. (2005) is that "this not only helps to minimise cost levels as much as possible but also enables the supply chain to be responsive to customer demands". Childerhouse and Towill (2000) suggest that lean principles are best suited to stable and predictable demand; however, when a market is turbulent or uncertain a hybrid strategy is necessary. Naylor et al. (1999) define leagile as "the combination of the lean and agile paradigms within a total supply chain strategy by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the marketplace". Beresford et al. (2005) explain the decoupling point "effectively separates the part of a supply chain driven by customer orders from the part based on forecast demand". They propose that lean principles are decoupled at a point in the supply chain and combined with agility in order to increase responsiveness.

Leanness does not imply agility; however, an agile supply chain implies that many of the principles of lean have been adopted (Scholten et al., 2010). Mason-Jones et al. (2000) dictate that what constitutes 'waste' in a lean organisation maybe considered essential in an agile organisation, as eliminating too much slack can lead to decreased flexibility in operations. Christopher and Towill (2001) contend that "lean methodologies can be a powerful contributor to the creation of agile enterprises". Therefore it is important to consider 'leagile' strategies when implementing agility within an organisations supply chain (Mason-Jones et al., 2000; Naylor et al., 1999). Commercial supply chain management literature suggests that agility and the hybrid leagile strategies have allowed mainstream organisations to handle increased uncertainty and volatility in demand more effectively. On the one hand, it is suggested that HA organisations are already agile and commercial business should take note of their capabilities. However, it is also argued that HA organisations lack some of the fundamental characteristics that allow an agile supply chain to operate. It is therefore important to investigate the extent to which HA organisations are truly agile and to identify what are the most common barriers to the integration of agility within these organisations.

3. KEY CHALLENGES FOR AGILE STRATEGIES IN HUMANITARIAN LOGISTICS

3.1. Agile and Lean Strategies

The research revealed that all the HA organisations supply chains meet the basic definitions of supply chain agility. This is evident as they are able to quickly establish their supply chains and mobilise staff, equipment and materials in response to natural disasters. However, when it comes to an overriding supply chain strategy, there is an evident diversity among organisations; the extent to which they are employed and the general knowledge of supply chain strategies available is also variable. Many of the organisations involved clearly face challenges and need to focus on their supply chain strategy or lack of strategy. Some organisations undoubtedly have no supply chain strategy and as a result have thorough and cumbersome procurement regulations and processes to deal with internally. In contrast, some organisations have several plans/strategies in place to deal with different scenarios (droughts, earthquakes, floods, cyclones, etc). These organisations highlight the importance of having the ability to approach a disaster with a broad degree of flexibility. They suggest that rather than a lean/agile strategy, a better description of their strategies would be a cost-effective and flexible approach. However, there was evidence of a leagile strategy in some responses: "We now have a new global strategy for 2011-2016; it's all about being faster, cheaper and better" (Regional Logistics Coordinator). This suggests that leagile tools and techniques could be involved as leagility "not only helps to minimise cost levels as much as possible (cheaper) but enables the supply chain to be responsive to customer demands (faster and better)" (Beresford et al., 2005). As Christopher and Tatham (2011) explain, there are a number of key prerequisites for an organisation to be agile. Agile organisations "tend to exhibit certain characteristics; agility implies that they are demand or event driven, they are network based, they are process orientated and they are virtually integrated through shared information".

3.2. Customer/Market Sensitivity

"Agility implies that the supply chain is demand driven, reading and responding to real demand" (Scholten et al., 2010). The research indicates that HA organisations are primarily demand -driven. However, in most cases there is also a use of prepositioned stock. Many of the organisations argue that it has to be a mix due to the diverse nature of natural disasters and individuals' needs. They explain that in emergencies prepositioned stock is not sufficient to supply all the items required and that it may not be appropriate to the needs of beneficiaries in a given emergency scenario. In terms of demonstrating sensitivity to cultural, religious and climate-related needs, some of the organisations show better awareness than others. These organisations hold prepositioned stock levels of items that are of equal importance to everyone. Other items held are basic necessities such as blankets, tents, jerry cans etc. so do not need to be customised to individual needs. Many HA organisations have collected information on all major disasters for the last 20 years and use their previous experience to predict needs according to area/country, type of disaster and culture/religion of the locals. The organisation that best displays a leagile approach contends that "For unusual items e.g. fuel bowsers, boats, etc then it is direct procurement as required. All provision of goods be it from stock or production is always against a determined need (or pull) rather than forecast based" (Logistics Manager).

As mentioned previously, HA organisations follow a top-down approach and do not provide choice to consumers. The research also suggests that often not only are the products wrong, but the way in which they are distributed is incorrect, therefore, it is difficult to describe HA organisations as sensitive to their customers/markets. This opinion is shared by Scholten et al. (2010) who argue "while the NGOs interviewed showed some sensitivity to the particular cultural, religious and climate-driven needs of aid recipients in different disaster areas, this falls short of the market sensitivity, required by agile supply chains".

3.3. Virtual Integration

"Virtually integrated IT is a necessity for agility as it enables data sharing between buyers and sellers" (Scholten et al., 2010). This is supported by Christopher and Tatham (2011) who explain that by definition there must be a corresponding level of connectivity for supply networks to achieve high levels of agility. Respondents highlighted the many layers of approval for the procurement of relief supplies and a lack of clear communication between procurement and logistics as a hindrance. When asked whether there was data sharing across the organisation and with suppliers the answers varied from: no data sharing to limited internal sharing to some sharing with suppliers, but more information than data. Many organisations' ICT systems are not robust enough and there are often incompatibilities between suppliers and their organisations systems. Many of these organisations still rely purely on a paper or spreadsheet system, therefore virtual integration is not an option. Further, it appears that some HA organisations have not built the relationships needed in order to achieve data sharing. Suppliers respond to their requests and are often treated to an adversarial style of contract management where failure to adhere to specification or quality requirements result in severe repercussions. Organisations that have worked on building relationships explain their supply chain is still some way off from being fully integrated but are optimistic. Christopher and Tatham (2011) make clear that the real challenge in becoming virtually integrated is "the reluctance that still exists within some organisations to share information across boundaries – be these internal or external". This is supported by the findings as some of the respondents suggest they would not want to achieve full information sharing as it would affect the transparency of vendor selection.

3.4. Process Integration

In order to achieve process integration there needs to be cooperation between all members of the supply chain as well as the elimination of any barriers obstructing the free flow of information/data. The clear trend from the organisations investigated is that their ICT systems are not advanced enough or robust enough to provide accurate real time information. Many of the organisations find the idea of introducing vendor-managed inventory (VMI) an interesting one but assert that suppliers and they themselves do not have the skills to introduce such systems. For a VMI system to work suppliers need to reliably provide goods and services, however “often, due to cost or supply reasons, our vendors back out of their responsibilities and schedules” (Head of Logistics). Some HA organisations have introduced VMI into some aspects of their operations. They suggest the use of supplier stock in a response is common; however, the need to tailor packages and the economies of moving the combined goods needed rather than repeat sets of one good restrict the use of VMI. Christopher and Tatham (2011) argue it is critical that processes are aligned across organisational boundaries for a supply network to be effective across multiple units. They suggest that VMI is a good example of a concept that can enable this, therefore it is apparent that some of the organisations are making significant inroads to achieving a higher level of process integration, however, it is also evident that suppliers for the organisations are not always reliable enough.

3.5. Network Integration

Network integration assumes all members in the supply chain are involved and there is information sharing as well as transparency right the way through. Christopher and Tatham (2011) explain “one way organisations can enhance their agility is by making use of the capacity, capabilities and resources of other entities within the network”. It revolves around the merging of individual supply chains into one holistic supply chain aligning all the echelons so as to maximise efficiency and also relies on organisations having a high degree of process integration. However, there is an apparent gap in the level to which HA organisations’ and their suppliers cooperate. Indeed the majority of organisations argue the biggest obstacle to achieving information sharing and transparency throughout their supply chains as ‘the cluster system and the lack of desire of many organisations to collaborate over supply chain practices and specification of goods” (Logistics Manager). Again this supports the findings of Scholten et al (2010) that due to there being limited evidence of process integration, the foundation for network integration is absent among HA organisations.

3.6. Leagility

It has been suggested in previous research that HA organisations are more suited to leagile strategies. This is because of the increasing pressure on funding and the need to eliminate waste while providing rapid relief in response to natural disasters. Scholten et al. (2010) argue that emergency relief supply chains can be cautiously described as leagile as prepositioned stocks are decoupled in warehouses and once they leave these locations it operates in a responsive and agile way. The research indicates that a number of the organisations use prepositioned stock but keep this to a minimum and order goods that are not generic. As well as this it is evident that stock is often customised after it leaves the warehouse in order to respond to individual needs; according to region, culture, religion, climate, etc. As suppliers do not have the capacity to respond rapidly to the demands associated with a quick-onset natural disaster, it is necessary to preposition stock, despite it not necessarily being cost effective to do so.

3.7. ICT and Technology

Power (2005) explains that in order to be agile there needs to be significant use of technology to enable ‘connectivity’ i.e. the ability for organisations to share information in ‘real time’. This is supported by Oloruntoba and Gray (2006) who argue information technology is an essential enabler of agility. The research reveals that HA organisations are support the role of ICT and technology but identify that in terms of logistics their systems are below the level they need to be at. However, the research also suggests that many of these organisations are currently assessing the best option due to the levels of investment required. Overall the indications are that is that not only do they realise the importance of better ICT but their organisations are actively seeking ways in which to improve. Gustavsson (2003) supports these findings and argues that due to the lack of investment in electronic infrastructure HA organisations suffer from increased time to handle information and process a shipment. It is argued that this leads to inefficiencies, duplication of functions, increased inaccuracies in reporting and increased costs. The lack of ICT and/or the constraints on HA organisations ICT processes seem to be the biggest obstacle preventing HA organisations from meeting the definition of an agile supply chain. As stated by Scholten et al. (2010) "this is expected to change over time as the development and implementation of the required technology and supporting systems drives the creation of virtual networks across global value chains, even in NGOs". However, this can only occur when humanitarian donors fully appreciate the importance and value of providing resources for appropriate information systems and technologies.

4. INTERPRETATION AND CONCLUSION

The research revealed a number of interesting insights on the state of current and future HA operations. It appears there is diversity in the emphasis put on logistics and supply chain management within different organisations. The smaller organisations revealed they do not have a supply chain strategy in place, whereas the larger organisations employ a number of strategies. These strategies are ones that they have been adapted and developed in order to best suit different scenarios. However, it is evident that none of the organisations have taken a holistic view of their supply chain. Many have failed to recognise the importance of efficient collaboration with all members within their supply chain. It appears that logistics is seen from a functional perspective rather than a strategic one in HA organisations. Despite this, there is evidence of agility within humanitarian organisations. Due to the nature of natural disasters, humanitarian organisations have developed some competencies in rapidly aligning their supply chain. They are able to use market knowledge and logistical processes to be flexible in their responses to turbulent environments. However, their organisational structures and information systems are sometimes insufficiently developed to enable them to act as 'virtual corporations'.

While many of the organisations demonstrated agile capabilities, it is evident that it is common practice to hold prepositioned stock. It appears this is out of necessity due to suppliers being unreliable and ill equipped to match surges in demand when natural disasters occur. It is evident that humanitarian organisations lack the ICT capability to link networks and that in many cases their suppliers often lack the capability to meet such volatile demand requirements. As well as this, postponement principles are often used, as prepositioned stocks are customised according to, for example, region/climate/religion at the last minute before they are deployed. This suggests that a leagile strategy is more useful, implementing lean principles upstream of the prepositioning point and agile principles downstream. This is becoming particularly relevant as donors are increasingly pressurising HA organisations to do more with less.

In addition to a lack of coordination with other HA organisations the questionnaires revealed there is very little collaboration with suppliers. There is little evidence of strong relationships with suppliers bar two organisations (and that is only for certain products with their most reliable suppliers). This, coupled with a lack of coordination with other HA organisations, acts as a significant barrier to process, virtual and network integration. Another barrier, and arguably the most significant, is a lack of ICT and technology within HA operations. It is impossible for HA organisations to achieve the levels of integration required to be 'truly agile' without significant investment in their systems. A few of the bigger organisations have invested heavily and as a result have a better level of integration than the others. This has allowed them to introduce VMI in some form with success; however, they are far from being fully integrated. Without building relationships and an overall upgrade of all the members ICT systems the benefit of one organisation investing is significantly reduced.

Overall it is clear that, although barriers still exist, some of the leading HA organisations are becoming more agile. The biggest challenges currently being faced are: lack of investment in ICT, unreliable suppliers as well as a lack of a strong relationship with suppliers. The findings reveal that a significant problem area is a lack of coordination with other humanitarian organisations. It is evident that as well as this there is a clear gap in the collaboration with other members within their supply chains (suppliers, donors, etc.) which restricts the degree to which their supply chain is integrated. The majority of organisations (both large and small) illustrated key characteristics of agile organisations. They are able to rapidly align their network and operations despite the volatile and turbulent environment in which they operate. Furthermore, there was evidence of postponement in nearly all the organisations as the use of prepositioned stock appears commonplace. The popular practice is to hold generic stock and then customise 'last minute' to cater for individual needs. The organisations involved suggest their supply chains are predominately demand driven; however, prepositioned stock is used as suppliers can often be unreliable in crisis conditions and generally do not have the capacity to provide goods at very short notice on the 'just-in-time' principle. For unusual items that are very specific to certain disaster types the organisations use direct procurement in order to rapidly respond.

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A WEB-BASED APPROACH TO DESIGN ENERGY-EFFICIENT PRODUCTION SYSTEMS

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ABSTRACT

Nowadays, companies are faced with ecological challenges like increasing the energy efficiency of production systems. Mostly isolated measures are executed to increase the efficiency of a specific system element. The reason for that is the lack of a holistic approach of energy-orientated production system design in both science and industry. The developed approach aims to abolish these deficits. The paper describes the following findings: systematization of measures to increase energy efficiency, system elements with substantial impact on the energy efficiency of production systems and interactions between these elements. The paper closes with the explanation of the holistic method, which supports the evaluation and design of energy-orientated production systems.

INTRODUCTION

In 2009, the German industry held a proportion of approx. 26% of the total final energy consumption [1-4]. Although the potentials for economizing energy in the industrial sector can be considered very high at 25 to 30 % [5] and the sustainable, especially energy and resource-efficient production is gaining importance [6] [7], so far only very isolated measures for their increase can be found.

The current measures for the increase of energy efficiency are mainly being carried out in factory operation and therefore generally linked with very high costs [8]. In addition, companies primarily place emphasis on the increase of energy efficiency of individual equipment [9]. At this, however, the fact is being neglected that individual equipment is embedded into the complex total system "factory". As a consequence, the interactions, which occur within the factory, remain unnoticed and thus also the resulting potential for resource economization. For example, the layout planning and, at this, the alignment of facilities in the new planning or reorganization of a factory occur depending on the floor plan of the building. At this, energy-relevant building characteristics remain disregarded, however. This can lead to the fact that processes with a high heat emission may be aligned ideally in the sense of the material flow, but a lower height of the hall or the direct sun radiation require the actually avoidable cooling of the area.

Although the later energy consumption of the factory is decisively determined in the early phases of factory planning [6], energetic questions are only insufficiently considered within the framework of holistic factory design. Primarily, this can attributed to the fact that in operational practice as well as in research there is a lack of methodic supports for the design of sustainable, energy-efficient factories [6, 8, 10].

Therefore, the target of the project, which is supported by the Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung), is the development of a method for the holistic evaluation and design of sustainable, resource-efficient factories. The method to be developed should be supported by an internet-based evaluation tool so as to facilitate the handling for the user.

The observational focus of the project is directed at the interactions of all system components, which can be assigned to the fields of influence site, building services, process and organization, existing within the total system "factory".

To realize this, an integral consideration of the problem by an interdisciplinarily assembled team is necessary. This consists of architects (RMA Architekten GmbH & Co. KG), building services technicians (ENAKON Wolfenbüttel GmbH) and factory planners (Institute of Production Systems and Logistics of the Leibniz University Hannover, IFA). According to the corresponding competences the architects are responsible for the fields of influence location and building, the building services technicians for the field of influence building services and factory planners for the fields of influence process and organization (Figure 1)

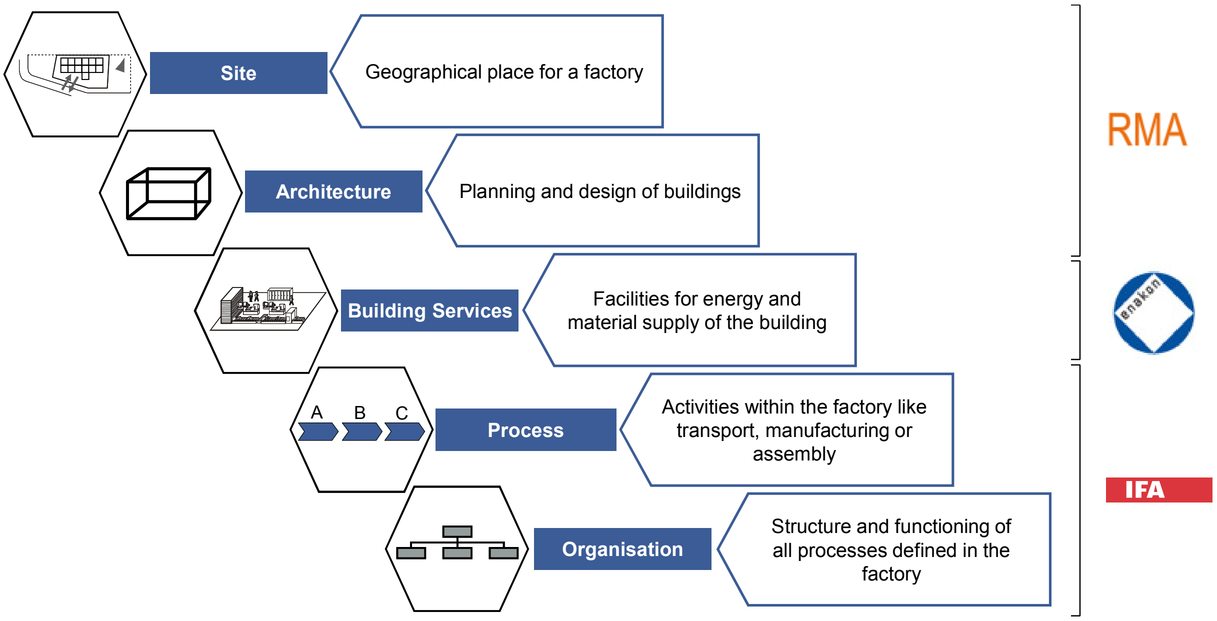


Figure 1: Fields of influence of factory planning

The research process basically consists of three main steps: In the first step, measures to increase the energy efficiency of production systems were gathered and systematized. In the second step, the system elements with the most substantial impact on energy efficiency of production systems were analyzed. Based on this second step, a holistic method was developed (3rd step), which supports the evaluation and design of energy-orientated production systems. Within the framework of the method, a practice-orientated and manageable course and structure are necessary so that a simple and goal-orientated application is possible. The use of this method enables especially small and medium-sized companies to evaluate their factories concerning a sustainable and resource-preserving design and derive corresponding measures. This is reached by means of a scalable degree of method detailing. For an estimated contemplation, the variables to be polled are firstly reduced to key variables, which can be analyzed in more detail in a second step.

The research process was accompanied by a comprehensive literature review and interviews with a panel of experts. In addition, a dependency structure matrix was used to identify the relation between different factory elements. All findings were checked in a concurrent validation with industrial partners.

FINDINGS

Systematization of measures to increase energy efficiency

In the first working step of the project, the focus was on the investigation of the aspects manifested by a sustainable industrial building. For this, literature research and analyses of former industrial projects were primarily carried out. The thus gained insights were additionally complemented by a survey of experts. Within the framework of this project, people from the environment of the three project members were named as experts. The interviewees had a vast body of experience concerning the planning of energy-optimized production systems.

The investigations have shown that all measures for the increase of energy-efficiency, independent of their effective area, can finally be attributed to a limited number of aspects. For example, [6] and [8] also identify six action approaches (effective degree, reduction of losses, recovery, substitution, dimensioning and mode of operation) for the increase of energy-efficiency in a widely set literature investigation.

Measures in the fields of influence location, architecture, building services and process can be attributed to these approaches. However, these approaches do not comprehend all the measures within the field of influence of organization. But since precisely this field of influence is of large significance against the background of a socio-technical system understanding, the action approaches were extended to the aspect "sensitization" within the framework of the project. At this, sensitization is especially aimed at the people, who act within a factory and therefore have a direct influence on the energy-efficiency. Together they form the "Seven Dimensions of Energy-Efficiency"(Figure 2).

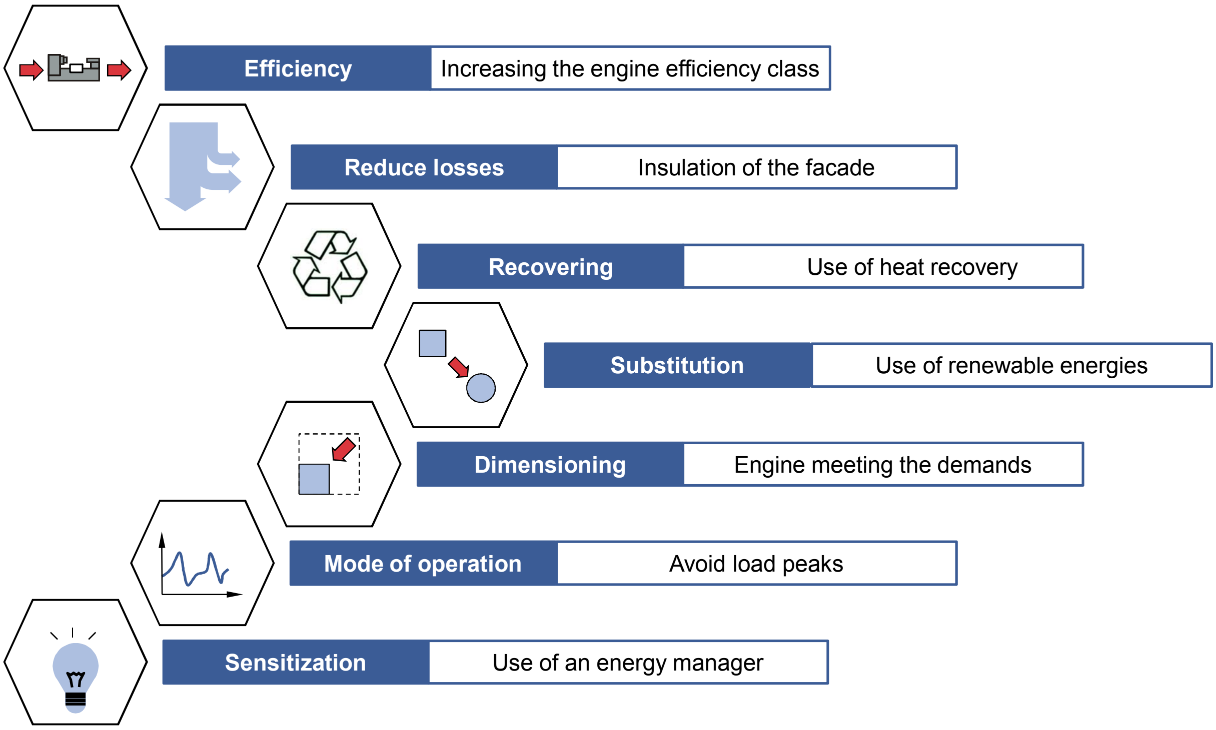
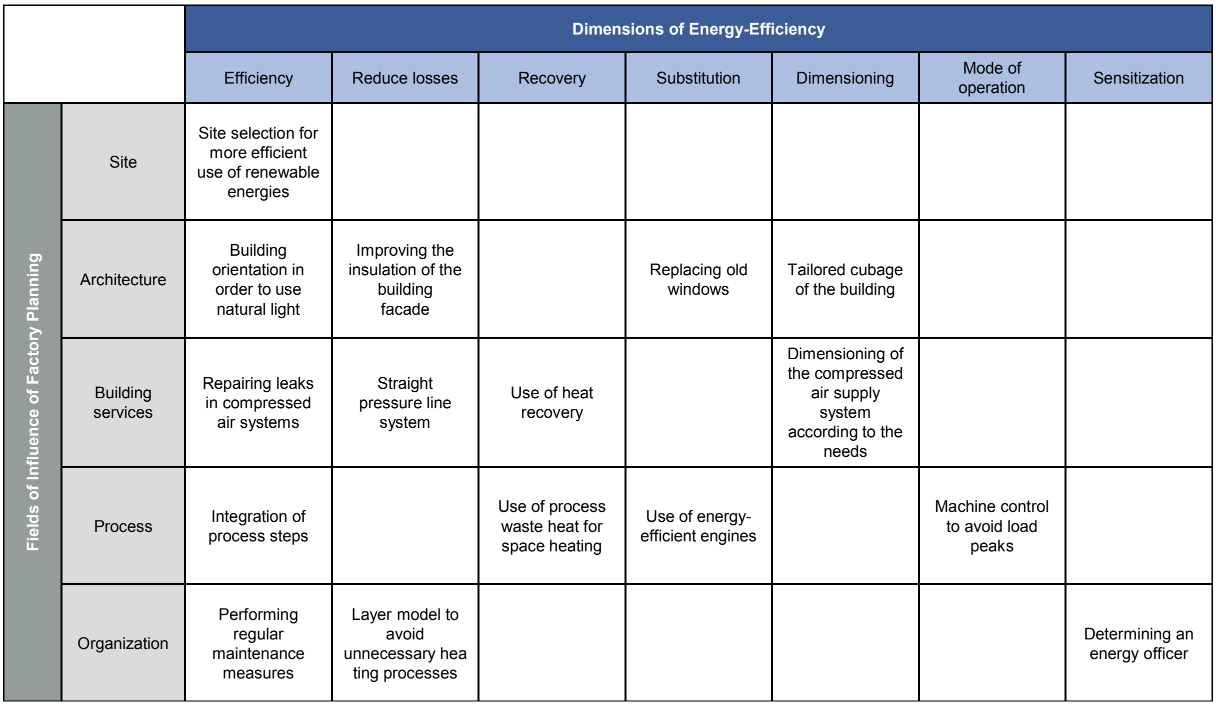


Figure 2: Seven dimensions of energy-efficiency [11]

A matrix was erected based on the "Seven Dimensions of Energy Efficiency" and the five fields of influence. This matrix represents the basis for the systematization of design recommendations for the increase of energy efficiency. With the aid of this systematization it is possible to structure Best Practices in a clear way for the users. Figure 3 shows an extract of this matrix. For example, if one regards the field of influence organization and the dimension of sensitization, a possible optimization measure is the assignment of an energy officer or the introduction of an energy-orientated bonus system for the employees.



		Dimensions of Energy-Efficiency						
		Efficiency	Reduce losses	Recovery	Substitution	Dimensioning	Mode of operation	Sensitization
Fields of Influence of Factory Planning	Site	Site selection for more efficient use of renewable energies						
	Architecture	Building orientation in order to use natural light	Improving the insulation of the building facade		Replacing old windows	Tailored cubage of the building		
	Building services	Repairing leaks in compressed air systems	Straight pressure line system	Use of heat recovery		Dimensioning of the compressed air supply system according to the needs		
	Process	Integration of process steps		Use of process waste heat for space heating	Use of energy-efficient engines		Machine control to avoid load peaks	
	Organization	Performing regular maintenance measures	Layer model to avoid unnecessary hea ting processes					Determining an energy officer

Figure 3: Systematization of guidance to increase energy-efficiency [11]

Relevant Factory Elements

At the Institute of Production Systems and Logistics, a factory model has been developed, which divides the factory into levels and design fields. Within this division, system elements can be described on the different system levels [12]. This model was used as the basis for the identification of the energy-relevant system elements. Within the frame of the determination of the relevant system elements, the original model was modified such that, for example, new elements were introduced or existing models merged. The identified system elements can be systemized by means of initially defined fields of influence.

The field of influence site puts the factory into a global context and, in addition, addresses location-wide aspects for the increase of the energy efficiency of the factory. Therefore, the field of influence site is divided into the two rough objects ecology and infrastructure/media.

The field of influence building deals with the building installations on the factory premises. To detail this field of influence, a differentiation of the rough object into hall building, low building, multi-storied building and special building is carried out.

The field of influence building services deals with the supply of resources directly at the place of consumption. This field of influence is differentiated into six rough objects. The rough objects heat supply, cold supply, ventilation system, compressed air supply, electricity supply and lighting systems were derived.

The field of influence process mainly determines the energy consumption within the factory and focusses all main and side activities, which are part of the performance compilation process. These process characteristics result in requirements towards the other fields of influence. All in all, this field of influence is divided into four rough objects: production, assembly, transport and storage.

Apart from purely technical measures there are also numerous organizational measures, which lead to an increase of the energy efficiency within a factory. These soft factors are comprised in the field of influence organization. In addition, further parameters, such as turnover or the number of staff are inquired for the categorization of the investigation object in the dimensioning column (Figure 4).

	1 Site	**2 Architecture**	**3 Building Service**	**4 Process**	**5 Organization**
Objects	1.1 Ecology 1.2 Infrastructure/ Media supply 1.3 Renewable energy	2.1 Hall construction 2.2 Low-rise buildings 2.3 Multi-storey construction 2.4 Special buildings	3.1 Heating 3.2 Cooling 3.3 Ventilation 3.4 Compressed air 3.5 Power supply 3.6 Lighting	4.1 Manufacturing 4.2 Assembly 4.3 Transportation 4.4 Storage	5.1 Organizational structure 5.2 Operational structure 5.3 IT 5.4 Branch 5.5 Revenue
Assessment	Annual consumption, energy, the generated amount of renewable energy and age of the infrastructure in relation to plant areas	Ceiling heights, gross floor area, natural lighting, and building age	Energy-related process elements, design and age of equipment	Major energy producers and effectiveness of energy supply	Energy issues within the organization

Figure 4: Relevant system elements

Method for the evaluation of the energy efficiency of production systems

A two-step method has been developed for the systematic evaluation of the energy efficiency of a factory. In the first detailing step, the so-called quickcheck, an estimated evaluation of the factory is initially carried out with the aspects to be inquired concentrating on the key characteristics. For the examination of the observation object, so-called portraits are compiled for each field of influence, which then serve for the recording of data.

In the second detailing step, a detailed analysis is performed with the aid of the so-called scantool. At this, the rough objects defined in the quickcheck are further divided into so-called fine objects and subjected to a more exact analysis. Figure 5 illustrates the structure of the method schematically. It is recognizable that, for example, the rough object low building is classified into the fine objects roof, front and floor surfaces.

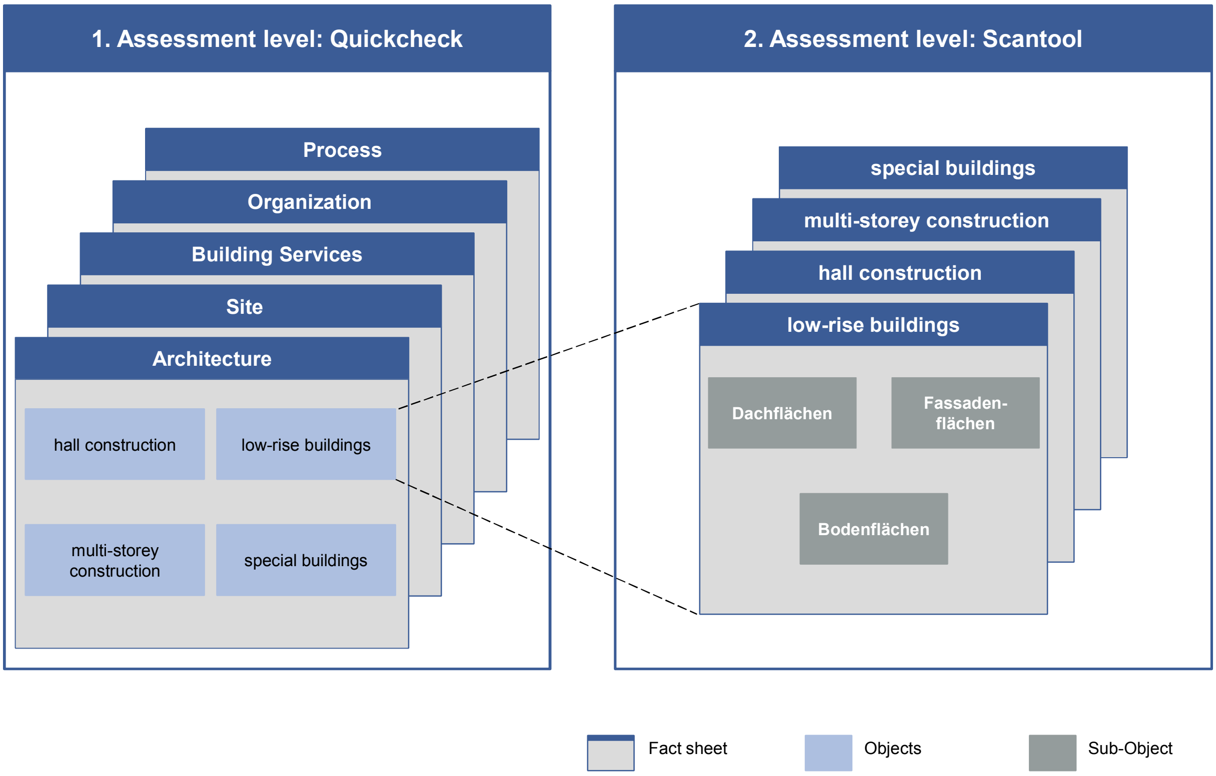


Figure 5: Schematic structure of the method [13]

The procedure model within the scantools is divided into six steps, which will be explained in more detail in the following:

1. Query of the factory data

By means of deposited portraits the data of the fine objects required for the further processing are collected within the five fields of influence.

2. Calculation of the energy needs and gains

The collected data are now to be balanced. The needs are intentionally identified as a basis of the analysis. A subsequent comparison of the calculated needs and consumptions will help to detect possibly inefficiencies in the utilization of the factory, buildings and installations.

3. Illustration of the analysis results as an "energy tree"

In the third step, the calculated energy needs and gains are transferred to a so-called energy tree. The visual capture at one glance facilitates the recognition of fundamental influences on the total balance and the assessment of decisive set screws for the enhancement of potentials.

4. Derivation of design recommendations considering interactions

In the fourth step, the derivation of possible design recommendations takes place. An especially success-orientated line of action implies a prioritization of the optimizing measures, which an order of handling can be derived from. At this, the prioritization occurs by means of the two target criteria energy efficiency potential and cost effectiveness. For the derivation of design recommendations the initially described systematization of the measures is resorted to on the one hand. On the other hand, a further matrix containing the deposited interactions between the different system elements is used. This directly demonstrates what kind of effects the execution of single measures has on the total system. By this means the generation of local optimums can be prevented; however, the total system finally deteriorates.

5. Illustration of optimization potentials in the "energy tree"

The fifth step serves to illustrate the potentials for energy saving and energy gain detected in step 4. The effectiveness of single measures in their extent up to the influence on the total balance is to be understandable. This enables the trading off of the design recommendations against each other, which is very beneficial against the background of the arising costs and compulsions in the execution of the optimization measures.

6. Detection of the achievable eco-factory energy category

In the sixth step, the classification of the production system into an eco-factory category is carried out.

Eco-factory categories

The evaluation of the energy efficiency in factories is based on the philosophy of lean production. This places its main focus on the target of avoiding any kind of waste and only carrying out purely value-adding activities [14]. Transferred to the energy consumption in the factory this means that the target is to remove any kind of energy waste and that the energy to be consumed has to flow into purely value-adding activities. Since on the one hand, there are numerous energy-consuming processes/objects within a factory, which are not directly value-adding but urgently necessary, and on the other hand, losses coercively occur due to physical laws, a modification of the understanding has to carried out.

Therefore, in the sense of the project we speak of an energy-efficient factory – eco-factory, – if the energy consumption of the process has been reduced to a minimum based on the standard of technology, a zero-energy building is being used and all energy needs for building services and other non-value-adding aspects are being covered by process energy losses as well as regenerative energies.

VALIDATION EXAMPLE

In the following, the content of the method is introduced with the support of a practice partner in an exemplary manner. As the first practice partner the production location of Modine Europe GmbH in Kottingbrunn could be explored. At this, the developed inquiry systems and evaluation schemes were examined concerning their plausibility and practicability.

The practice example showed that thermic processes as well as varnishing and drying processes exist. Thus, the possibility of heat coupling exists. However, it was not being used and thus influenced the evaluation negatively.

The very young works structure and few applied forms of energy supply had a positive influence on the evaluation. A further analysis clearly showed that few of the customary measures to increase the energy efficiency had been implemented so that the total result was influenced negatively.

Figure 5 shows the formerly mentioned energy tree for the validation example. It becomes clear that energy losses occur especially in the area marked in grey and an increased optimization potential exists at this point.

All in all, it was detectable that the right questions are being asked within the framework of the method and the handling is considerably easier due to the web-based tool.

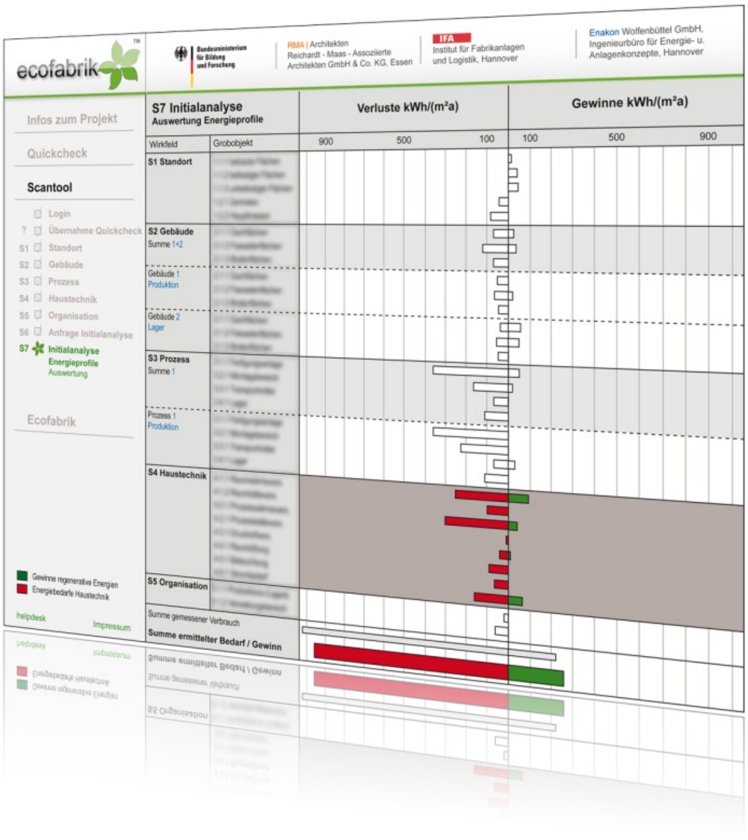


Figure 6: Analysis results depicted as an "energy-tree"

SUMMARY AND OUTLOOK

Against the background of the current development and challenges, energy-efficient production is increasingly gaining importance, even in less energy-intensive branches. So far, however, only single measures are often being executed to increase the energy efficiency in the factory. Due to this, many potentials of a holistic optimization remain unused. The article on hand is taking this problem on and introducing an internet-based evaluation method, which takes these deficits on and enables an integral evaluation and design of energy-efficient factories. At this, the method introduced is especially directed at small and medium-sized companies and tries to create an effective and efficient balance between analysis effort and benefit generation.

Based on the two-step methodology a data base is to be generated with the aid of further practice partners in future. After the evaluation of these sets of data, a branch-related benchmarking of energetic state-of-the-art solutions on the way to the energy-efficient eco-factory will become possible.

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A MULTIDIMENSIONAL APPROACH TO PACKAGING WASTE REVERSE LOGISTICS EVALUATION IN RETAILING

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ABSTRACT

Deriving from insights gained on a concrete project research, the aim of the paper is to present the results and methodology of a packaging waste logistics exploratory study that was conducted in cooperation with a leading south eastern European retailer.

INTRODUCTION

Principles of sustainable development have been steadily permeating into business reality from the realm of declarational constructs and political rhetoric through purposively oriented legislation and corporate citizenship initiatives. Minimizing the ratio between the material needed to maintain certain level of economic activity and the provision of goods and services, waste prevention and reduction of the share of its disposal and exploiting residuals as secondary resources instead of virgin raw materials are an economy-wide commonplace and will be even more pronounciated going into the future. Additionally, we are experiencing a significant retail logistics and supply chain transformation (Fernie, Sparks & McKinnon, 2010) where retail companies have become the architects of supply chain – from supply to consumption. In such environment, retailers play a double role: that of consumption enablers or catalysts and generators of significant (negative) direct footprint themselves, by their own operations. Logistics in retail may be perceived as equal to production in manufacturing and packaging being its integral component is inherently present in associated material flows that are furthermore closely correlated with the level of commercial activity (Triantafyllou & Cherrett, 2010, p. 16, 58). Consequently, every item issued, shipped, distributed, received, stored and sold leaves a trail of residuals and packaging is ultimately according to McLeod, Hickford, Maynard, Cherrett & Allen (2008, p. 76): »... the most significant waste stream produced by the retail sector«.

LITERATURE REVIEW

Packaging waste (PW) has been characterized as being an important and growing waste stream (EEA, 2005, p. 5). McKinnon (in Fernie, Sparks & McKinnon, 2010) identified 6 components of retail logistics transformation, one of them being the augmented involvement of retailers in reverse logistics (RL) operations, amplified by increased flow of packaging (PCKG) and handling equipment returned for later treatment or re-use. Efficiency in connection to retail RL was studied in DfT (2004) on the segment of product returns. PCKG RL with consumer-based primary PCKG return system possibilities was researched in a project, reported by McGhie (2001). Retail waste management (WM) was already studied in the context of city logistics reverse flows (McLeod, Hickford, Maynard, Cherrett & Allen, 2008, Maynard & Cherrett, 2009) or on the scope of a dedicated shopping centre (Triantafyllou & Cherrett, 2010). Pitt (2005) focused on the performance of a group of UK shopping centres in regard to waste production and disposal over several years, while facility-centred WM efficiency had additionally been extended also to airports (Pitt & Smith, 2003). An inverse logistics and recycling facilities network evaluation system was developed and applied to collecting and recycling municipal waste plastics by means of simulation and virtual engineering in Yoshinaga, Nishina, Inoko, Saito & Tsuyuguchi (2002). Further outside retail domain construction site material and waste flow was modelled and examined (Shakantu, Muya, Tookey & Bowen, 2008), while Hogland & Stenis (2000) conducted an assessment and analysis of an industrial waste management system (WMS) at a large paper company and Abeliotis, Karaiskou, Togia & Lasaridi (2009) developed a decision support system for analysing solid WMS on national and municipal level. Methodologically, European Commision Environment DG (2003) proposes a WM planning guidance and UNEP (2009, p. 7-9) sets forth basic analytical perspectives on WMS. Finally, literature review revealed at least 4 distinctive – though not mutually exclusive – concepts of efficiency: physical (Samuelsson & Tilanus, 1997), technical DEA (Cooper, Seiford & Zhu, 2011, p.5), economic (applied to environmental policy measures in EEA, 2005) and eco- (WBCSD, 2000, p. 4) efficiency, that are potentially applicable to the problem of WMS evaluation.

PROBLEM DESCRIPTION

PCKG WMS (PWMS) efficiency evaluation was carried out for one of Slovenia's leading retailers, commanding a more than 30 % market share and with an annual turnover nearing 3 billion euros. Company is the single biggest corporate waste producer, having generated over 8 % of all commercial waste, generated by commerce, trade and motor vehicle maintenance sector in 2010. Several factors, making retail PCKG WM (PWM) in general and in our topical case a pressing issue with specific implications were identified: sheer material volume, spread of origination points, source-based sorting, legislative requirements and constraints regarding PW collection and recovery (Directive 2008/98/EC, EEA, 2005, European Parliament and Council Directive 94/62/EC), questionable internal closed loop recycling feasibility (apart from returnable transport items and other handling equipment re-use), limited potential for seamless inter-firm by-product exchange (resulting from differences within separate supply chains (e.g. McLeod, Hickford, Maynard, Cherrett & Allen, 2008, 121-123)) and FMCG assortment price sensitivity to any costs incurred by extra activities. In next several quarters the company intends to implement a set of measures as part of its strategic WM plan: updating internal WM policies and guideline, centralized electronic waste register launch, mapping of WM processes and tenant relationship integration within WM practice. Overall goal of the project (dealt within the reported case study), which was set by the company, was to gain a better understanding of the existing PWMS on domestic Slovenian market and improve the visibility of its underlying processes, specifically on store level. An additional request was to conceptualize a model for PWM cost allocation in reference to the waste origination points – sources represented by individual retail units. Those make up a network of 516 retail locations (excluding franchises and company operated restaurants and tourist agency offices), which are supplied from 9 distribution locations, with yearly cumulative output of sorted and collected PW refuse from all domestic locations company-wide exceeding 11.000 t.

RESEARCH WORK

Research study work breakdown structure followed the process of WM planning and methodology set out in European Commision Environment DG (2003). We derived from 3 WMS analytical perspectives when defining the domain and setting the basis for the research (UNEP, 2009, p. 7-9): life-cycle, management and generational. Against that backdrop, existing topically-related research was used to refine the study proposition and methods, although similarly focused and comprehensive (in design and scope) studies are not common. Epitomizing the research aim, the main study question was formulated as follows: What is the efficiency of PWMS and how is PWM implemented and actually performed in the specific setting? Primary unit of analysis was the conceptual entity of PWMS at the respective retailer. Being a less well defined unit of analysis (Yin, 2003, p. 23), the single case design would further evolve into a single-case embedded case-study design (Yin, 2003, p. 40-45). A designated hypermarket (HM) assumed the role of the primary embedded unit that would serve for representational abstraction of the superior research problem (PWMS), offering the examination of PWMS' specific operational details. It was selected firstly, because HMs as the largest and most complex retail units include the entire range of RL activities, exhibited by a retail network and secondly, the concrete store was moderately to strongly correlated with 14 out of 21 HMs on the basis of monthly PW output, the most out of all HMs. The HM was the largest part of a shopping centre, which is owned and managed by the retailer who is also its anchor tenant. Furthermore, additional supportive embedded units were included for comparative and derived validation purposes, research instruments testing and case-related scope integrity. The inter- and inner- format replication was confirmed by visiting 2 other HMs, 2 supermarkets (SMs) and 2 retail shops (RSs) through video-documenting, process-mapping and comparing associated PWM processes. The focus was on the retail back-office, where pure PWM activities weren't just an integral part of regular process, no other functional units such as sales goods were bundled in the activity and excluding certain movements or handling that would've been performed regardless of PW presence (such as shop-floor handling and return when re-stocking). Reverse flow of interest was limited to commercial PW (secondary and tertiary PCKG (European Parliament and Council Directive 94/62/EC)). Huge Brodin’s (1997) perspective of RL systems was adopted with addition of collection phase and minus re-processing, considering the reverse feedback loop as a supply chain on its own. PCKG design and minimization were thus intentionally omitted (dealing with the waste generation profile as it is), however, they also weren't included in the scope of the underlying project. Multiple sources of evidence were used, consisting of: focused interviews with executive logistics director, executive purchasing advisor and environmental department team members, with whom 2 milestone meetings were carried out during the project; waste stream measurements at the selected source by means of weighing; on-site employee open-ended interviews, process analysis and mapping through direct and participant observation; and PWMS policy documentation and archival records, considering the PW collected on company and selected origination points level. Finally, findings were reported and discussed with the companies' internal stakeholders (logistics, environmental, sales and purchasing representatives alongside the respective management board member) and the management of PWM company (PWMC), who runs the collective PWMS.

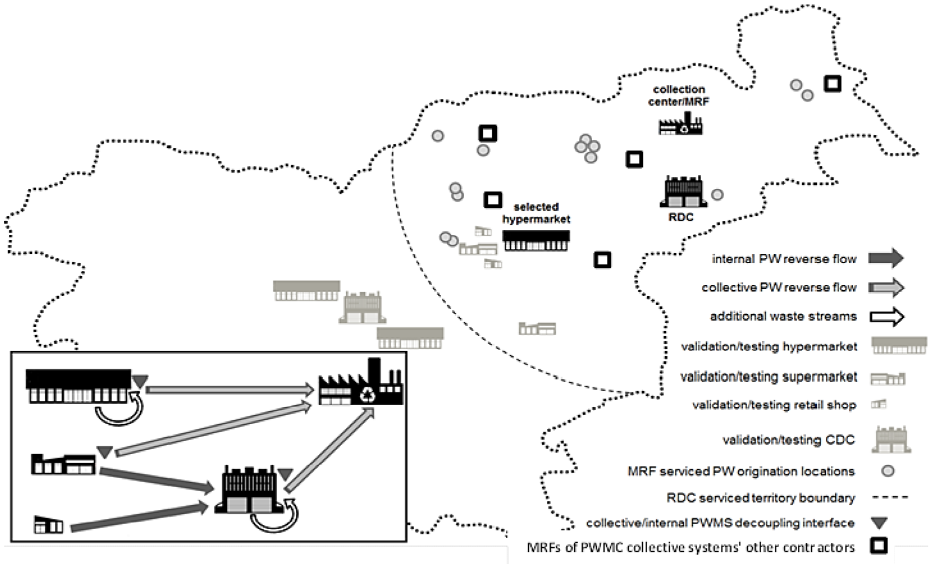

Figure 1: Examined PWM network subsystem and its accompanying RL channel structure.

ANALYSIS AND RESULTS

Company is a complier in a collective PWM system and utilizes a partially integrated outbound and RL network configuration and disposition in an open-loop collective system, according to its organization (DfT, 2004, 24-25) and material flow (Bain, Ashton and Shenoy, 2009), respectively. Internal PW reverse flow starts with the process of primary collection at the source (origination point) which is the retail unit or origination point (ROP), where PW is generated: on the shop-floor when the goods are re-stocked at the shelf (then on the return to the storage area PW is sorted and transferred – usually from a shopping trolley – into a roll-cage (RLC)), in the storage area during goods receipt and storing (again the PW is deposited into the respective RLC, depending on the PW type and storage section), during stock-picking in the storage area before shelf replenishment (PW can be deposited into the RLC directly at the point of de-packing, or transferred en-route to the shop floor, depending on the original goods storage location). RLC is the basic receptacle and PW handling unit, which is in bigger store formats (HMs, larger SMs) placed at a fixed storage-section-specific collection point, where normally 2 RLCs – 1 for paper and cardboard and 1 for foil and plastics – are situated. Number of collection points in bigger retail formats depends on the number of goods sections (for instance: drinks, confectionery, fruit and vegetables, meat and dairy). When collection RLCs are full, the PW is transported manually to the waste service bay on the loading dock, where the refuse is sorted and transferred by hand into appropriate containers, according to the type of PW (usually there are 3, 1 for each type of PW: paper/cardboard, foil/plastics and wood). Containers represent decoupling interfaces where primary collection ends and the secondary collection in the domain of a 3rd party service provider begins. PW is carried over into the collective reverse flow, which is external to the company and is managed by a waste collector under contract with the PWMC, who represents and manages the umbrella collective system. PW from larger store formats is transported to the collector's material recovery facility (MRF) by hauling full containers or transhipping the refuse at the ROP into a receiving container on a flatbed truck. In comparison to larger ROP, when the internal PW flow originates from RSs and regular SMs it can be broken into 2 segments: an expanded primary collection (extending beyond in-facility collection), which is coupled with preliminary storage stage. PW is not transferred at ROPs into containers by the collector but awaits pick-up, stored in RLCs, and is back loaded onto retailer's goods delivery vehicles in exchange for primary shipments at each store that was serviced in order to be transported on their return trips back to the regional or central DC later on. The collection is integrated deeper in the retailer's operations, where DCs serve as internal PW flow consolidation points. There, delivery vehicles are unloaded, RLCs with PW are temporarily stored on an appointed dock, and are later emptied into collection press containers that compact the refuse. PW is then transported in container-unit loads by the collector to his MRF. Primary collection here doesn't end with with PW handling within the ROP, but includes also the transport to the DC and the internal PW reverse flow integrates an extra stage of preliminary storage (Directive 2008/98/EC on waste, art. 16) of waste pending secondary collection. PW is unloaded and prepared for further pick-up and transport for recovery at the MRF.

Research aim required a development of an analytical framework which conceptually directed data collection and analysis and highlighted different problem-specific areas that were included and examined in the research (see Figure 2). Data was analysed and findings interpreted using the proposed framework and contrasted to virtually-engineered reference options, representing an ideal case situation for the current PWMS evaluation purposes. The framework comprised an efficiency model, integrating different PWMS pillars of efficiency with interdependency areas, which defined the main attributes for evaluation and adhered to 4 general PWMS efficiency principles. Its use was aimed at determining waste stream characteristics (generation quantities, dynamics, composition and treatment), waste origination points, handling locations and technology, PWM processes and corresponding RL channels. In following sections we present the outline of main framework-derived findings.

PWMS was analysed, considering both, the structural and flow component. The first one concentrates on the overall performance in terms of quantities generated, collected and disposed on a nodal-specific or network-wide level. The out coming network disposition efficiency was examined by comparing the current network configuration with a simulated ideal scenario where resources (trucks, collection equipment, recovery facilities) from different contractors, operating under the PWMC, whose complying participant is also the retailer, could be pooled together. Such joint RL platform would offer collaborative services, taking the advantage of complementary geographical coverage and capacities. Associated ideal network flow had been modelled and external flow, managed currently by a single exclusive waste collector was simulated to have been rediverted to alternative destination MRFs (see Figure 1), that already operate under the same collective PWMS. This would require an intervention outside the retailer's boundaries, but could potentially significantly improve network efficiency as the company is the scheme's largest PW generator, and such strategic shift in the eastern retailer's network subsystem could lower yearly overall network PW transport intensity in tonne-kilometres on average of up to 45 percent (in reference to 2010 baseline PW generation profile).

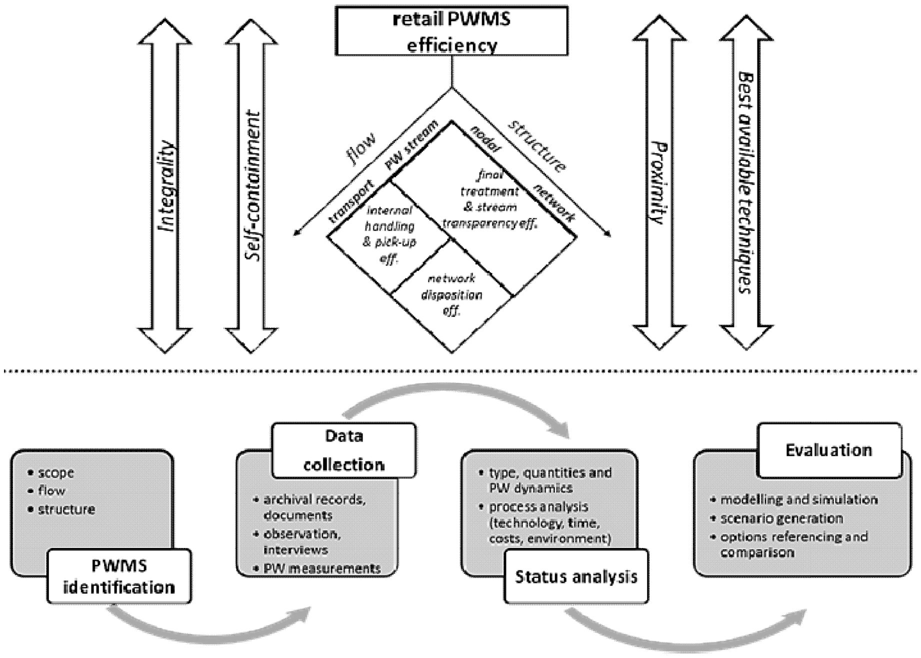

Figure 2: Employed analytical framework and methodology with PWMS efficiency model.

In parallel, nodal and flow interface at the transport level includes internal handling efficiencies in connection to time and space utilization and pick-up/haulage efficiency. Different collection technologies were tested by adding press-containers with and without self-loading mechanism, which could at the same time facilitate the most labour intensive activity: PW transfer from RLCs into containers, and reduce the number of yearly required pick-ups by a factor of up to 6, which approximately corresponds to the compaction ratio between bulk and pressed refuse (the benchmark values were obtained from several manufacturers and empirically from the hauled press-container weight data at the central and regional DCs, where the technology is being employed to prepare the PW prior secondary pick-up by the waste collector). At the same time, using the combination of waste stream and nodal perspective enabled the conceptualization of a source-based ROP PW handling cost model. We have conducted continuous 1-week measurements of collection RLCs in the selected HM by weighing them before they were emptied into external collection containers. The weekly sample included 112 outbound PW collection RLCs, which were weighed and photographed and whose handling activities were timed (see Figure 3). Measure or attribute, which determines the activity costs was PW quantity, expressed as the average estimate of net RLC weight: cost driver unit measurement was translated into the net weight of full PW-filled RLC (RLC equivalent unit, REU). With the transposition of unit measurement into weight dimension and generalization of sampled waste stream composition a cost allocation model can be specifically applied to any ROP, using the following inputs: facility layout, PW type-specific quantities and process technology (containers, compactors, or back loading). Further costs, associated with the extended internal primary collection and preliminary storage, when taking into account also the DOPs and smaller ROPs, were alternatively proposed to include several extra factors: RLC loading/unloading, delivery vehicle downtime, dedicated storage and handling area floor-space, register-keeping and administration and opportunity costs (costs of interference with the primary business activities and forward flow).

Lastly, the final efficiency intersection of structural and waste stream components included the evaluation of transparency and shares of PW output according to different waste hierarchy treatment methods (Directive 2008/98/EC on waste, art. 4) and compared to the inbound goods flow. For 2 PW removals exact HM PW output, restricted to the retailer as the anchor tenant of the shopping centre, was empirically measured. In addition to HM generated paper/cardboard PW, a surplus of 60% and 100% of PW that had been processed by the HM's PWMS during the observation period indicated an existence of unaccounted waste streams, indicating secondary shopping centre tenants and other sources contributions or in-process imbalances. Similarly, a regression analysis, using volumes of goods received and issued and the number of handled transport units as predictors from referential warehouses that don't handle PW back loading, indicated, that in the non-integrated part of the PWMS (one with intermediary storage at DCs) as high as 86 % of the PW, which is aggregately assigned to DCs, is coming from individual smaller ROP and is masked in the DOP PW output, while the unaccounted stream, resulting from pure DC operations makes up the rest.

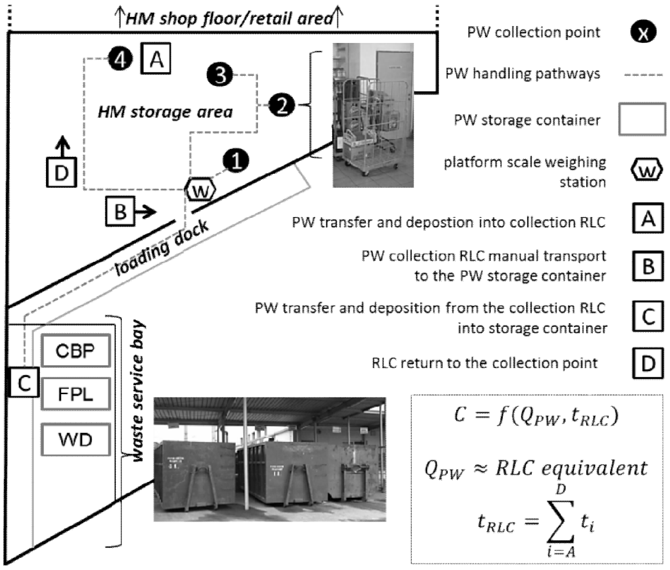

Figure 3: Selected hypermarket's PW handling process layout with general cost model.

DISCUSSION

Presented hierarchical efficiency model, extending the principles of Samuelsson and Tilanus' (1997) transport physical efficiency, was applied to a real-life retail PWMS evaluation problem, where we built upon logistics system analysis approaches, proposed by Coyle, Langley, Gibson, Novack & Bardi (2009, p. 62-69). Besides what to explore and how to analyse and juxtapose PWMS characteristics with ideal reference options, specific guidelines were also acknowledged on a flow and structural PWMS level: the network should enable PW recovery at the nearest available facility with best available techniques (Directive 2008/98/EC, art. 16, Council Directive 96/61/EC, art. 2), without over-burdening the business system's regular processes by taking on excessive and sustainability-wise unjustifiable PW amounts (self-containment) and recognizing RL processes in full length (integrality). The methodology allows for different evaluations: internal benchmarking of peer ROP, external company-wide benchmarking or ideal options comparisons with incumbent PWMS characteristics. It enables a conceptually proven approach and provides a structured extension to quantitatively based methods that can be used in RL and WMS problems, such as MCDM and DEA analysis, as well as OR and optimization procedures. The proposed and demonstrated framework was applied on a limited retail network scope, although it provides a basis for decision-making and potentially regular or one-off evaluations on different company and network levels. Further research gaps that may be considered in the future are the inclusion of DOP operations in the scope of PWMS evaluation, management of unaccounted waste streams, and to achieve a system wide transparency, coupled with complete source output visibility, feasibility study for setting up a smaller store format PW quantity monitoring and registry.

CONCLUSION

Packaging waste is an immanent retail challenge. If its associated reverse logistics is to become a true function of sustainable development that could also be sustained in the long-term not only on a declarative level but also on the level of underlying processes, conventional efficiency thinking must be adapted to a sustainability context: "making or selling more with less", coupled with "doing or processing more with causing less", while retaining economic viability. Better reverse processes visibility and well-defined pertaining performance measures should contribute towards an organizational and physical network structures re-evaluation, founded on tangible and practically-relevant criteria, as it is presented - in improved physical organization, better system transparency and potential cost reductions.

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CUSTOMER SEGMENTATION BASED ON BUYING AND RETURNING BEHAVIOUR: SUPPORTING DIFFERENTIATED SERVICE DELIVERY IN FASHION E-COMMERCE

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ABSTRACT

PURPOSE:

Designing supply chains and organisational strategies in the fast-moving consumer goods business, especially within fashion e-commerce, requires a profound understanding of customer behaviour and requirements. The purpose of this paper is twofold: firstly, to empirically test and support whether a "one size fits all" strategy really fits all in the fashion e-commerce business. Secondly, this study aims to evaluate whether consumer returns are a central part in the creation of profitability, and if so, the role of returns management in the overall supply chain strategy

RESEARCH APPROACH:

Historically, customer segmentation based on buying behaviour lacks empirical evidence to support its usefulness (Godsell et al., 2011). This study was conducted in collaboration with Nelly.com, a Nordic e-commerce site that specialises in fashion and beauty. Transactional sales and return data from a two-year period were analyzed. Data from four markets was used to categorize customers based on their buying and returning behaviour and investigated according to each customer's net contribution to the business.

FINDINGS AND ORIGINALITY:

In theory, segmentation based on the customer's buying behaviour should be performed using point of sales data or a more qualitatively based understanding (Gattorna, 2010). In the fast-moving business of e-commerce, customer returns are a valuable service parameter.

If return management is not effectively used, returns often decrease profitability. The e-commerce business collects and stores vast amounts of data; yet, this wealth of information is seldom used in developing service differentiation. Organisations often offer the same level of service to all customers irrespective of each customer's net contribution. In this study, behaviour patterns were analysed, and it was determined that grouping customers based on both sales and return patterns facilitates a differentiated service delivery approach. It enables the company to offer different delivery and return conditions to specific customers in order to increase their net contribution. Interestingly, we found that the most profitable customer is the repeat customer who frequently returns goods.

RESEARCH IMPACT:

The research reported in this paper empirically supports the theory that customer buying and returning behaviour could be used to categorize customers in order to guide a more differentiated approach. However, to create a deeper understanding of the requirements for each customer group, future and more qualitatively oriented research is needed.

PRACTICAL IMPACT:
The main purpose for differentiating service delivery levels is related to the problem of over and underservicing when using a "one size fits all" approach (Gattorna, 2006). Our findings support and suggest the implementation of service delivery based on a more dynamic approach that nurtures resources and links the supply chain and/or organisational strategies with categorized customer buying and returning behaviour.

Keywords: Strategy, Customer Segmentation, Differentiation, E-Commerce, Buying Behaviour, Supply Chain Management

Paper type: Research paper

INTRODUCTION

In shifting market conditions, the choice of supply chain strategies is critical when competing to serve customers (Gattorna, 2010). It is accepted in theory that the "one size fits all" approach to supply chain design is no longer valid (Christopher *et al.*, 2006; Gattorna, 2010; Ericsson, 2011; Godsell *et al.*, 2011). Still organisations, even in the highly competitive e-commerce market, utilise a "one size fits all" strategy to create and deliver value to their consumers, thereby implicitly assuming that consumers' demands and buying behaviour are homogeneous, and therefore, there is no profitable reason to differentiate delivery in terms of service.

However, e-commerce consumers' buying behaviour is not homogenous, especially in the fast-moving consumer goods (FMCG) business. FMCG organisations compete not only in products and price, but also in a large variety of services. For example, accessibility and speedy delivery are critical determinants for success. Returns management (RM) is clearly a part of the parcel, and, if handled properly, it can decrease costs, while simultaneously increasing revenue and serving as a means of competition. The total offer is called the "value package" and consists of the physical product plus the services surrounding it. Some of these services are the order qualifiers, and some are the order winners (Ericsson, 2011).

If customer groups exist with different service requirements, then it makes sense to try to match these with differentiated supply chain strategies (Godsell et al., 2011). Gattorna (2010) argues that organisations, or rather supply chains, need not only to understand the competitive forces, they need also to understand their customers' buying behaviour. Furthermore, they need to understand how to use the knowledge internally to offer and deliver suitable value propositions. In e-commerce this has implications on service delivery as well as the sourcing of products and thus on how we design the supply chains. In designing supply chains, Godsell et al. (2006) express a need to replace the focus from the product to the end-customer and specifically on the end-customer's buying behaviour. Traditionally there are two different schools of thought in supply chain design (Godsell et al., 2011). The first theory is the lean-agile supply chain design, which is product driven. The second school of thought is that strategic alignment is driven by customer buying behaviour. Both schools take a supply chain approach; thus, neither theory focuses on the consumer or the end-user as is done in this research.

Supply chains are omnipresent (Gattorna, 2010), and e-commerce organisations exist in many supply chains or supply networks. As noted earlier, it is accepted that the "one size fits all" approach to supply chain design is no longer valid, and the suggested number of parallel supply chains varies and is naturally context dependent. It depends upon diverse variables such as demand uncertainties, product characteristics, replenishment lead-times, etcetera. Traditionally literature describes supply chain design from a manufacturer's perspective, trying to link the supply side with the demand side, often with a product focus (see Croxton et al., 2001; Christopher et al., 2006). In e-commerce, the focus would naturally shift to the e-commerce organisation, which changes the focus from manufacturing towards sourcing of and delivery of finished goods. However, as e-commerce organisations grow, they are likely to try to design and produce their own products and brands in search of greater margins, which shifts the focus back towards manufacturing or at least a combination of sourcing and manufacturing. This exemplifies the need for at least two supply chains, probably even more. In e-commerce, the critical focal point is to match the demand from consumers with an appropriate set up of sourcing, final distribution and returns-handling activities. If demand variations for different products exist, it is probably useful to apply diverse sourcing strategies in order to match demand uncertainties with responsive supply strategies. Gattorna (2010) argues that in a typical supply chain three to four dominating customer buying behaviours exist that need to be understood in detail. Further, these dominating behaviours cover approximately 80% of the customers, and the same dominating patterns fit other markets as well.

Christopher et al. (2011) explain the need for combining both product characteristics and market considerations when designing supply chain capabilities and selecting supply chain pipelines. In the selection of pipeline types there are eight theoretical types to choose from depending on whether products are standard or special, demand is stable or volatile and lastly if the replenishment lead-time is short or long (Christopher et al., 2006). According to Christopher et al. (2006), standard products tend to be more stable in demand with longer life cycles, whilst special products tend to be the opposite, i.e. erratic demand and shorter life cycles. Therefore, there is a connection between demand predictability and product characteristics, which reduces the amount of theoretical pipeline types to four (Christopher et al., 2006, p. 282). Depending on product demand and supply characteristics, Christopher addresses a lean, agile or a combination of the two, i.e. a *leagile* approach (see Christopher et al., 2006, p. 283).

In many markets, especially the e-commerce market where several organisations are competing, i.e. selling the same brand or similar products with little or no difference in price, it is difficult to maintain a competitive edge trough the product itself (Christopher, 2005). Therefore, the service level and the delivery service as such becomes a critical determinant for market success. The e-commerce supply chain often appears, in theory and practice, as a one-dimensional chain. However, in reality, it is a spaghetti bowl of interrelated activities or processes sourcing thousands of SKU's, receiving, storing, picking, packing and distributing them to the end user and later receiving and handling consumer returns. In the e-commerce business, especially in fashion, delivery from stock to consumers makes it difficult to apply the lean/agile approach for the final distribution. However, customers buying and returning behaviour might affect the profitability if it is not matched with a suitable delivery and return strategy.

In the fashion e-commerce business, a trend towards more liberalised delivery and return conditions as a way to cope with competition inside the industry has become evident. Additionally, these lenient return policies attract new consumers from the traditional retail chains. Consequently, return policies are a part of marketing practice (Autry, 2005), and therefore returns management (RM) is surely a part of the value creation process. RM is the part of supply chain management that includes returns, reverse logistics, gatekeeping and avoidance (Rogers *et al.*, 2002, pp. 5). Mollenkopf et al. (2011) investigate the marketing/logistics relationship relative to RM. They found that the effectiveness of RM was enhanced when firms coordinated their strategic and operational activities. Clearly RM needs to be efficient; in some cases, however, it seems that it is also a part of the value creation not only the value recovery. Stock (2009) emphasises that product returns will continue to be a part of business operations, and literature indicates that competition is increasing and consumer demands are surely following this development. Therefore, there is a need to align RM within the supply chain strategy where the whole supply chain needs to operate efficiently and effectively and returns are no exception (Stock, 2009).

The aim of the changes in delivery and return conditions is to attract and create loyal and repetitive customers, thereby increasing sales. However, a liberal return policy increases returns (Wood, 2001). There is, however, no direct correlation between increasing sales and maximizing profitability. Differences in service requirements might affect both sales and profitability. When utilizing a "one size fits all" strategy correctly, one would expect to find a uniform response or behaviour from consumers, i.e. no grouping when analysing consumers' loyalty in terms of repetitiveness and profitability in terms of contribution margin.

This study set out to characterise customer segments in terms of buying and returning behaviour as a starting point for grouping customers and their response to a "one size fits all" approach. If there are considerable differences in how customers behave, then one ought to investigate these differences in more detail and analyse how it might reflect upon product characteristics and the sourcing of finished goods. Gattorna (2010) indicates that the most critical point to start with is the customers' buying behaviour, especially in the e-commerce business focusing on sourcing of finished goods and delivering from stock. Segmentation as such is a well-established concept (Gattorna, 2010; Christopher et al., 2011), but ways to segment are quite widespread. (For reviews of traditional segmentation techniques see (Bonoma and Shapiro, 1984; Cooil *et al.*, 2008)). Identified segments, regardless of the technique used, indicate a need for a differentiated product and service delivery, thus abandoning the old and out-dated "one size fits all" approach.

Designing the matching supply chain should mirror the demand side requirements, and in e-commerce this means delivering the appropriate product and service to the consumer/end-user. If differences exist in how customers respond to a "one size fits all" strategy, then it is logical to increase the understanding of customers buying behaviour. Gattorna (2010, pp. 62-63) presents five different ways to perform the behavioural segmentation. These methods would likely fit, although they are quite time consuming. Often literature presents business techniques developed for customers. In the rapidly evolving business to consumers (B2C) e-commerce, the fifth method where Gattorna (2010) creates consumer insight using point of sales (POS) data and uses sophisticated data mining techniques could be used. However, e-commerce business maintains a vast amount of transactional data that could be used to segment the consumers based on their behaviour. It could be used to segment consumers based on their buying and returning behaviour measuring their net contribution. A "one size fits all" supply chain strategy inherently assumes that there is one large segment of customers in the market with the same requirements and demands for products and services. It is assumed that a homogenous customer group with the same requirements and demands share a similar buying behaviour.

Organisations perform a vast number of different activities and procedures, such as the delivery and return processes. These activities drive costs that affect the price charged for products and services. In addition, these activities mean different things to different consumers, i.e. they are more or less important. Therefore, performing activities better or more efficiently might result in a competitive advantage (Porter, 1996). Performing different activities than competitors might also result in a competitive advantage; however, this is not necessarily cost dependent as it might deliver a value advantage. According to Porter (1996), differentiation arises from a choice of activities and from how organisations perform them. In the rapidly growing e-commerce business, especially in fashion, the competition is quite fierce. Depending on what products e-commerce consumers are purchasing, the delivery and return policies might be more or less critical. Non-adopters or new customers might therefore hesitate to purchase products where fit and size problems are apparent, such as shoes or certain non-flexible garments. Certain companies in the shoe business (Zappos.com, Brandos.se, Hippo.se) are truly generous and offer all customers (Zappos only domestic customers) both free delivery and free returns. This is an indication that these companies see the delivery and return conditions as critical to their business. However, even here the strategy is "one size fits all" and they are therefore likely to over-service some customers (Gattorna, 2010). Overservicing is costly and will affect profitability, and customers who misuse this service will increase costs that will have to be paid by all customers returning or not. Misuse occurs when the liberal delivery and return policies affect a consumer's buying behaviour, i.e. ordering more than one size, etcetera when returns are free. In the global retail industry, companies are likely to see the surrounding complexity but attack it with an operational sledgehammer (Gattorna, 2010). It might be easier and cheaper to deliver only one service level to all customers; however, it is not the most profitable way, as it will undoubtedly under or overservice some customer groups.

Traditionally organisations have seen commercial product returns as a nuisance (Blackburn et al., 2004; Guide and Van Wassenhove, 2006) and a necessary evil, a painful process, a cost centre and an area of potential customer dissatisfaction (Stock et al., 2006). Organisations have realized that effective RM can provide a number of benefits, such as improved customer service, effective inventory management and product dispositioning (Norek, 2002; Rogers et al., 2002; Stock et al., 2006; Mollenkopf et al., 2007a; Mollenkopf et al., 2007b; Frankel et al., 2010; Mollenkopf, 2010). If organisations view returns as a cost driver rather than a competitive edge, they miss the potential value it could add to them and their customers (Mollenkopf et al., 2007a). From a consumer's perspective online purchases represents a certain level of risk (Mollenkopf et al., 2007b) relating to product quality, size and fit issues. The customer has to await the delivery and the execution of service delivery as well. Mollenkopf (2007b) argues that a well executed handling of returns could act as a service recovery opportunity, where the customer evaluates the ongoing service delivery during a particular purchase experience. According to Andreassen (2000), service recovery affects customer loyalty. This also follows the arguments of Harrison and van Hoek (2008) that service performance is important, as customers' perception of delivered products and services is what creates loyal customers. Thus, the importance of RM should not be underestimated in distance sales. RM has started to gain a strategic role in organisations (see Rogers and Tibben-Lembke, 1999). It is time to position RM in its proper place in the supply chain strategy.

This paper views segmenting customers based on their buying behaviour as the starting point and driver for supply chain strategies. Globalisation has reduced consumers' behavioural homogeneity within countries and increased commonalities across countries (Broderick et al., 2007). This facilitates a development of global strategies targeting similar segments in different countries. In a consumer context, behavioural homogeneity deals with the decision-making processes that lead to a purchase-decision, and it is used to predict and explain market segment responsiveness (Broderick et al., 2007). Hoyer (1984) investigated consumer decision processes regarding repeat purchases and Broderick et al. (2007) used this in their study of consumer behaviour. They performed a survey using questions such as "How often do you purchase?" to analyse behavioural homogeneity. Asking questions regarding future purchase and/or historical return behaviour will likely present bias, as one can evaluate how questions and answers are interpreted as well as the accuracy of the responses. It is possible that respondents say one thing and then do another (Alreck et al., 2009). Further, there are also problems when trying to foresee the future and/or remembering the past. Observing customers' behaviour online presents other methodological issues, especially post purchase behaviour, as certain decisions might involve a continuous rather than a discrete processing (Hoyer, 1984), i.e. whether or not to return a purchased item. Any data tend to be an historical snapshot of a phenomenon under study. In this case, consumers are a moving target in a continuous change due to increased competition and an increased focus on service delivery. Kim and Kim (2004) investigated customers' purchase intentions for clothing and expressed that their conclusions might not hold for long given the rapid development in e-commerce. In the fast moving global e-commerce business, it is probably difficult to predict and/or explain consumer behaviour using any type of data. However, customer (consumer) insight can be created using transactional data, and according to Gattorna (2010), using behavioural data alongside transactional data makes it possible to better predict customer behaviour. Transactional data including purchase and return behaviour, can therefore be useful when segmenting customers. Utilizing actual purchase and return data to uncover how customers behave regarding delivery and return policies, reduces certain methodological issues regarding data collection, i.e. perceptions about the future or remembrances of the past. The data as such follows a buying behaviour over time (not a snapshot) and should, therefore, result in fewer validity problems as it measures and follows (if data is updated) a real behaviour, not intentions or perceptions.

In designing supply chain strategies, the literature describes, from a manufacturer perspective, that "one size fits all" is no longer valid, and further, that organisations or rather supply chains need to align with consumers' buying behaviour (Gattorna, 2010). Stock and Mulki (2009) argue for the importance of RM within supply chains, as returns are likely to continue to be a part of business operations. Consumer returns are a central part of e-commerce market operations. The overarching hypotheses for this paper are firstly, that the "one size fits all" strategy does not fit in the fashion e-commerce market either (Christopher et al., 2006; Gattorna, 2010; Ericsson, 2011; Godsell et al., 2011). Secondly, RM is a central part of the supply chain (Autry, 2005; Stock and Mulki, 2009; Mollenkopf et al., 2011) and should be aligned in the design of supply chain strategies. Therefore, the purpose of this paper is twofold: firstly, to empirically test and support whether a "one size fits all" strategy really fits all in the fashion e-commerce business. Secondly, this study aims to evaluate whether consumer returns are a central part in the creation of profitability, and if so, the role of RM in the overall supply chain strategy.

RESEARCH DESIGN, METHOD AND MEASUREMENT

Designing supply chain and organisational strategies in the fast moving consumer goods business, especially within fashion e-commerce, requires a profound understanding of customer behaviour and requirements. Therefore, the development of supply chain strategies needs to be both context specific and close to the competitive environment; therefore, it is relevant with a single case design for testing the well known "one size does not fit all" theory. To test the overarching hypotheses presented in the previous section, we need to select a case organisation, determine a unit of analysis and collect and analyse data. The selected case organisation Nelly.com was selected mainly because they fit the purpose to test specific theories, i.e. they do not segment customers or differentiate what they offer customers in terms of products or services. Further, the organisation was willing to support the research with transactional data to test the theory on an organisational and customer level. For the quantitative analysis, Nelly.com exported transactional data from their ERP system. The data contained all (256,233) customer orders for a period of two years (2008-2009) covering their four markets in Denmark, Finland, Norway and Sweden. As the analysis was performed on a customer level, the authors performed detailed calculations to reveal each customer's order sales figures, return figures, contribution margin, etc. Thereafter each customer was analysed in terms of total sales, average sales per order, total contribution margin, average contribution margin, total number of orders, and total number of returns. The organisation's operations manager was interviewed on site during the research and supplied the researchers with vital information regarding freight costs, return freight costs and costs related to the handling of orders and returns.

To test the hypotheses in terms of construct validity, the financial contribution of customers was categorised according to their buying and return habits. Customers were categorised as either repeat or non-repeat customers, depending on whether they made only one purchase or several purchases during the period. They were also categorised as either returners or non-returners, depending on whether they returned at least one item during the period or not. Using this perspective, four different types of customers emerged, and they were categorised as Type A, Type B, Type C, and Type D (see Figure 7).

		Return Habits (RH)	
		Non-returner (0)	Returner (1)
Buying Habits (BH)	Non-repeat Customer (0)	Type A	Type B
	Repeat Customer (1)	Type C	Type D

Figure 7 The four types of customers

Differences in contribution per order and contribution per customer and year among the four types of customers were described on a country basis and were further analysed with two-way ANOVAs.

RESULTS

Contribution per order

Table 1 presents descriptive statistics regarding the contribution per order for all four countries.

Table 1 Contribution per order. Note: number of orders n* in 1000

			SWE			NOR			DK			FIN		
		RH	Mean	SD	n*	Mean	SD	n*	Mean	SD	n*	Mean	SD	n*
BH	0	0	327	356	80	559	523	23	438	414	15	376	385	12
		1	157	339	19	349	637	4	238	417	3	220	362	4
		Total	295	359	98	525	549	27	406	421	18	339	386	16
	1	0	327	272	29	571	413	8	440	313	4	385	309	4
		1	300	317	37	513	430	7	392	324	3	338	291	5
		Total	312	298	66	544	422	14	418	319	7	358	300	9
	Total	0	327	336	109	562	497	30	439	396	19	378	368	16
		1	253	331	56	448	528	11	318	380	6	287	329	9
		Total	302	336	165	532	508	42	409	396	25	346	358	25

Two-way ANOVAs were conducted on the data for all countries to explore the observed differences in contribution per order more in detail.
Table 2 presents the ANOVA for the Swedish subsample (the significant patterns are again identical for all four countries).

Table 2 ANOVA on contribution per order in Sweden

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	456861012	3	152287004	1383	< 0.001	0.025

Intercept	9640321806	1	9640321806	87525	< 0.001	0.347
Buy habit	158668911	1	158668911	1441	< 0.001	0.009
Return habit	303417785	1	303417785	2755	< 0.001	0.016
Buy habit * Return habit	158949373	1	158949373	1443	< 0.001	0.009
Error	18127084710	164577	110143			
Total	33575189056	164581				
Corrected Total	18583945722	164580				

Repeat customers and non-returners generate a significantly higher contribution per order (F = 1441, p < 0.001 and F = 2755, p < 0.001 respectively). There is also a significant interaction effect between the factors (F = 1443, p < 0.001). For non-returners, the contribution per order is not significantly different depending on whether they are repeat customers or not. Returners, on the other hand, generate significantly higher contribution per order if they also are repeat customers.

Total contribution per customer and year

Table 3 presents descriptive statistics regarding total contribution per customer and year for all four countries. Note that the values for non-repeat customers are the same as in Table 1.

Table 3 Total contribution per customer and year, note number of orders n* in 1000

			SWE			NOR			DK			FIN		
		RH	Mean	SD	n*	Mean	SD	n*	Mean	SD	n*	Mean	SD	n*
BH	0	0	327	356	80	559	523	23	438	414	15	376	385	12
		1	157	339	19	349	637	4	238	417	3	220	362	4
		Total	295	359	98	525	549	27	406	421	18	339	386	16
	1	0	921	944	29	1599	1495	8	1152	996	4	1021	946	4
		1	1321	1747	37	2090	2450	7	1337	1486	3	1250	1270	5
		Total	1147	1467	66	1828	2012	14	1237	1249	7	1150	1145	9
	Total	0	484	630	109	824	989	30	579	644	19	532	636	16
		1	936	1542	56	1405	2127	11	807	1237	6	807	1111	9
		Total	637	1056	165	979	1412	42	635	835	25	629	845	25

Two-way ANOVAs were conducted on the data for all countries to explore the observed differences in total contribution per customer and year more in detail.

Table 4 presents the ANOVA for the Swedish subsample (the significant patterns are again identical for all four countries).

Table 4 ANOVA on total contribution per customer and year in Sweden

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	31762561573	3	10587520524	11475	< 0.001	0.173
Intercept	58055895333	1	58055895333	62922	< 0.001	0.277
Buying habits	24136466847	1	24136466847	26160	< 0.001	0.137

Return habits	413915532	1	413915532	449	< 0.001	0.003
Buying habits * Return habits	2537269709	1	2537269709	2750	< 0.001	0.016
Error	151849456970	164577	922665			
Total	250478290897	164581				
Corrected Total	183612018543	164580				

The fact that repeat customers generate a significantly higher total contribution per customer and year (F = 26160, p < 0.001) is not surprising, to say the least. More interesting is the fact that returners generate a significantly higher total contribution per customer and year than non-returners (F = 449, p < 0.001). The interaction between the factors is also significant (F = 2750, p < 0.001). For non-repeat customers, the total contribution per customer and year is significantly lower if they also are returners. For repeat customers, however, the total contribution per customer and year is significantly higher if they also are returners.

DISCUSSION AND CONCLUSIONS

Gattorna (2010) highlights the importance of understanding the dominating buying behaviour in a supply chain. This study tested whether the "one size fits all" strategy results in a homogenous behaviour in fashion e-commerce. The grouping of customers (see Figure 7) performed in this paper is not a segmentation as such; however, it surely indicates a heterogeneous buying behaviour thus requesting further qualitative research regarding a differentiated service delivery. The results from the quantitative analysis show an interesting pattern which supports both Gattorna's (2010) theory that the dominating behaviour found in one market appears in the others as well. Further, the findings also support the theory about reduced behavioural homogeneity within countries and increased commonalities across countries (Broderick et al., 2007) as the analysis did find a heterogeneous pattern within markets and matching patterns among markets. The research design used does not allow for discussion as to whether the behaviour has changed over time as suggested by (Broderick *et al.*, 2007); it only acknowledges the matching patterns.

The increasing competition of channels versus channels rather than companies versus companies puts the highlight on all types of relations between and among entities in the supply chain. Relationships grow deeper and more profound and develop into new areas. RM is one of the emerging and important new areas. It is important in all the consecutive dyads in the chain, but it is of particular vital interest in the link between the retailer and the consumer. RM is of great importance for building strong and lasting relations in most dyads, but ultimately, it is decisive in gaining competitive advantage and profitability. RMs role as order winner has not been studied explicitly previously, but this study shows that using purchasing and return data as bases for segmentation can improve performance considerably.

Most eBusiness companies have a wealth of data concerning returns. However, it can be stated that even though they are drowning in data, they are starving for information. This means that they need a guideline for how to analyze existing data and how to collect valuable information.

Experiments with different tariffs for transportation and returns show that consumer behaviour is influenced by differentiated costs. The question is how to use this in a systematic segmentation model. This research shows one possible approach is to use return data as a vital part of the model and complement it with purposefully collected data concerning buying behaviour (Ericsson, 2011). This fits quite well with the evolving demand chain approach with its focus on consumer behaviour, insight and alignment of marketing, sales and logistics activities.

It also goes hand in hand with the development of retailing with increasing co-creation and reliance on social media. The term co-creation is not new, however, but it is now receiving more attention as companies endeavour to differentiate themselves from the competition. Where in the past value was created by companies in the chain, value today is co-created at multiple points of interaction. Not only the physical product, but also the services in the value package can be co-created. RM is one of the most promising areas for co-creation!

To summarise these research findings and relate the results to the overarching hypotheses and research purpose, the authors conclude that there is conclusive support for both hypotheses. The behavioural model described in this pattern shows that customers behave in a heterogeneous way and this indicates that the "one size fits all" theory is obsolete as the literature indicates (Christopher et al., 2006; Gattorna, 2010; Ericsson, 2011; Godsell et al., 2011). The results also support previous findings that RM is an important part of the supply chain (Norek, 2002; Rogers et al., 2002; Stock et al., 2006; Mollenkopf et al., 2007a; Mollenkopf et al., 2007b; Frankel et al., 2010; Mollenkopf, 2010), as consumer returns are an important part of e-commerce customer behaviour and therefore important both to the case organisation and its partners, including the customers. Further, Mollenkopf (2007b) highlights the risks involved in e-commerce and the importance of RM in the service recovery process.

This research empirically supports the importance of RM in the service recovery in fashion e-commerce, as quite a large group of customers are systematically returning. However, companies using a "one size fits all approach" are focusing solely on RM efficiency and therefore missing the opportunity to create a competitive edge. They are missing the potential value it could add to the organisation and their customers (Mollenkopf et al., 2007a) as well as their supply chain partners. A differentiated return service might attract new customers (non-adopters) and better support the customer groups with diverging patterns or returns identified in this paper as RM. Clearly, this is a part of the value creation, at least to certain customers.

We are all hard-wired with a range of values as humans, and we all have different expectations towards products and services. So, therefore there is an interaction between product/service categories and buying behaviour, but it is the buying behaviour that determines demand patterns (Gattorna, 2010) and therefore how we should engineer our supply chains, forward and reverse (RM). And it is the range of buying behaviours which determine the number of supply chains in the end- with a bit of approximation to make the whole thing workable.

FUTURE RESEARCH

The findings reported in this study show how customers behave and that there clearly is a heterogeneous response from customers on the "one size fits all" strategy. It is important though to stress that the segmentation is but a starting point for aligning resources of the firm (Gattorna, 2010) and the supply chain. Future research should include qualitative research that creates a detailed understanding of why customers behave differently, it is important to investigate their values, and how to, from a supply chain perspective, design and deliver matching value propositions.

E-commerce is an extremely competitive market place (Kim and Kim, 2004). Therefore, the demand predictability is troublesome, and customers returning goods increase the uncertainty and variability of demand. Early indications of demand, in season, might turn out differently and change the pattern when returns arrive later in time. This might have implications on how we source and replenish products. Therefore, future research needs to address the behaviour pattern described in this paper in combination with different product categories. This means testing Gattornas (2010) dynamic alignment approach in e-commerce aligning customers/market, strategy, internal cultural capability, and leadership style.

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SETTING TARGETS FOR REDUCING CARBON EMISSIONS FROM LOGISTICS OPERATIONS: PRINCIPLES AND PRACTICE

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ABSTRACT

This paper examines the different approaches that companies can take to setting targets for the reduction of carbon emissions from their logistics operations. The research suggests that target-setting practices differ widely in this field. It is common for firms simply to apply corporate-level targets to logistics, despite the fact that carbon abatement potential and cost-effectiveness vary by function and activity. A small minority of firms have systematically analysed the possible carbon savings from specific interventions and technologies. To improve their credibility and consistency, carbon reduction targets need to conform to certain principles. The paper proposes a series of principles applicable to the decarbonisation of logistics.

INTRODUCTION

Scientific evidence of a pronounced global warming effect continues to accumulate, while more governments around the world are developing carbon reduction policies for their economies. Although binding international commitments to reduce greenhouse gas (GHG) are taking much longer than expected to agree, consensus is building in government and business circles that dramatic reductions in GHG emissions will have to be made over the next few decades to avert climatic and ecological disaster. It is against this background that companies are examining ways of reducing their carbon footprints.

Businesses can have numerous motives for cutting carbon emissions. The most compelling for many companies is simply the desire to save money. The pursuit of 'eco-efficiency' is often driven mainly by financial concerns but presented as an environmental endeavour for marketing and CSR reasons. The early efforts that companies made to reduce their GHG emissions have typically involved harvesting the 'low hanging fruit' wherever it can be found, but not part of a structured programme of carbon mitigation. As their commitment to carbon reduction has strengthened and their understanding of their carbon footprint has deepened, their quest for carbon savings has become more systematic. Some of the corporate leaders in sustainability have now developed, or are developing, explicit carbon reduction strategies. These strategies naturally prioritise those core activities accounting for a large share of the corporate carbon footprint and / or offering the most cost-effective options for carbon reduction. For logistics service providers, wholesalers and many multiple retailers, transport and warehousing are clearly core activities. Even in manufacturing businesses, however, where logistics' share of total GHG emissions is often less than 10%, it is still seen as being potentially an important source of emission savings.

An earlier paper outlined a seven-stage procedure that companies can use to develop a decarbonisation strategy for logistics (McKinnon, 2011). One of the key steps in this procedure was the derivation of a carbon reduction target for the logistics operation. This paper examines this process of target-setting in greater detail. It considers the reasons for setting a target for future carbon emissions, explores the different types of targets that companies can adopt and shows how an industry-level target can be established. The paper concludes by proposing a series of principles for companies to follow when deriving carbon reduction targets for logistics.

METHODOLOGY

The paper is based on reviews of the literature on environmental target-setting in business, previous research on the decarbonisation of logistical activity and the public policy context for climate change initiatives in logistics. Primary data has been collected from discussions with a sample of managers in companies that have set carbon reduction targets for logistics. Some of these companies were early entrants to the Logistics Carbon Reduction Scheme (LCRS), set up by the UK Freight Transport Association in 2010. The interviews investigated whether companies had specific carbon reduction targets for logistics, and, if so, the extent to which they were based on quantitative analysis and aligned with corporate, industry and governmental goals.

REASONS FOR ESTABLISHING CARBON REDUCTION TARGETS

The setting of targets is a fundamental part of the strategy development process. They establish clear goals for the company to meet, define its future direction, concentrate the minds of managers and provide a benchmark against which the success of the strategy can be judged. Targeting is widely applied in other areas of business activity such as sales, customer service, finance, operations and HR, and so its application to environmental policy, and in particular carbon emissions, would seem logical. There are, nevertheless, two important differences between carbon reduction targets and most of the other business targets which companies routinely set. First, carbon targets are often declared publicly, for marketing and CSR reasons, in contrast to many other targets which are essentially for internal consumption. Indeed targets can be used as a form of 'competitive greenery' where companies use their environmental credentials as a differentiator and try to outbid each other in terms of their future environmental performance. Second, unlike most other targets over which the company has full discretion, carbon reduction targets, to be credible, must be aligned with externally-defined climate change policies and objectives emanating from governments, trade bodies or environmental agencies. By publicly committing to cut carbon emissions by a certain amount and by a specified date, a company shows that it is trying to conform to wider industry norms and government expectations.

TYPES OF CARBON REDUCTION TARGET FOR THE LOGISTICS SECTOR

The targets that companies have set for cutting logistics-related GHG emissions can be differentiated in several ways:

Top-down and Bottom-up Targets

Top-down carbon reduction targets for logistics are imposed by higher level management, such as a board of directors or executive board. They are often company-level targets applied uniformly across all functional areas. In most cases they are not based on a detailed analysis of the potential for cutting carbon emissions either at a corporate of functional level and instead are aligned with targets quoted by competitors, trade bodies and/or government agencies. As such they have several shortcomings:

1. They lack credibility because they are not based on an analysis of what is possible within operational, technological and financial constraints.
2. They fail to recognise important differences between companies in terms of their GHG-generating characteristics, their past record of environmental improvement and the baseline conditions pertaining at the time when the target is set.
3. Applying the same target across the business ignores the fact that there are wide cross-functional variations in the potential for carbon abatement and its cost-effectiveness. This is illustrated, in an idealised way, in Figure 1. It shows how the shape of the carbon abatement cost curve can vary between business functions (F1-4), both in its highest value (maximum potential carbon saving) and its gradient (cost per tonne of carbon saved). This gradient is unlikely to be constant

as the initial carbon savings can normally be obtained more cheaply than the later ones. This explains why the lines are curved rather than linear. It is desirable to set higher targets for those functions offering greater GHG savings and savings that can be achieved at a lower cost per tonne of emissions.

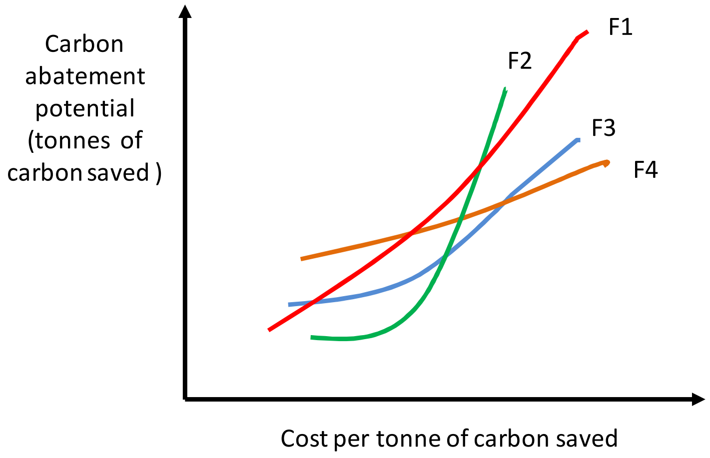

Figure 1: Carbon Abatement and Related Cost Profiles for Four Business Functions

Bottom-up targets generally overcome all three of these problems. They are rooted in an analysis of GHG-generating processes and a micro-level assessment of the potential for cutting these emissions. This generally involves plotting a business-as-usual (BAU) trend for a specific function or activity and then estimating the extent to which the actual trend can deviate from this BAU projection as a result of the application of decarbonisation measures. The company must decide what measures are appropriate, at what rate they can be applied and what the resulting GHG savings are likely to be. Summing the savings achievable by a particular date can define the target. Software tools, such as a decarbonisation tool developed by Heriot-Watt University for the FTA[2], can be used to assist this calculation, testing various combinations of measures and various degrees of application. The analysis can also include financial data to assess the relative cost-effectiveness of the measures considered. In summary, therefore, bottom-up targets are company- and function-specific, grounded in an analysis of what is actually possible and affordable.

Absolute versus Intensity Targets

Meeting an 'absolute' target would reduce the total amount of GHG emitted by a logistics operation regardless of changes in the level of activity. Most companies fear that the pursuit of an absolute reduction will constrain the growth of their business and therefore carry a financial penalty. They therefore prefer to express the target as a decline in their carbon emissions relative to the level of business or logistical activity. They must then decide against which corporate or logistics variable(s), or 'normalisers', the reduction in GHG emissions should be measured. This can be difficult as there is seldom an ideal denominator for the carbon intensity fraction. Corporate-level economic variables such as turnover, value-add and employment may be appropriate for companies whose core activity is logistics, but for others, the link between these general indicators and logistics-related CO_2 can be fairly tenuous. Logistics-specific normalisers are clearly preferable as they are less susceptible to distortion by other structural changes within the business over the target period. These normalisers can include the number of units delivered, the number of units moved multiplied by the distance transported (e.g. tonne-kms, pallet-kms), warehouse throughput etc. For example, in 2007 Tesco adopted a target of cutting

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[2] A copy of this tool can be downloaded from: http://www.fta.co.uk/policy_and_compliance/environment/decarbonisation_tool.html

CO_2 emissions per case delivered by 50% over a five year period (Freight Best Practice Programme, 2010). In its annual CSR, the company reports this declining intensity value.

The main problem with intensity-based targets is that if the underlying level of activity continues to rise, there may be little or no net reduction in GHG emissions. This runs counter to government climate change policies which are setting absolute GHG reduction targets. UK governments, for example, are legally obliged by the 2008 Climate Change Act to cut total GHG emissions in 2050 by 80% relatively to their 1990 level. As the country is expected to achieve substantial economic growth over the next 40 years, there will have to be a dramatic reduction in carbon intensity per £billion of economic output. Just as within businesses, the potential for and cost of cutting GHG emissions varies between sectors, so across national economies there are wide inter-sectoral variations in these variables. To our knowledge, no national government has yet set GHG-reduction targets for individual economic sectors, though it has been acknowledged that these are unlikely to be uniform.

The European Commission (2011), for example, has recognised that it will be more difficult to cut GHG emissions in the transport sector than in the EU economy as a whole by setting a significantly lower GHG reduction target for transport: 60% by 2050 as opposed to 80-90%. These are absolute targets. As the transport target has not been split between personal and freight transport, let us assume that the 60% figure applies to freight transport. It has been forecast, on a BAU basis, that freight tonne-kms in the EU will grow by roughly 160% between 2010 and 2050 (Freightvisions, 2010). If this forecast growth of freight traffic were to materialise, for total GHG emissions from freight transport to fall by 60% by 2050 the average GHG-intensity of freight movement would have to be reduced by 85%. A company wishing to align its carbon reduction target for freight transport with that of the EU as a whole would then have to cut its emissions per tonne-km to less than a sixth of the 2010 level. This would be a daunting task.

Scope of the Target

This can be defined in organisational, geographical, functional and hierarchical terms:
Organisational: This relates to the division of emissions between a company, its contractors and trading partners in the supply chain. This usually reflects the allocation of financial responsibility between these organisations. As a general rule, whoever pays for the activity should be assigned the related CO_2 emissions. The Greenhouse Gas Protocol established three 'Scopes' to differentiate emissions for which a company was directly responsible (Scopes 1), emissions related to its electricity consumption (Scope 2) and those released 'indirectly' by other organisations working on its behalf (Scope 3) (WBCSD, 2004). For example, a manufacturer outsourcing its entire logistics operation and measuring only Scope 1 and 2 emissions would effectively exclude logistics from its carbon footprint. It is now considered good, and soon to become standard, practice to record and report all three categories of emission. In setting GHG reduction targets, however, companies naturally prefer to focus attention on those activities over which they have strong or total control. The targets that companies have been setting over the past few years have tended to be specific to their logistics operation (either in-house or outsourced) and not to their wider supply chain. For example, retailers importing products on a free-on-board (FOB) basis and paying for the deep-sea container movement, typically regard the foreign port of exit as the boundary of their carbon calculation. This also defines the scope of the carbon reduction target for logistics. For logistics service providers, a major issue is whether to subsume emissions from sub-contractors within their carbon target. For example, DHL, which sub-contracts around 80% of its transport on the European mainland, initially set a 10% CO_2 reduction target for its 'own assets' for the period 2007-2012, but by 2020 aims reduce emissions across its in-house and contracted operations by 30% (Sonnabend, 2010).

Geographical: Multi-national companies typically set a single carbon reduction target for their entire logistics operation. There is, nevertheless, some merit in varying the target by country or continent to reflect differences in national government targets and incentive schemes, the nature of the logistics market and geographical factors, such as terrain, climate and the level of urbanisation.

Functional: This relates to the range of logistical activities covered by the target. It is common for targets to be confined to the freight transport operation. This is understandable as it accounts for around 90% of all logistics-related emissions (World Economic Forum / Accenture, 2009) and government climate change policies tend to treat transport as a separate activity. It is, however, desirable to keep the range of activities as comprehensive as possible and preferably inclusive of all the activities for which the logistics department has responsibility. One important reason for adopting this more holistic approach is that 'carbon trade-offs' often have to be made between logistical activities. For example, centralising inventory in larger warehouse will, other things being equal, tend to reduce energy use and emissions per unit of throughput, but at the expense of lengthening delivery distance and related transport emissions. Setting a target for the logistics operation as a whole forces the company to take account of these trade-offs when implementing a carbon reduction scheme.

Under this functional heading, consideration should be given the extent of the system boundary to be drawn around the freight transport operation. NTM (2009) has differentiated five cumulative levels of system boundary. To date, almost all measurements of carbon emissions from logistics and almost all the targets that have been set are enclosed within system boundary 1 (SB1) and relate to the direct emissions from the vehicles, handling equipment and warehouses. At SB2 level, the boundary is expanded to embrace emissions from the energy supply chain, making a 'well-to-wheel' assessment. SB3 also includes the servicing and maintenance of vehicles and transport infrastructure, while SB4 extends the boundary further to include emissions from the manufacture of the vehicles, construction of transport infrastructure and their subsequent scrappage and dismantling. SB5 brings emissions from related office functions and the activities of staff within the perimeter of the calculation. Data limitations currently confine most companies' carbon auditing, and hence targeting, to levels SB1 and SB2, though it should not be too difficult to include emissions from vehicle servicing, IT and personal travel. Emissions from the manufacture of logistics equipment and from infrastructure construction and maintenance are not only difficult to quantify, they are also outside the logistics operator's control and hence justifiably excluded from the target-setting.

Hierarchical: This relates to the level at which the target is applied and can range from the logistics operation as a whole to individual stock-keeping units (SKUs). It depends on the extent to which the company can disaggregate its GHG emissions data by market segment, product category, handling unit and SKU. Relatively few companies currently have the capability and hence there are very few examples of these lower level targets. In the longer term, carbon measurement and targeting may follow the same course as logistics cost accounting between the 1960s and 1990s. Over this period, companies moved from a 'total logistics cost' approach to increasingly disaggregated costing by customer, service, mission and product. Efforts have already been made to develop the carbon equivalent of 'cost-to-serve' (Braithwaite and Knivett, 2008) and 'direct-product profitability' (e.g. THEMA 1, 2009). The latter effort to carbon footprint individual products has generated a great deal of interest and debate (discussed in McKinnon, 2010), though following the long tradition of life cycle analysis (LCA) it generally adopts an end-to-end supply chain perspective and not does not simply focus on the logistics-related emissions. Indeed, the logistics-related emissions generally represent a small percentage of the total life cycle emissions (Carbon Trust, 2006). This fact, combined with companies lack of carbon measurement capabilities at the SKU level probably explains why no examples have been found of companies setting logistics emission targets at an individual product level.

Time-scales

All targets have to have a start and end year. These tend to vary between companies making it difficult to compare them. It is common for companies to set 2015 and / or 2020 as end years. Others prefer to fix a 3, 5 or 10 year time horizon beyond the date when the target is declared. Sometimes the base year is not the year in which the target is announced but an earlier year, giving the company an opportunity to factor past carbon savings into the calculation and thereby reduce the level of future carbon savings required to meet the target. For example , if over the past two years our company has acquired a fleet of double-deck trailers and switched 10% of its freight from road to rail, reducing it logistics carbon footprint by, say, 20%, there is naturally a strong temptation to set the carbon baseline for targeting at 2010.

The overall length of the target period is also significant. The longer the period the greater will be the degree of uncertainty about future economic and business trends, public policy and technological advances. Advice is available on these external trends to help companies set longer term targets. For example, various attempts have been made to project the development and uptake of various low-carbon technologies for road freight vehicles (e.g. AEATechnology / Ricardo, 2011), while some government documents, such as the EU white paper on transport (European Commission, 2011), outline a longer term policy framework for the decarbonisation of freight transport. The replacement cycle for vehicle and other logistics assets also dictates the rate at which the company can exploit the carbon benefits of new technology.

Setting a target for a single year in the distant future naturally raises suspicions about the credibility of the exercise. For example, the CEO of one large logistics firm once stated that its objective was to become carbon neutral, though he refused to say when and how this might be achieved. The further into the future the targeting extends the less likely it is that the current management will be around to see the targets delivered and more likely it is that people will have forgotten about them or that they will have been ‘overtaken by events’. To be credible therefore long term targets need to be accompanied intervening targets or ‘milestones’ for earlier years, thus plotting a carbon-reduction trajectory.

Reliance on Carbon Offsetting

Some carbon reduction targets relate solely to savings that can be achieved within the company’s operations. Others include an allowance for carbon off-setting, i.e. where a payment is made to another organisation to cut CO_2 levels on our company’s behalf by planting trees, financing the adoption of low carbon technologies etc. Logistics-related carbon reduction targets sometimes include provision for carbon offsetting to close the gap between the predicted decline in carbon emissions, as determined by the bottom-up analysis, and higher-level corporate or industry goals. Projections of the future cost of carbon offsetting need to factored into the calculation and compared with the cost-effectiveness of the company’s own decarbonisation measures.

INDUSTRY-LEVEL CARBON REDUCTION TARGETS FOR LOGISTICS

For companies wishing to adopt the top-down approach to target-setting one option is to join an industry-wide carbon reduction scheme such as the LCRS in the UK. This collective approach to target-setting is beneficial in that it gains the endorsement of industry peers, helps to build up momentum for decarbonisation across the industry, ensures greater consistency in targeting and demonstrates to government that business is serious about meeting its climate change obligations. The question that then arises is how a logistics-reduction target should be set for an industry rather than a single company. If the industry is fairly homogeneous, the companies are undertaking similar logistics operations and they are at a similar level of 'eco-efficiency', it should, in theory, be relatively easy to derive an industry target. The LCRS, on the other hand, comprises a diverse mix of manufactures, retailers, wholesalers and logistics service providers at different stages in the decarbonisation of their logistics operations. It was a challenge therefore, to determine a carbon-reduction target that would command wide support. Rather than simply impose a target, it was decided to ask members of the LCRS and the wider membership of the FTA what level of CO_2 reduction they thought would be attainable between 2010 and 2015 on a carbon-intensity basis. This consultation process could be regarded as 'bottom-up'. Some companies were able to base their responses on quantitative analysis of their past experience and / or future plans, but other answers were more speculative.

The questionnaire surveys of LCRS and other FTA member companies did not ask managers directly about possible reductions in carbon intensity. Instead they enquired about possible changes in a series of five 'logistics efficiency indicators'. These indicators are key parameters in a macro-level freight decarbonisation model (Piecyk and McKinnon, 2010): modal shift, average payload weight, empty running, fuel efficiency and carbon content of the fuel. The survey data was analysed using this freight decarbonisation model, weighting company responses by size of vehicle fleet. Subsequent analysis of the spread of responses revealed that the mean figures were being significantly skewed by a few extreme figures at the upper end of the distribution. It was decided, therefore, in discussion with FTA officials, to base the target on the response of the lower three quartiles in the samples. This yielded a target of 8% for the reduction of freight-related CO_2 emissions by 2015 relative to the level of business activity. A further round of consultation with members of the LCRS confirmed this target was acceptable and that for many companies it would be 'stretching'. The target was formally declared in the Annual Report of the LCRS (FTA, 2011) and has since been endorsed by the UK government.

This exercise showed how an industry-level target for logistics carbon reductions can be derived by analysing data from company surveys and supplementing this with a second round of consultation to test reaction to the proposed target figure. It essentially pooled industry knowledge and experience and kept the process fairly democratic.

GENERAL PRINCIPLES

The Greenhouse Gas Protocol lists five principles that companies should follow when measuring and reporting their carbon emissions (WBCSD/WRI, 2004). These are encapsuled in five words: relevance, completeness, consistency, accuracy and transparency. Some of these terms can also be applied to the setting of carbon reduction targets for logistics, but they need some reinterpretation and need to be supplemented by others.

Good practice in target-setting should observe the following six principles:

1. Company-specific targets should be based on a bottom-up analysis of the potential for and cost of cutting carbon emissions over particular time-frames.
2. Where possible, targets should apply to the whole logistics operation in recognition of the carbon trade-offs that exist between logistical activities.
3. Targets should be expressed in terms of carbon intensity with logistics output measures used as the normalisers.
4. Where the target period is greater than 3-4 years, 'bridging' targets should be set for intervening years to show the trajectory for carbon reduction.
5. The scope of the logistics carbon measurement and related target should be made explicit, delimiting the relevant organisational, geographical, functional and hierarchical boundaries.

6. Where appropriate, a company should join an industry-wide carbon reduction scheme and conform to the targets that it sets.

CONCLUSION

Setting a target for cutting logistics-related GHG emissions is a new experience for most companies. Guidance is available from government and business organisations on the measurement and reporting of these emissions but not on targeting. As a result companies have devised their own procedures and often set targets which are not consistent, not rooted in an analysis of carbon abatement potentials and promulgated for marketing rather than environmental reasons. This paper has reviewed current practices and problems and proposed a series of principles that companies should try to adopt when defining carbon-reducing targets for their logistics operations.

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REAL-TIME VEHICLE TRACKING AND TRACING BY MEANS OF RADIO TECHNOLOGY

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ABSTRACT

In times of growing supply chains and international business partners, managing logistic processes and tracking cargo within a value creation chain is an increasingly complex task. In order to stay competitive within international collaborations, manufacturing and logistics companies need an efficient process organisation, both internal and within the network. Innovative communication and identification technologies offer the possibility to increase the performance and robustness in logistic and production processes and support the cooperation between supply chain partners.

This contribution demonstrates the concept and development of a technical system for the automated real-time tracking and tracing by means of radio technology. An example from the field of presale vehicle distribution through a seaport-terminal serves as scenario for the interaction of identification, positioning and communication technologies. Furthermore, the benefit of exchanging the gathered information between supply chain partners is discussed.

INTRODUCTION

Today`s logistic processes strongly depend on reliable and up-to-date data concerning the states and positions of goods [1]. An efficient tracking and tracing is an important factor for the achievement of logistic objectives, such as cost efficiency or the adherence to deadlines [2]. The concept of tracking and tracing denotes all activities related to the identification and positioning of goods (tracking) as well as the creation and maintenance of a record, containing all passed locations and performed process steps (tracing) [3]. Currently, tracking and tracing activities mostly take place manually, using mobile devices and/or a paper-based documentation [4]. This proceeding leads to time consuming, inefficient logistic processes and partly outdated or incorrect data [1].

The distribution process of presale vehicles constitutes here no exception. An analysis of the currently used tracking-procedures on the seaport-terminal of the BLG Logistics Group[1] was conducted. The BLG Logistics Group moved worldwide 5.4 million vehicles to their designated car dealers in 2010 [5]. Roughly 2 million vehicles were shipped through the analysed compound in Bremerhaven. The analysis has shown that employees often document vehicle movements and conducted technical operations in paper lists or record the corresponding data using mobile data entry devices (MDE). The final transmission to the IT-system takes place manually, which tends to induce a certain time delay. As a result, the actual state and position of vehicles are often not up-to-date and therefore incorrect. The restrictions in data availability and actuality frequently lead to delays in the process chain and are often the cause for time consuming search procedures in the terminal area [1].

The tracking functionality aims to make vehicles easier to find and therefore reduces the number and effort of required search operations. An effective tracing helps to optimize the processes and to improve the organisational structures within the logistic network [6]. However, the implementation of such a system is often no easy task, due to the

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required coverage of wide spaces common for logistics compounds. With the advancing mechanization in logistics and the growth of wireless communication networks, the use of mobile tracking devices is a viable option to resolve this problem [7].

Furthermore, applying modern information and communication technologies (ICT) offers the possibility for real time tracking and tracing, which enhances the process organisation and efficiency as well as data transparency. The resulting company-wide availability of high quality real time data accelerates the processes and helps to exclude the human error as far as possible. The latter is closely linked to the application of AutoID-technologies for tracing purposes.

AutoID denotes the automated identification of objects or the automated retrieval of object information, respectively. Technically, the concerned information is encoded directly on an object and can be read by using a suitable device [8]. A manual and error-prone data entry is no longer required. Common technologies in this context are RFID (Radio Frequency Identification) or barcodes. This paper introduces a technical approach to provide real-time tracking and tracing information of presale vehicles within the distribution processes on an automobile seaport-terminal.

MOBILE TRACKING AND TRACING

One problem concerning mobile tracking and tracing of vehicles meant for sale is the general orientation towards customer preferences. Every vehicle can differ concerning the integrated components and may, since it is an object for sale, not be physically altered during the distribution process. This highly restricts the access to integrated sensory systems (i.e. vehicle navigation system, inertial measurement units or a compass). One way to deal with this problem is the use of a portable device that provides the required information through its own sensors. More specifically, for the purpose of tracking and tracing, the device needs (at least) to identify the subject vehicle, to calculate an estimated position and to communicate this information to a central unit for data storage or evaluation.

From the financial point of view, equipping each vehicle on a distribution compound with one of these mobile devices would be vastly expensive, even in a closed loop environment. The more useful approach is therefore, to monitor only vehicle movements, instead of continuously tracking every car at every moment [1]. This way, the number of necessary devices can be significantly reduced. A tracking and tracing system following this approach only needs to monitor car positions and movements to assure that all relevant data are available at an arbitrary point in time.

Besides the integration of the tracking and tracing functionality into the operational processes, the quality of such a system highly depends on the technical implementation. From the positioning/tracking perspective, three general possibilities exist to locate an object within the different levels of a logistic system. The first and best known approach is the Global Positioning System (GPS). On the basis of a global network consisting of navigation satellites, it offers a positioning accuracy of up to 10 meters [9]. The application of additional earthbound reference stations can increase the position accuracy up to less than five meters by correcting possible deviations due to atmospheric disturbances.

Within a logistic network, GPS is suitable to track the movements of transport vehicles such as tracks, trains, ships or airplanes. It is further able to monitor freights, which are large enough to be equipped with a GPS receiver. Due to the global orientation of the GPS approach, the logistic use mainly aims to navigation purposes or lays the groundwork for a coarse overview of cargo transportation.

The second positioning approach is the local positioning within delimited areas such as covered territories or buildings. Local Positioning Systems (LPS) base on a set of beacons with a limited range, such as WiFi - access points or radio broadcast towers. The signal strength is used to determine the distance of the considered object to the beacons. In practice, LPS techniques come into operation for local inventory tracking, for example in warehouses or factories.

The third positioning approach bases on the ad-hoc connection of personal devices, for example PDAs or cell phones. The data transfer within those Personal Area Networks (PAN) takes place via wireless technologies such as Bluetooth or IrDA. Further, WiFi or wired technologies basing on USB or Firewire are common. Therefore, PANs usually have a range of only a few meters. Accordingly, the application area is comparable to the LPS systems: positioning services in limited, mostly indoor areas [10].

To identify a specific logistic object for tracking purposes, three technologies are common. The use of barcodes is popular for everyday applications, such as shopping or airplane boarding. Barcodes encode object data in a combined graphical and numerical form following application specific schemes such as the Universal Product Code (UPC) or the European Article Number (EAN). The main advantages of barcodes are the high level of standardization and the comparatively small cost of barcode labels [7]. The disadvantages are the sensitivity of the paper-based labels to adverse environmental conditions [12] and the in some cases limited readability.

RFID represents the second widespread technology for identification and tracking purposes. The object is equipped with a transponder (short form: tag) that transmits the saved object data via radio waves [7]. The range of detection can differ depending on the type of transponder. RFID offers the possibility to detect more than one object at the moment. Further, RFID does not rely on a direct line of sight and supports the multiple use of a transponder through overwriting with new data. Finally, the acquisition speed is higher, compared to barcode systems [7]. Known drawbacks are faulty detection results, such as double detections or false positives. The latter occur, when a tag is detected, although it should be outside the associated range of the reader [13]. Further, mechanical damages of the tags can complicate or distort the detection. RFID-based solutions are, for example, common in the field construction industry or in the retail sector [14].

Finally, Optical Character Recognition (OCR) denotes a method for the automated detection of labels in text form. As the most objects are lettered anyway, a clear identification is in the most cases quite simple. Technically, the advantages and disadvantages are similar to the barcode approach. An indistinct labelling or an adverse perspective seriously affects the recognition results. Today, OCR systems automatically identify containers, truck plates and chassis in the field of container handling [15] or license plates in systems for toll or parking fee collection [16].

THE EASYTRACING SYSTEM

To provide a tracking and tracing in real time, the reporting process requires to be automated. Implementing a technical system that integrates the technologies described above is a possible way to realise this automation. Due to the need to monitor large spaces, mobile devices to record vehicle movements are often preferable. To ascertain the technical and physical requirements for such a system, as well as adjoining IT-systems, the vehicle dispatch process for presale vehicles in a seaport terminal was analysed.

This dispatching process defines a whole process chain. Frequent business processes within this chain are delivery, storage, technical treatment and disposition of vehicles [1]. The general proceeding is as follows:

New vehicles arrive via railway (train), sea routes (ro-ro-ferry) or via road (semi-trailer). In the next step, vehicles are either stored temporarily, when necessary receive technical treatment or are modified for customization, when requested. Technical processing may include refuelling and installing/replacing components. Vehicles are therefore moved over the terminal to multiple different stations according to their requirements. These requirements often differ from vehicle to vehicle. Therefore, the mobile tracking devices need to monitor all these movements. A possible way to implement this proceeding is to equip all vehicle-driving personnel with a wearable computer system that is outfitted with the components for identification, positioning and communication.

The easyTracing System (eTS) is such an implementation. This system consists of a central supervisory system (SVS) and an arbitrary number of mobile, wearable devices. The mobile units are equipped with GPS for positioning, an RFID-reader to identify vehicles[2] and a WLAN- and GPRS-interface to transmit process data. This data is sent to the database of the central supervisory system. The SVS itself sends back commands and information to the mobile units, when needed.

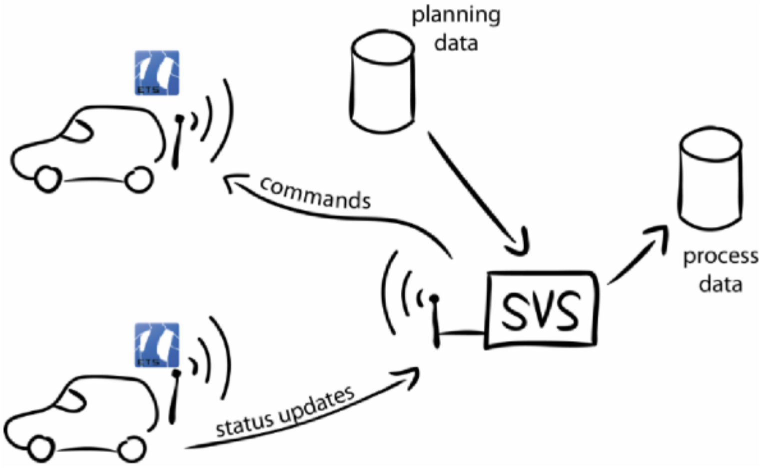

Figure 1: eTS concept overview

The mobile units are implemented in the form of a vest worn by vehicle moving personnel. When a driver enters a vehicle, the vest automatically identifies it and enquires the next process-step for this vehicle from the SVS. The SVS determines the required information from the planning data, which contains all orders and specifications (1). This information is sent back to the vest and displayed to the driver. Subsequently, the system leads the driver to the designated service station using the GPS component. Upon arrival, the driver eventually leaves the vehicle, which will be registered by the mobile device. Subsequently, target and actual GPS-coordinates are compared and upon match sent to the SVS. The driver is then free for a new assignment. Mismatching coordinates will result in an issued warning.

Outdoor usage for mobile devices requires a general robustness towards environmental conditions. This means, it has to withstand temperatures between -20 and +50 degrees Celsius as well as splash water. Therefore, all temperature- and water-prone parts of the vest are coated in isolating and water-repellent textile. Another usability requirement is the operating time of at least 8 hours without recharge. As a wearable computing system is restricted in weight and therefore capacity of the battery, a proper power management has to be implemented. Since a continuously active RFID-reader leads to an immense power-drain, specific readout-times are determined by a proximity-sensor located in the back of the vest. Since the vest is supposed to identify a car only at the time when the driver enters or leaves a car, the assessment if a driver is sitting is used as a trigger for the RFID-reading process.

REAL-TIME SUPPLY CHAIN INFORMATION EXCHANGE

The usefulness of a company-wide data transparency can hardly be argued. However, vehicle production and distribution, as it is practiced today, involves various different companies working together in a supply chain. These supply chains can be roughly sketched in form of an hourglass with the manufacturer (OEM) in the centre (2). Forecasting and planning, production and distribution heavily depend on information from ‘higher level’ partners in the hourglass and require an according supply chain wide data

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[2] It is assumed that all vehicles are set up with an RFID-tag with the Vehicle Identification Number (VIN) stored on it in accordance to VDA recommendation 5520 [26].

transparency [17]. Moreover, with the introduction of 'lean' principles, such as *Kanban* and *JIS*, the need for regular information sharing increases, as irregularities in the higher levels of the supply chain can result in grave implications in the central or lower levels. So can, for instance, stock calculation errors propagate throughout a supply chain, resulting in increasing discrepancies in subjacent tiers. This is also known as the so called *bullwhip effect* [19] and can be mitigated by regular information exchange between the involved parties [20].

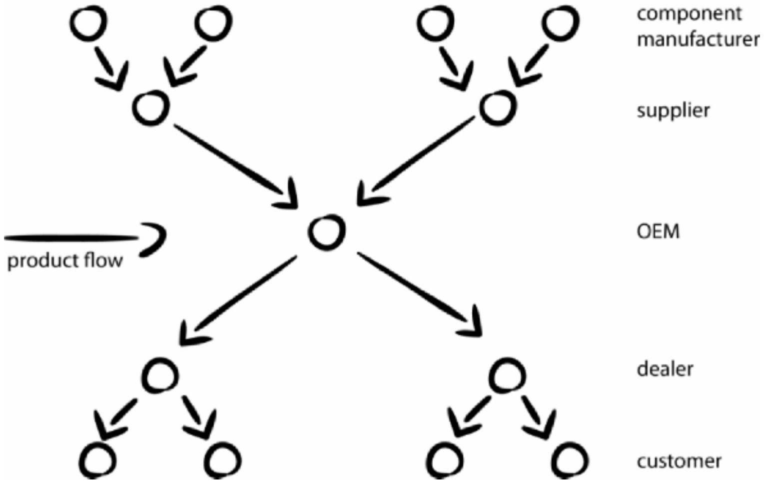

Figure 2: Simplified automotive supply chain, adapted from [21]

Information exchange in supply chains generally works through messages to a directly over- or underlying partner. Due to the lack of a trustful business relationship with other supply chain members, this often results in growing delays, the more the information travels through the network. During automotive production and distribution, this deficit concerning the transparency often leads to unreliable production figures, resulting in incorrectly stocked inventories and imprecise planning [22]. Furthermore, the need of information exchange does not cease with the end of production: End-to-end communication in supply chains can help to avoid long order-to-delivery times by optimizing the distribution process and can simplify expensive call-back procedures.

However, a direct exchange of real-time information between all supply chain partners firstly requires establishing a network of trust between all involved parties [23]. Secondly, a joint data interchange infrastructure and a generally accepted exchange format are essential. The on-going project RAN[3] attempts to define a standard for both infrastructure and exchange format, designed specifically to meet the requirements of automotive supply chains. This standard bases on GS1's EPCIS, which suggests, as opposed to the Electronic Data Interchange (EDI) standard EDIFACT, a push-based information exchange method [24] to comply with the high security requirements in automotive industry. Furthermore, EPCIS allows communicating in an n-to-m relationship and can therefore easier alleviate the requirement to distribute information to multiple supply chain partners at once. But the most decisive argument for choosing EPCIS is that it is a well-established standard. It comes with wide variety of products and protocols designed around the standard reaching from capturing (e.g. ALE) to data storage. In RAN, a distributed network of extended EPCIS repositories, automatically exchanging information between authorized supply chain members, is serves as an exchange platform and is defined as part of the standard. This network is called Infobroker[4] and is designed to distribute event-based process data to partners, who may require it.

The combination of the standards from the RAN project and the easyTracing System is a promising approach to enable a real-time end-to-end vehicle traceability. By providing

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[3] www.autoran.de

[4] For a more detailed explanation to RAN and the Infobroker, see [28]

tracking information directly to supply chain partners the resulting system achieves a very high degree of data transparency. To implement this, a modification of the above described SVS-component is used, which generates EPCIS-compliant event-data and transmits it to the local EPCIS repository, when vehicle transportation is completed. The Infobroker infrastructure forwards this information to business partners, such as the OEM or logistics sub-contractors (see 3).

Analysis of current information exchange procedures between the BLG Logistics Group and supplying OEMs (e.g. Daimler or BMW) have shown a low degree of automation and that data is often exchanged 'by hand' (i.e. by fax or telephone). With the use of a machine interpretable exchange standard like EPCIS, information-sharing processes like inventory audits or enquiries on delivery times can be automatically processed, which is normally less time-consuming. Moreover, the real-time aspect allows increasing efficiency in processes such as vehicle call-back procedures by allowing access to data of current logistics activities and vehicle positions. Furthermore, this access benefits 'lower' supply chain partners as well, allowing a more precise planning. For example, a car dealer may receive regular status updates for a specific vehicle and is able to forward this information to the customer.

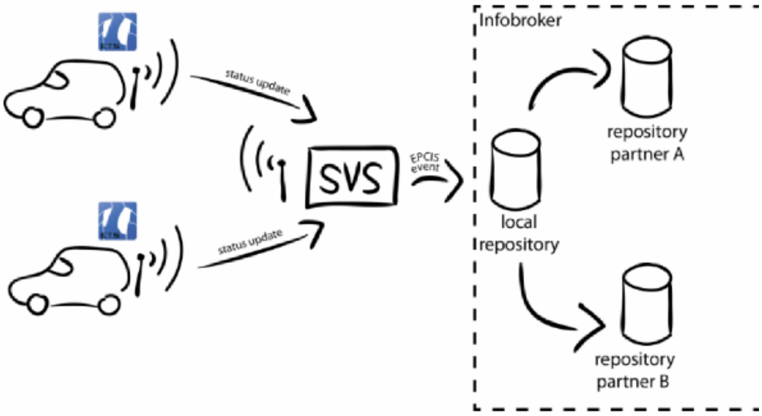

Figure 3: Combining eTS and the Infobroker

CONCLUSION

In the field of vehicle logistics, the transparent distribution of process information in single companies as well as within the whole supply chain is from unquestionable benefit. This transparency can be achieved by using technical systems. As such, the easyTracing System is capable of automating the required generation of event-based process-data. The analysis of this tracking and tracing data can help to further optimize the distribution process. Furthermore, the utilization of real-time information often eliminates necessary error handling such as vehicle searches and allows a more precise planning in follow-on process steps.

Additionally, the eTS has the potential to combine centralized and decentralized logistics control as it allows the implementation of more robust distribution processes. Switching between a local control and supervising centralized process supervision enables to benefit both from quick reaction times and data transparency [25].

By routing all data through the eTS central unit supervision and management of distribution processes can be made easier or even automatable. This facilitates the adoption of more sophisticated control strategies such as vehicle clustering for easier access in follow-on processes or to prioritize more urgently needed vehicles.

ACKNOWLEDGEMENT

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KERBSIDE WASTE MANAGEMENT – INVESTIGATING THE DETERMINANTS IN THE CONTEXT OF A METROPOLITAN CITY COUNCIL

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ABSTRACT

Purpose: This study aims to identify the critical determinants of successful implementation of a kerbside waste management system in a metropolitan city council in Melbourne.

Design/Methodology/Approach: The critical case sampling method is used to identify the case for this study. Eight determinants of kerbside waste management were identified and used in this study. The analytic hierarchy process (AHP) methodology, which integrates simultaneously qualitative and quantitative information for prioritizing alternatives when multiple criteria must be considered, is used for data analysis.

Findings: Results indicate government's legislation, alliance and coordination with stakeholders, infrastructure, and community education and engagement are critical determinants for a successful implementation of kerbside waste management systems.

Originality/Value: This study contributes valuable insights into critical determinants of kerbside waste management systems in the context of metropolitan city councils.

Keywords: AHP, Australia, Kerbside waste management.

1.0 INTRODUCTION

The management of waste is critical to the health, environmental integrity and longevity of a community. Regulation on waste management in Australia has over the last decade focused on reduction of environmental impact from waste collection and conservation of resources from waste. Victorian State Government, Australia is totally committed to the strategic goal of achieving 'Zero Waste' through a strategy called *Towards Zero Waste* (TWZ, 2005). This strategy sets the direction and vision for a more sustainable Victoria. It seeks to minimise the amount of waste generated and maximise opportunities for recovering materials. The TWZ strategy is guided by three major goals (DSE, 2009):

1. to generate less waste,
2. to increase the amount of materials for recycling and reprocessing, and
3. to reduce damage to our environment caused by waste.

Municipal solid waste (MSW) is generated from municipal or residential activities, and comprises hard waste, recyclables, organics and residual materials (commonly referred to as garbage). MSW may also include materials from municipal activities, such as emptying litter bins, sweeping streets and maintaining parks. MSW can also include some quantities of materials from municipal construction and demolition works. MSW is mostly collected by councils from the kerbside. The aim of this study is to identify the critical determinants of successful implementation of kerbside waste management (KWM) systems in metropolitan city councils. The rest of the paper is organised as follows. Section 2 provides a brief discussion on the waste profile of Victoria. Section 3 provides a review of literature and identifies the determinants of successful implementation of kerbside waste management systems. This is followed by the research methodology in section 4. Section

5 presents the results of the analysis and section 6 discusses the findings and sensitivity analysis. Finally, a conclusion is drawn in section 7.

2.0 Waste profile of Victoria

Waste is categorised as three types (DSE, 2009):

- municipal solid waste (MSW) (from households and council operations);
- construction and demolition (C&D); and
- commercial and industrial (C&I).

C&D and C&I waste account for 73 per cent of the total waste stream. MSW accounts for 27 per cent. The amount of MSW generated is measured by proxy, through the amount of waste that municipal councils collect. The statistics on MSW collected from kerbsides between 2001-02 and 2008-09 shows that (VAR, 2011):

- the amount of municipal waste collected from households through garbage, recycling and organic kerbside collections increased from around 1.6 million tonnes to 1.9 million tonnes (around 0.3 million tonnes, or 19 per cent);
- the majority of this increase (0.2 million tonnes, or 76 per cent) occurred in metropolitan Melbourne; and
- waste collected in regional Victoria increased by around 0.07 million tonnes, contributing the remaining 24 per cent.

Of the 1.9 million tonnes of municipal solid waste collected in 2008–09, around 1 million tonnes (54 per cent) was garbage, followed by recyclables and organics (32 per cent and 14 per cent respectively).

Melbourne's population will continue to grow significantly during the life of the Strategic Plan 2006-7-2013-14, and so will its waste generation. Figure 1 shows the projected waste generation in metropolitan Melbourne between 2005–30. Assuming a continuation of trends expected under TZW, initial projections suggest that some 2.3 million tonnes more waste from all sources will be produced in metropolitan Melbourne in 2030 compared to 2006–07. In other words, total waste will increase to 9.7 million tonnes or a further 31 per cent in 23 years. The projections show a declining need for landfill, compared to the amount of material being recovered. However, landfills will be required for the foreseeable future.

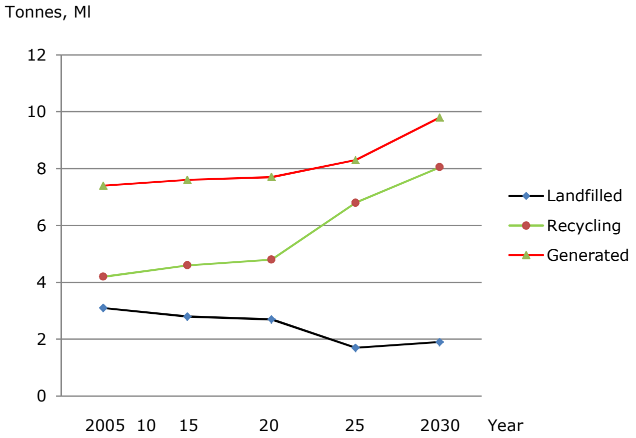

Figure 1: Projected waste generation, recycling and landfill in metropolitan Melbourne, 2005 - 20030 (Source: DSE, 2009)

A map of the municipalities in the Melbourne metropolitan area is shown in Figure 1. This study was conducted in one of city Councils to analyse its KWM operations.

Figure 2: Map showing municipal councils in metropolitan Melbourne, Victoria

3.0 LITERATURE REVIEW

3.1 Factors Affecting Reverse Supply Chains

Several conceptual models that suggest ways to design and implement reverse logistics have been developed. The model developed by Carter and Ellram (1998) identified two sets of factors – internal and external. The two external factors of government regulations and customer demands and the internal factor of policy entrepreneur were considered by Carter and Ellram (1998) to be the main drivers of reverse logistics systems. The principal internal driver is the existence of a policy entrepreneur within the company who is personally committed and willing to take responsibility for reverse logistics activities. Other determinants to the implementation of reverse logistics systems include the support of top management, stakeholder commitment, incentive systems, quality of inputs and vertical integration. Stock (1998) suggested that factors related to management and control, measurement and finance determine the success of a reverse logistics program. Dowlatshahi (2005) suggested a five-factor strategic framework to design and implement recycling operations in reverse logistics. The factors being strategic costs, strategic quality, customer service, environmental concerns and legal concerns. Using these studies, Rahman and Subramanian (2012) proposed a conceptual model of reverse logistics systems comprised of eight determinants categorized as the internal and external environments of reverse logistics systems. In this study we have adapted Rahman and Subramanian model to investigate the determinants of kerbside waste management in the context of a metropolitan city council. These factors are explained as follows:

3.1.1. Legislation

Legislation refers to regulations or Acts passed by government agencies to ensure firms take back, recycle and reuse the products at the end of life cycle. The major aim of this initiative is to protect the environment, avoid landfill and prevent contamination of water. Research suggests that government legislation is one of the main drivers for a firm's environmental efforts. Walker et al. (2008) stated that environmental regulations can be seen as a motivator to innovate and reduce the environmental impact at low cost rather than cause for litigation.

3.1.2. Community education and engagement

Education and engagement are vital components of waste minimisation. Raising awareness amongst householders, businesses and across government is an essential part of resource efficiency and resource recovery programs. Education and information about resource recovery services that result in participants supporting, and correctly using, such services can significantly affect the quantity and quality of materials being supplied to facilities.

3.1.3. Administrative Leadership

Stock (1998) suggested that the commitment of the senior management is the key driver in reverse logistics activities. As allocation of resources towards environmental and educational programs increases, it is more likely that a firm institutes a system of environmental management, which would determine the direction to reverse logistics and environmental activities. While legislation is the milestone of any change, administrative leadership with effective management process is crucial.

3.1.4. Monitoring and evaluation

Effective implementation of KWM requires sound planning and monitoring. Typically this produces a plan that aligns policy objectives with implementation. To assess the performance, it is essential to develop monitoring, evaluation and reporting frameworks.

3.1.5. Quality and quantity

Guide and van Wassenhove (2009) stressed that the volume of returns and quality of products are major drivers for recycling. Pokharel and Mutha (2009) emphasized that the pricing of product should be based on the quality of the returned products. They also found that good quality product requires fewer processes to reuse it. The volume of return products is critical for implementation of reverse supply chains (Carter and Ellram, 1998).

3.1.6. Incentive/levy/funding

Its being suggested that the right incentives would enhance return rates. For instance, through the $10 million Victorian Advanced Resource Recovery Initiative (VARRI), the state government is currently exploring the use of new technology to process waste into clean energy and products, such as compost. The importance of having incentives (e. g., landfill levy) to drive further resource recovery remains a critical determinants of successful KWM operations.

3.1.7. Infrastructure

Dowlatshahi (2005) stated that the overall success of reverse logistics systems depends on the effective use of available resources. The available resources are referred to as facilities, personnel, material handling /processes capabilities and computer system.

3.1.8. Alliance and coordination

The lack of a structured approach to coordination may result in a range of inefficient and ineffective practices across the municipal waste sector. The role of coordination and the importance of communication in both speedy and early disposition of returned products have been discussed extensively (Hess and Meyhew, 1997; Daugherty et al., 2005; Fleischmann, 2003; Yalabik et al., 2005). Few attempts have been made to also improve integration and coordination with the use of an information support system (Chouinard et al., 2005; Daugherty et al., 2005). Efficient information systems are needed to individually track and trace product returns, to forecast returns and for inventory management (de Brito et al., 2002).

Based on the conceptual model that we have developed and used in this study is shown in Figure 3.

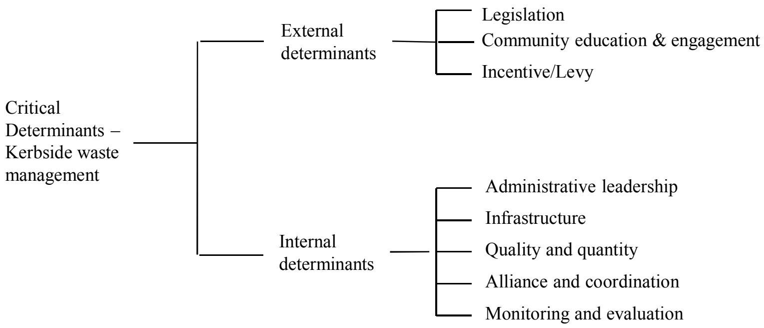

Figure 3: Model for kerbside waste management (Adapted from: Rahman and Subramanian, 2011).

4. RESEARCH METHODOLOGY

4.1 Method

This study employs the analytic hierarchy process (AHP) method for analysis. It's a decision-making approach which integrates simultaneously qualitative and quantitative information for prioritizing alternatives when multiple criteria must be considered. AHP has been widely used to decision problems in areas such as supply chain risks assessment (Schoenherr et al. 2008), 3PL selection (Gol and Catay, 2007); supplier selection (Wang et al. 2004). With AHP complex decision problems can be decomposed into a set of manageable decision-making problems. The modeling process of AHP involves four steps:

1. assessment of the critical determinants of kerbside waste management,
2. structuring the problem as a hierarchy and building the AHP model,
3. collection and compilation of respondents' opinions and application of the prioritisation procedure, and
4. determination of critical determinants through the synthesis of normalized priority weights and checking the consistency of opinions of respondents.

As indicated in step 4, AHP offers not only a methodology to rank priorities but also provides a direct measure of consistency of judgment elicited by the decision-makers. Saaty [1977] demonstrated that $\lambda\text{max} = n$ is a necessary and sufficient condition for consistency. Inconsistency may arise when λmax deviates from n due to inconsistent responses in pair-wise comparisons. Therefore, the matrix A should be tested for consistency using the formula:

$$\text{CI} = (\lambda\text{max} - n)/(n - 1), \qquad (1)$$

$$\text{CR} = \text{CI}/\text{RI} \qquad (2)$$

where CI is the consistency index, RI is random index generated for a random matrix of order n, and CR is the inconsistency ratio. The CR refers to the degree to which decision-makers adhere to the rank order specified and measures the extent to which an established preference is kept. A $\text{CR} \leq 0.1$ is recommended as acceptable [Saaty and Kearns, (1985)]. If $\text{CR} > 0.1$, it is suggested that the decision-makers reevaluate their judgments. Homogeneity of challenges within each group, smaller number of challenges in the group, and better understanding of the decision problem would improve the consistency index [Saaty (1993)].

4.2 Sample municipal council and Respondents

To investigate the criticality of the determinants affecting kerbside waste management a study was conducted in late 2010 with a municipal council located in Melbourne, Australia. A two-part questionnaire was employed for data collection. Part A contained questions (in AHP format) designed to capture respondents' opinions on the relative importance of the determinants, whereas, Part B contained general questions about the municipal council and respondents' background, and related management issues. Five senior managers were chosen from the shire council who has reasonably long experience with the KWM operations of the councils. The interviews and data collection for the AHP Methodology were conducted on two separate days. Interviews were conducted face-to-face. Interviewee answers were recorded and then transcribed. Respondents were assured that their answers would be kept confidential.

None of the respondents were familiar with the AHP data collection procedure. Therefore, the following two steps were considered:

1. Respondents were explained the meaning of the integer scores of the 1-9 scale.
2. Respondents were explained how these scores need to be considered while making the pairwise comparisons between any two determinants.

These two steps were critical to ascertain the accuracy of data.

5. ANALYSIS AND RESULTS

In order to determine the priority weight of each determinant, judgment matrices, based on managers' interviews, were translated into the largest eigenvalue problems, and then calculated the normalized and unique priority vectors of weights by using the Expert Choice® Software. The overall inconsistency index of judgments was then calculated. This was done taking all responses together. The results are shown in Figure 4.

Numerical analysis was conducted in two stages: (1) determination of weights of each higher level determinant-category; (2) determination of weights of each determinant under each higher level determinant-category. Hence, the outcome of the first stage would identify the degree of importance for each determinant-category as a percentage of total importance over all measures. Based on the outcome of this evaluation, determinants contributing to each higher level determinant-category in KWM operations could be prioritised, so that municipal council can choose the appropriate levels of those determinants in their KWM implementation projects.

Figure 4 and 5 indicate that the main determinant is government legislation, with an overall weight of 0.268. The second most important determinant is Alliance and coordination (weight = 0.213). This is followed by Infrastructure (weight = 0.136), Community education & engagement (weight = 0.109) and quality and quantity (weight = 0.099). The level of inconsistency is 0.06 and is acceptable.

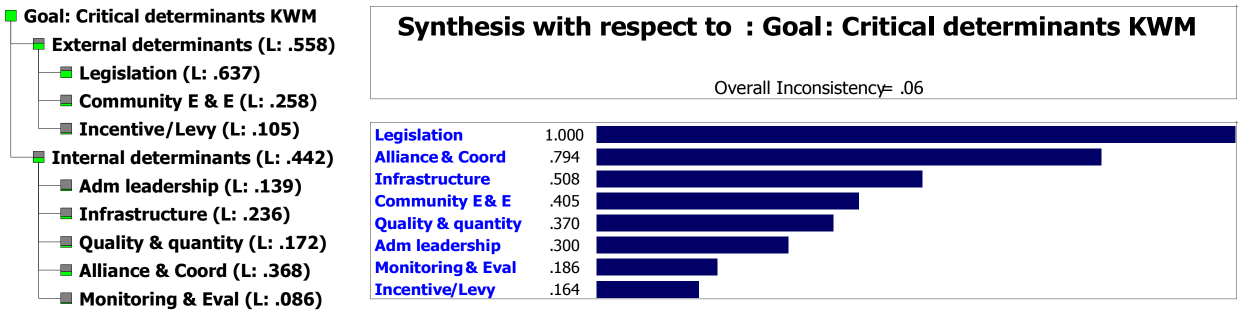

Figure 4: Weight priorities of the determinants

6. SENSITIVITY ANALYSIS AND DISCUSSION

In the context of AHP sensitivity analysis is performed to investigate whether small variations in the model parameters would change the ranking of the enabling determinants considered in the study. The final weight priorities of the determinants depend on the weights associated with the higher level determinant-category. Therefore, minimal change in the higher level determinants could potentially change the ranking initially determined.

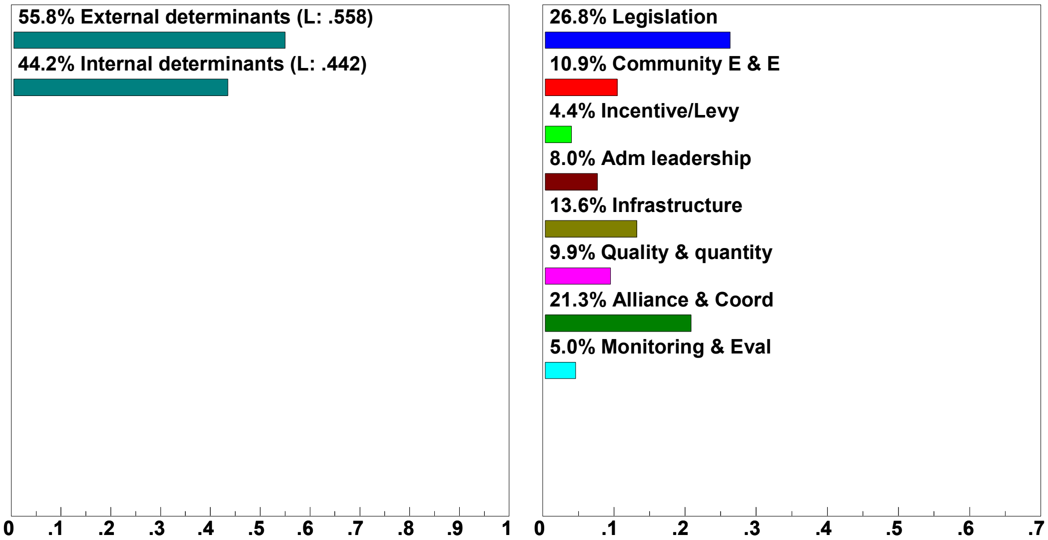

Figure 5: Dynamic sensitivity of the determinants affecting KWM operations

First, the weight of the external determinant-category was varied. Figure 6 demonstrates how the final weight priorities of eight determinants perform with respect to the change in external determinant-category. When weight is increased from 0.558 to 0.687, the priority of the determinant is changed, i.e., Community education and engagement becomes the second most important determinant. When the weight is decreased from 0.558 to 0.516, ranking of the determinant is also changed, i.e., Alliance and coordination becomes the most important determinants and legislation remains as the second most important determinant.

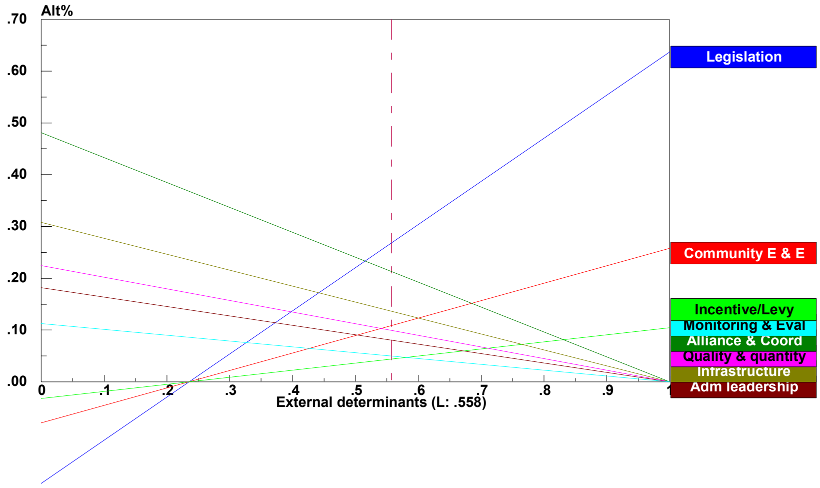

Figure 6: Gradient sensitivity analysis of final weight priorities when external determinant-category is varied

Second, the weight of the internal determinant-category was varied. When weight is increased from 0.442 to 0.512 (see Figure 7), the priority of the determinant is changed, i.e., Alliance and coordination becomes the most important determinant. Ranking of the determinants is relatively insensitive when the weight of the internal determinant-category is decreased.

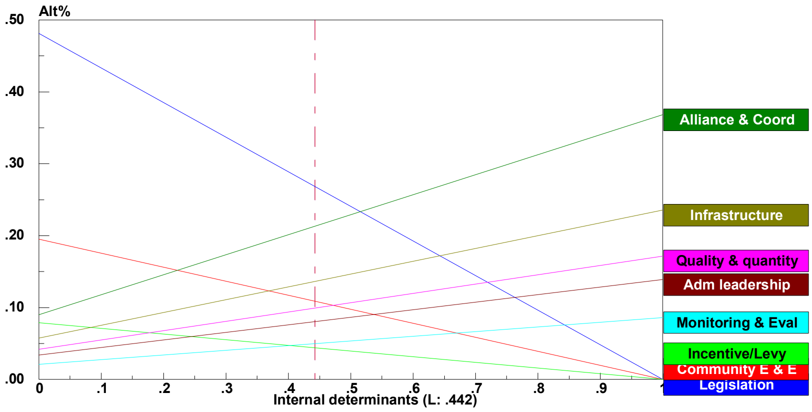

Figure 7: Gradient sensitivity analysis of final weight priorities when external determinant-category is varied

7. CONCLUSION

The population in the metropolitan Melbourne is growing and so is it waste. The Victorian Government's *Towards Zero Waste* (TZW) Strategy seeks to minimise the amount of waste being generated and to maximise opportunities recovering materials. This study investigates the critical determinants of successful implementation of TZW strategy in a city council. The results indicate that both external and internal determinants are important. The top five determinants are legislation, alliance and coordination, infrastructure, community education and engagement, and quality and quantity. It can be suggested that the managers should concentrate on these determinants so as to implement efficient KWM systems.

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OPTIMIZING END-TO-END MARITIME SUPPLY CHAINS: A CARBON FOOTPRINT PERSPECTIVE

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INTRODUCTION

The purpose of this research was to develop optimisation methods for minimising total logistics related carbon emissions for end-to-end supply chain distribution systems. Appropriate tools for calculating the carbon emissions for the maritime leg of global supply chains are discussed. The study is based on real life global supply chains case data and demonstrates that end-to-end logistics carbon emissions can be reduced by 16% to 21% through direct delivery to the UK as opposed to delivery via Antwerp. Value Stream Mapping appeared to be a flexible tool that can be adapted to measure and analyse CO2 emissions with different calculation methods. The application of the different calculation methods, which depend on the data availability, are presented followed by the discussion on the results.

REVIEW OF RELEVANT LITERATURE

With the raising concern of anthropogenic CO2 emissions on climate change, companies are showing an increased interest in managing the climate change risk impact of their activity. The growing number of participating members of the Carbon Disclosure Project's well known Supply Chain report (Carbon Disclosure Project, 2012) illustrates this evolution. In the procurement field, the measuring of carbon footprint from end-to-end supply chains is one of the steps towards answering this concern. Standard methodologies are only just beginning to emerge(GHG Protocol, 2011).

Carbon footprints of maritime supply chains are particularly difficult to measure due to a variety of factors, including different emission factors and apportionment possibilities depending on the vessels, routes, operational conditions, etc. A major report from IMO (2009) provided an important set of emission factors data (vessels emissions in kgCO2/T.km) by ship type and sizes, and these results where reused by Defra (2011) as a reference for the UK. In parallel, the industry-led Clean Cargo Working Group approach (CCGW, 2009) also produced emissions factors by trade routes for container vessels, (measured in CO2/TEU) and based on real fuel consumption. New emerging approaches are also trying to rate emissions factors at the vessel level (IMO, 2012).

Value Stream Mapping (VSM) is a lean mapping tool originally created for application to reduce waste and increase productivity from industrial processes (Rother and Shook, 2009). Some attempts to apply it to sustainability issues have been carried out in the past. Lean researchers and practitioners have already defined concepts such as "Sustainable Value Stream Mapping" (Simon and Mason, 2003; Norton, 2007), "Carbon Stream Map" (Windsor, 2010) or the "Voice of Environment Value Stream Mapping" (Olson, 2009). The purpose of the case study reported in this paper is to investigate its application to end-to-end maritime supply chains arriving in the UK, with specific attention to the construction and formalisation of the VSM databoxes.

DESCRIPTION OF THE PROBLEM

This research is based on an industrial case using the supply chain optimisation of a UK-based distributor of plastic products. Most products for the case company are sourced from the suppliers DCs, located either in the UK or in the EU, but the original production facilities are based in Asia and the Middle East. Once sourced, products are stored in a central warehouse in the UK's East Midlands and then shipped to more than 600 delivery points in the UK.

The scope of our analysis covered the end-to-end supply chain, from the production facility in Saudi Arabia to the final customer in the UK. The optimisation levers considered were the study of alternative delivery routes (including direct delivery to the UK) and the the customers' centre of gravity.

The company had not carried out supply chain carbon mapping before this research and therefore there were no available supply chain environmental data. All logistics operations (warehousing, upstream and downstream transport) are carried out by logistics service providers. Upstream transport is provided either by transporters (for local sourcing by road) or by freight forwarders (for distant sourcing by maritime transport). The warehousing operations and the final delivery to the customers is provided by the distributor's main logistics service provider based in the East Midlands, who runs the UK warehouse. The distributor works only with logistic service providers. Emissions need to be measured for the supply chain. In this research the emission measure covers only the supply chain operations (emissions from the distributor offices or employee business travels are not included), and whenever required we have used emission factors from Defra (2011) which provides the national standards for the UK. We are using the 'carbon footprint' expression as a generic synonym for emissions of carbon dioxide or greenhouse gases expressed in CO2 equivalents (Wiedmann and Minx, 2008).

METHODOLOGY & ANALYSIS

The first main step for this research was to map the end-to-end supply chain current state map (Rother and Shook, 2009). Considering the extent of the scope for analysis, a specific attention was given to geographical location addresses.
When possible, emissions were assessed using emission factors and methodology as provided by Defra (2011). When the supplier was able to provide its own emission factors, those replaced the standard values as provided by Defra. The approach used consists of defining a set of product and packaging data (pallet weight, pallet per container, pallet per lorry trailer) transversal to the map and, for each supply chain stage, and a specific approach for carbon footprint calculation is used.

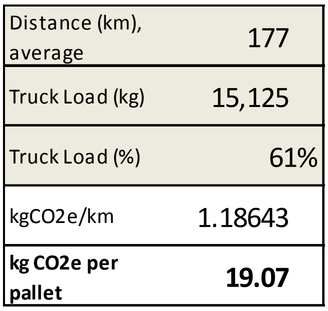
Product & packaging data

Product & packaging data contain mainly product weight, size and packaging specifications. Products are transported in containers and are palletised. Each 40 foot container is able to transport 18 pallets weighing on average 1.375 Tonnes, representing 24.75 Tonnes in each loaded container. This information is important as it allows to convert weight data into logistics units (trucks, containers) and vice-versa, and then uses the emission factors, which can be based on both weight and transport unit.

Road transport

For the case of Full Truck Load (FTL) traffic, corresponding mainly to the upstream traffic to the UK distributor, carbon emissions were calculated using emission factors in a vehicle.km basis. This was preferred to the Tonne.km basis since Tonne.km assumes percentage weight laden and average payload of 61% and 11.49T respectively, which didn't match to our case study data where it can be seen from the product specifications, average weight laden is close to 100% (24.75 Tonnes). Every transport voyage, either in Saudi Arabia, in Europe or in the UK is a full truck with one single location reference, so the average emissions are rather simple to calculate since each voyage is similar in terms of average load and number of products.

For the case of the final delivery from the UK distributor to the customer, the exact measure is more complex, since deliveries are realised in Less than Truck Load (LTL) mode, to multiple customers, and with delivery routes that can change depending on the daily demand pattern. The difficulty here lies in defining the appropriate apportionment rule considering the available data as collected by the transport operator. The data covers one year of activity and does not track the routes used by the transporters for each of the delivery points. Considering the available data, we were able to assess the emissions from final deliveries using two approaches: the first one was to use the emission factors provided by Defra in a vehicle.km basis, and assuming a truck percentage weight laden of 61% (the average UK market according to Defra (2011)). Even though it does not represent the exact situation of each delivery, the use of an average here can be justified by the fact that the LTL deliveries are typically for multi-references and multi-drop deliveries. The application of this rule provided a result of 19.07 kgCO2e per pallet for the final delivery. The approach is summarised in Table 1:



Distance (km), average	177
Truck Load (kg)	15,125
Truck Load (%)	61%
kgCO2e/km	1.18643
kg CO2e per pallet	**19.07**

Table 1: Sample databox to calculate road traffic emissions

Where:

- Distance average: is the weighted average distance between the warehouse and the final customers (weighted by the tons delivered);
- Truck Load (kg): is the average truck load assuming 11 pallets carried;
- Truck Load (%): the resulting value of truck load (kg) expressed in % of the truck capacity (assumed here at 25T). This result (61%) is used to ensure that ….
- kgCO2e/km : emission factor applied in kgCO2e per vehicle.km
- kgCO2e per pallet : CO2e emissions per pallet.

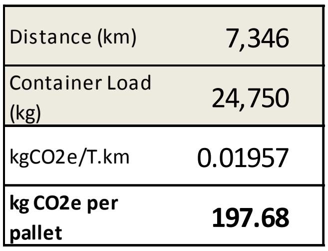
The second approach consisted in asking the transporter for the emissions based on their actual fuel consumption. Theoretically, this approach is more accurate since we measure the actual fuel consumption from this transporter, but on the other hand the transporter wasn't able to provide a better customer apportionment method than a share based on the total tonnages delivered (which does not include the distance factor). For this reason, the Defra method was used and the transporter result was used to corroborate the result. The transporter average emissions were 16.93 CO2e per pallet, which represent a difference of 11% when compared the first approach. For FTL transport (upstream transport, in our case), the same data is applied, but using the appropriate emission factor for 100% truck load and using the exact distance between the origin and the destination points (which are known points, such as ports, factories or warehouses).

Maritime emissions

Emissions Factors from maritime traffic were also collected from Defra methodology, which are based on previous results obtained from the IMO's Greenhouse Gases Study published in 2009 (IMO, 2009), excepted for Ro-Pax vessels. Defra added the CO2e Emission Factors from CH4 and N2O to the IMO results. These emissions are expressed in kgCO2e/T.km.

Just as for road traffic, Emission Factors from maritime traffic depend heavily on the vessel used for the journey, and the IMO has segmented emission factors based on the ship type and ship size.

For an accurate End-to-End Supply Chain 'Carbon mapping', it is then imperative to collect such information about the vessels that are transporting the goods. When the company has an appropriate traceability by way of Bills of Lading (B/L) - which includes the Vessels name - it is possible to track the exact vessels specifications. When such information is not available, the information can be collected at the shipping company level. In our case, for the service between Jeddah and the UK, a 5700 TEU container vessel was used as a reference. Due to the lack of electronic B/L, the use of information provided by AIS (Marine Traffic, 2012) was very useful to validate if vessels associated to shipping services were actually used. Maritime Distances were calculated on a port to port basis and were adjusted when the previous calls where not in an ideal direct trajectory. Tonnages were directly provided by the distributor.



Distance (km)	7,346
Container Load (kg)	24,750
kgCO2e/T.km	0.01957
kg CO2e per pallet	**197.68**

Table 2: Sample databox to calculate maritime emissions

Where:

- Distance: is the maritime distance between the port of loading and port of unloading;
- Container Load: is the average load of a 40 foot container;
- kgCO2e/T.km: Emission Factor as provided by Defra for 5000-7999 TEU containerships;
- kgCO2e/T.km: resulting CO2e emission per pallet for the voyage (considering the number of pallets per container provided in the product and packaging section).

Port emissions

There isn’t, at present, any carbon emissions factors from Port operations provided by Defra. But some UK ports have recently started to measure their carbon footprint operations (Mangan et al., 2011), and some information is thus available. However, the information is released as an aggregate value for all port operations, regardless of the type of cargo loaded and unloaded. This can be a problem since some cargo such as dry and liquid bulks tend to be much heavier than unitised cargo, causing then distortions if we apply a direct apportionment based on the weight only. To avoid this problem, two specific UK ports that actually measure their carbon emissions were used as reference ports: Felixstowe for containers, and Dover for Ro-Ro. The main reason that led to this choice is that these ports are specialised ports, with most traffics being containerships and Ro-Ro vessels, respectively (DfT, 2010). We assumed then that the port activity profile was the best driver to assess emissions in the absence of detailed emissions by ship type. However, due to their small impact in the overall supply chain, as it was pointed by Mangan et al. (2011), we decided not to include port operations in the Value Stream.

Warehouse emissions

Defra does not provide average emission factors for warehousing operations. It was then necessary to define an appropriate framework and identify the possible data sources. In this case, the information provided by the UK Logistic service provider in charge of the distribution could be directly used, since it is easy for logistic operators to calculate the share of products belonging to a specific customer. The resulting warehouse emissions, using the logistics provider data is detailed in the databox below:

Days of Stock	21
Pallets delivered	12,828
KWh / year (electricity)	22,800
kgCO2/KWh (Electricity UK)	0.525
kgCO2/year	11,961
kgCO2 / pallet	**0.93**

Table 3: Sample databox used to calculate warehouse emissions

Where:

- Pallets delivered: is the annual number of pallets delivered for the distributor;
- kWh / year (electricity): the annual electricity consumed by the logistics provider allocated to the distributor (including logistics operations, such as the forklifts);
- kgCO2/kWh (Electricity UK): average emission factor applied for the electricity generation in the UK;
- kgCO2/pallet : resulting CO2 emissions associated to each pallet delivered.

For the warehousing operations situated outside the UK in Antwerp, Belgium due to lack of information from the logistics supplier, the same energy consumption as in the UK was used for operations, but using the electricity emission factor (in kgCO2/kWh) from Belgium.

An alternative way to assess warehouse emissions was using results with square meters as a basis. We have used a method based on an emission factor of 17,30 kgCO2/m²/year, provided by Cox and Graham (2010) for a typical large warehouse. The result, presented in the table 4 below, shows the flexibility allowed in the use in the databox.

Days of Stock	21
m² WH / pallet	1.0
kgCO2 / m²/ year	17.30
kg CO2e per pallet	**1.00**

Table 4: Alternative possible databox to calculate warehouse emissions

Where:

- Days of stock: is average days of stock for this specific reference;
- m² WH / pallet: the average ratio of warehouse surface and pallet capacity;
- kgCO2/m²/year: average annual CO2 emission factor for the warehouse per m²;
- kgCO2/pallet: resulting CO2 emissions associated to each pallet delivered. The resulting emission is calculated by multiplying the three previous values and dividing by 365 (for example, a pallet with 365 days of stock would provide here a result of 17,30 kgCO2).

The logistic routes and their carbon footprint

The list of possible logistics routes was identified based on available options, and they were classified in three groups:

- "Ro-Ro routes": end-to-end routes from Saudi Arabia, with a warehousing operation in the supplier's facility in Antwerp (20 days of stock), then a transfer to the UK warehouse using one of the available Ro-Ro services;
- "Direct Lo-Lo routes": end-to-end routes with direct delivery to the UK with a transhipment operation in Continental Europe;
- "Direct routes": end-to-end route with a direct delivery to a UK port.

For each route 13 generic steps where defined, and the total carbon footprint associated to a container delivery was then calculated for each route by adding the emissions generated at each point of the supply chain.

RESULTS AND ANALYSIS

Value Stream Mapping is a flexible tool that could be adapted to measure and analyse CO2 emissions with different calculation methods. The databox is an efficient tool to calculate carbon emissions using our approach based on emission factors. Figure 1 below provides an illustration of the VSM for carbon footprint calculation, focused on the main operations.

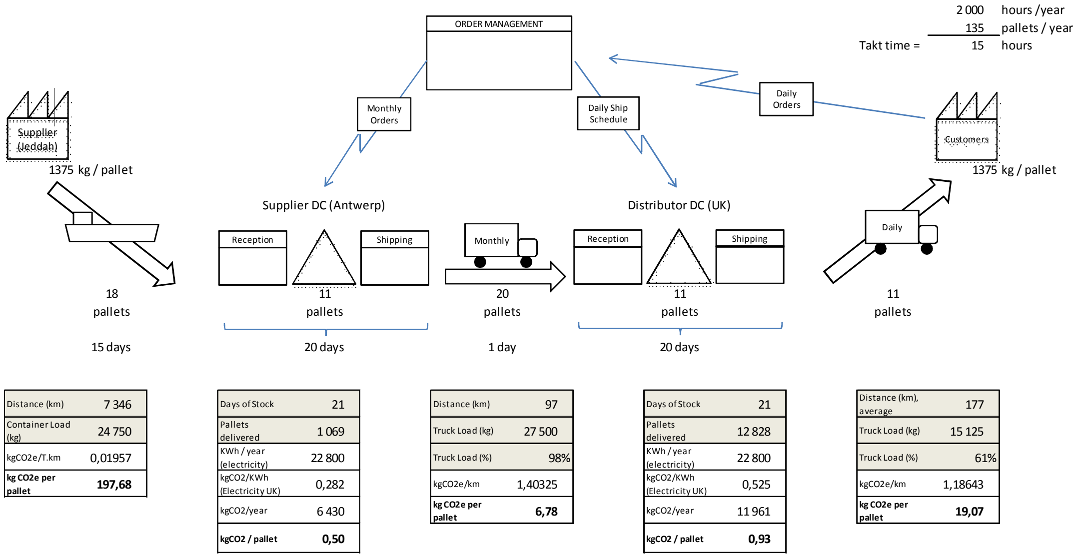
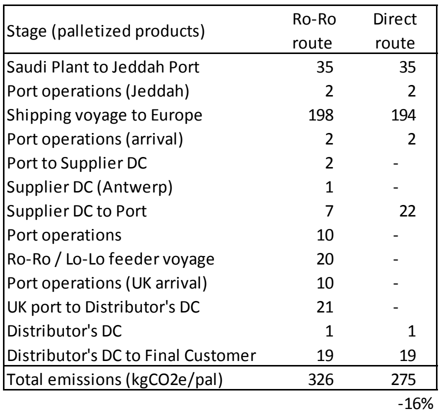


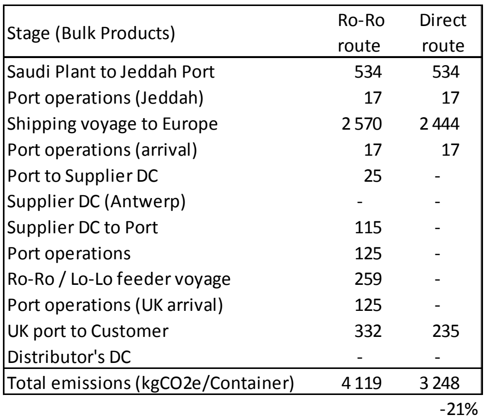
Figure 1: Current state Value Stream Mapping (illustration)

The end-to-end supply chain measure showed that the maritime leg was the main source of CO2 emissions. We can see in table 5 that through direct deliveries, these emissions could be reduced by 16% to 21%, depending on the references and routes.

The analysis of the centre of gravity showed that the current location of the distribution centre was already near to the optimal even considering the impact that the direct deliveries could have in the total flow within the warehouse. This analysis was carried out using a Tons.km minimisation using transportation models.



Stage (palletized products)	Ro-Ro route	Direct route
Saudi Plant to Jeddah Port	35	35
Port operations (Jeddah)	2	2
Shipping voyage to Europe	198	194
Port operations (arrival)	2	2
Port to Supplier DC	2	-
Supplier DC (Antwerp)	1	-
Supplier DC to Port	7	22
Port operations	10	-
Ro-Ro / Lo-Lo feeder voyage	20	-
Port operations (UK arrival)	10	-
UK port to Distributor's DC	21	-
Distributor's DC	1	1
Distributor's DC to Final Customer	19	19
Total emissions (kgCO2e/pal)	326	275
		-16%



Stage (Bulk Products)	Ro-Ro route	Direct route
Saudi Plant to Jeddah Port	534	534
Port operations (Jeddah)	17	17
Shipping voyage to Europe	2 570	2 444
Port operations (arrival)	17	17
Port to Supplier DC	25	-
Supplier DC (Antwerp)	-	-
Supplier DC to Port	115	-
Port operations	125	-
Ro-Ro / Lo-Lo feeder voyage	259	-
Port operations (UK arrival)	125	-
UK port to Customer	332	235
Distributor's DC	-	-
Total emissions (kgCO2e/Container)	4 119	3 248
		-21%

Table 5: Detailed emissions, illustrations for bulk and palletized products, with the Ro-Ro route (Zeebrugge-Purfleet) and Direct routes.

DISCUSSION AND CONCLUSIONS

Results based on the analysis of the case study presented in this paper suggest that inbound logistics from global sea ports direct to the UK via ports of Felixstowe and Southampton are the best options to minimise carbon emissions to deliver plastic products from Saudi Arabiato the customers in the UK. For the case company, among the existing routes from the continent to the UK, Zeebrugge-Purfleet by Ro-Ro has the lower carbon footprint, followed by container feedering through Zeebrugge-Immingham service. Current apportionment choices used by Defra generate higher carbon footprints for routes using Ro-Pax vessels and thus penalise those routes.

This research mapped the end-to-end carbon footprint for the given supply chain by the industrial partner. The methodology used enables the companies to exchange information about emissions with the partners in the supply chains including logistics service providers.

From a management perspective for the case company, direct sailing to the UK ports will have an impact on inventory management practices with reference to a need to recalculate the safety stocks for the new delivery times for the customers. On the other hand it should have a limited impact on order sizes, since this is unlikely to change with the suggested route of direct sailing to the UK.

The question of data availability and the apportionment rule are crucial to the modelling process, and results robustness must be analysed with regard of these restrictions. For the establishment of the emission factors, we used datasets with the following:

- Level 1: International averages or National averages extended to other countries (used for international shipping and foreign road transport);
- Level 2: National averages applied to the corresponding country (used for the UK road transport and Ro-Ro shipping);
- Level 3: Company Benchmarks from equivalent business (used for the port activity, or - as a possible alternative - for warehousing);
- Level 4: Company averages (used to corroborate final distribution values);
- Level 5: Company averages for this specific business (used for warehousing in the UK, and the homogeneity of warehousing activity made it possible for the logistic provider to calculate it).

In our opinion, in complex supply chains, such as the case study presented in this paper, the availability of more accurate data (exact emissions or fuel/energy consumptions for each logistic operation) is difficult. The use of averages and standard emission factors are part of the optimisation process and such constraints have an impact on the range of optimisation study conclusions. Also, such approach is perhaps only acceptable way to use the VSM in a “Lean” way, i.e. with calculation rules that are accessible to logistics operators . GHG Protocol (2011) points out in its guidelines the importance of formalising the business goals of each study before starting any modelling process. We think that this step is crucial to help to build models with enough accuracy in the areas where optimization levers are applicable, and with simpler rules in areas that won't have an impact in the final results and conclusions. The tools recommended in this paper should not be seen as actual accurate GHG measurement methods, but as tools that aim to help companies to make steps in the right direction for achieving CO2 emission reductions.

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LOGISTICS MANAGEMENT AS A POWER TOOL TO SUSTAINABLE DEVELOPMENT OF ECO-TOURISM ON KOH LAN CORAL ISLAND

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ABSTRACT

The paper applies Koh Lan, as a case study, to examine how to apply logistics into tourism. Koh Lan is an island just out from the beaches of Pattaya City, in Chonburi province, Thailand. Koh Lan has become an important tourist destination. This study applied principles of logistics management to the tourism industry under the hypothesis that moving tourists from Pattaya to Koh Lan more efficiently and effectively, including providing an effective transport networking system, would increase and support tourism on Koh Lan. An objective was to examine an appropriate demand forecast model for tourism on Koh Lan. The results could be used for planning infrastructure systems and facilities, including strategies for transport networks and logistics systems to support the future growth. The result showed that tourists is expected to doubly increase in the next decade. Designing transport and logistics systems from Pattaya City to Koh Lan need to be urgently done. Today, more than 1,500 trips a day by ferry and speed-boats are used for tourist travel from Pattaya City to Koh Lan. Effectively designed infrastructure systems and facilities are required to support sustainable tourism on Koh Lan. Further, new and fantastic tourist facilities would be increasingly built on the island. Finally, this study pointed out that a reverse logistics is becoming a critical issue for logisticians to disposal and manage garbage from tourism. Rapidly increasing garbage is a problematic issue for logistics related to a sustainable, green, eco-friendly environment. It concludes that strategic and integrated logistical management is necessary, with participation from all stakeholders.

Keywords: Tourism, Logistics, strategy, Island, Thailand

1.0 INTRODUCTION

Nowadays, tourism has become a significant industry to Thailand's economy growth. It generates high revenues as compared with the revenues from exporting. The paper focuses on adoption of logistics management to eco-friendly tourism on the island in Thailand. However, ever-increasing tourism has created problems in Koh Lan related to the sufficiency of its infrastructure systems and facilities. These problems include growing demand on natural resources and an escalation of environmental pollutants. The use of logistics in the tourism industry is currently recognized as a strategic tool for enhancing tourist satisfaction in relation to lower travel costs, one-stop services, other conveniences and safety.

2.0 LITERATURE REVIEW

It reviews the literature related to the role of tourism (and in particular, eco-friendly tourism) to the economic growth of Thailand. It also considers the adoption of logistics management in the tourism industry, especially island tourism. Two relevant sources (Acharya 1995; Briguglio 1995; Bryden 1973) point out that logistics management contributes to the success of sustainable tourism development. These sources also review definitions of logistics and logistics management as they pertain to sustainable development of tourism, but no one provides what is tourism logistics and how it contributes to tourism success.

Butler 1980; Briguglio 1996 points out that before logistical planning for tourism infrastructure and facilities can be achieved, there needs to be an accurate demand forecast developed. It reveals patterns of tourist behavior and other factors influencing travel decisions, as well as identifies problematic issues with tourist destinations (Conlin and Baum 1995). Conlin and Baum (1995) states that there is a relationship between adoption of logistics management in the tourism industry and the success of sustainable tourism development.

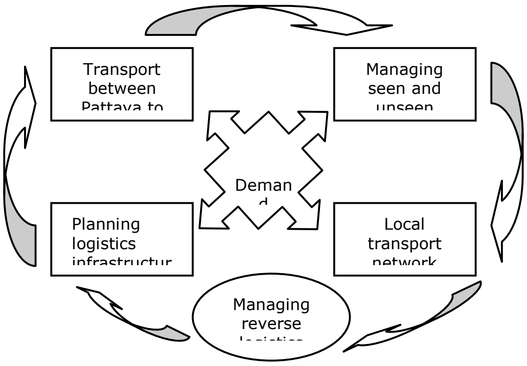

Figure 1 Relationships between activities in tourism logistics

When considering the factors affecting logistics management adoption and implementation in tourism, particularly, tourism on islands, the literature points out the major factors are economic and political realities (Thor 1994). The research (Conlin and Baum, 1995) highlights the relationship between such factors and the adoption of logistics management, like fluctuating tourist counts and tourist satisfaction. It concludes there is a literature gap related to the examination of issues related to adoption of logistics management (and its effectiveness) within the tourism industry, and specifically for islands. In particular, there needs to be an examination of the factors contributing to the logistics adoption phase and the factors influencing sustainable tourism development. This study therefore proposes a theoretical framework (Figure 2) derived from a previous study (Theppitak 2006).

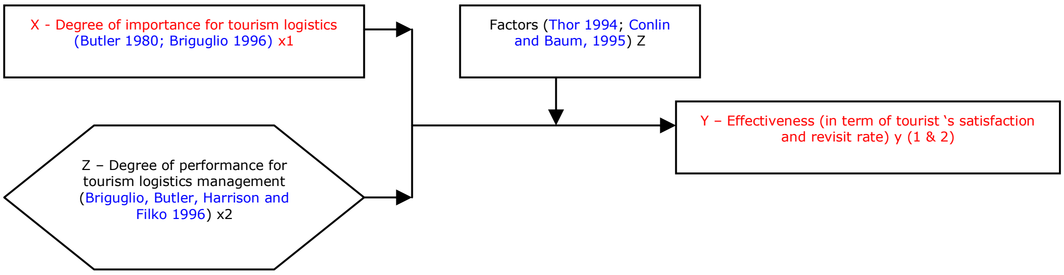

Figure 2 Theoretical Framework of the study

Figure 2 shows the theoretical framework of variables in this study. The literature revealed that building a sustainable tourism industry, especially tourism on islands, required widely applied logistics concept and strategies. Success of sustainable tourism development requires a high priority of importance on adoption of logistic planning. It applied the model of performance-importance analysis to test hypothesis. A main objective is to find ways to improve tourist satisfaction. This study examines relationship between variables (*X*, *Y, Z*), defining degree of importance to the adoption of logistics management as *an independent variable* (V*ariable X1* and X2) and performance of logistics management by defining as the effectiveness of logistics management to tourism on Koh Lan, in terms of tourist satisfaction (i.e. convenience, safety for transport network, infrastructure and facilities on Koh Lan), and return rate of tourist as *a dependent variable* (*Variable Y1 and Y2*). It also considered that other influential factors, such as economic and political realities, were significant to the adoption (or non-adoption) of logistics management that could develop or enhance tourism on the island. These influential factors are defined in the framework as *an intervening variable,* (Variable Z), which influences both the independent variable (V*ariable X*) and the dependent variable (V*ariable Y).* It was therefore assumed that the level of such influencing factors would have a direct correlation to the degree of importance placed on the adoption of logistics management, as well as to the effectiveness of any logistics used on the island.

3.0 RESEARCH METHODOLOGY

An interview technique was used jointly with questionnaire surveys in order to obtain relevant and in-depth information from tourists on Koh Lan. To obtain the data, the study used a sample of 270 randomly selected tourists, which included both Thai and foreign tourists traveling on Koh Lan. This number of face-to-face questionnaires was based on a randomly stratified sampling. The rate of response was very good, with 245 respondents, or 90.74 percent.

3.1 Research Questions

To answer the above issues, the study define the following questions:

1. How can behaviors of tourists be used to design logistics infrastructure and facilities on Koh Lan?
2. What is tourists' expectation to tourism logistics to Koh Lan?
3. What is tourists' perception to performance of logistics on Koh Lan?
4. What are efficiencies and effectiveness of tourism logistics management?

3.2 Research Hypotheses

This study therefore examined a relationship of the variables under following hypotheses.

H_1 = There is a relationship between tourism logistics and a degree of tourist satisfaction.

H_2 = There is a relationship between tourism logistics and increasing return rate of tourists to Koh Lan.

4.0 RESEARCH FINDING

It showed that male and single tourists made up the greatest number of respondents in the sample at 55 percent, followed by female tourists at 45 percent. It showed that 60 percent were between the ages of 13 to 28 years. Most of them, or 40 percent, had an age between 21 and 28 years. Secondly, 25 percent had an age between 13 and 20 years. The major targeted groups of tourists on Koh Lan are now adolescent and young adult. The most tourists (80 percent) came from ASEAN countries (e.g. Thai, China, Taiwan, and South Korea). The greatest percentage of tourists, or 70 percent, traveled with their friends. Only 20 percent came with family, and their group was less than 4 persons (58.6 percent). Most of them or 33.3 percent, traveled to Pattaya City by personal car, 30.6 percent of them visited by bus, and 17.1 percent by tourist bus, respectively during October – December (67.8 percent). Most of tourists or 87 percent identified that they did not stay overnight on Koh Lan because of improper and inconvenient infrastructure and facilities.

Table 1 Hypothesis testing and measuring relationship between variables

Variable		Correlation	p-value
Independent	Dependent		
X1	Y1	0.48	0.000
Z	Y2	0.67	0.000
X2	Y2	0.65	0.000

Table 1 shows summary of hypothesis testing. It tested that adopting tourism logistics (X_1) would have relationship with tourist satisfaction (Y_1). Further, effective tourism logistics management (X_2) increasingly encourage and promote increasing tourists' return rate to Koh Lan (Y_2). In term of tourism Logistics cover activities related to demand forecasting to a number of tourists and organizing logistics networks (e.g. linking between seen and unseen traveling places, transport, accommodation) within the island. Tourism logistics management covers how well logistics management is used to create and promote tourism industry on Koh Lan, including providing reasonable costs, satisfying tourist need. The result shows that adopting tourism logistics (X_1) has strongly relationship with generating tourist satisfaction (Y_1). It also reveals that tourism logistics management (X_2) has also moderately relationship with increasingly promoting tourists' return rate to Koh Lan (Y_2).

5.0 DISCUSSION AND IMPLICATIONS

When consider levels of importance and satisfaction with various transports systems between Pattaya City and Koh Lan (an eight kilometer distance), it reveals normally, tourists have two choices of transport to the island: ferry or speed boat. It showed that tourists have intermediate expectation levels of service quality (e.g. convenience, safety and fee) for speed boats and ferries. After actually traveling to Koh Lan, they had satisfactory levels lower than their expectation levels. It reflected that with speed boat services, fees and safety were the main sources of dissatisfaction. For ferry boat services, convenience and safety were the main sources of dissatisfaction. Tourists are satisfied when their perceptions equal or above their expectations. Therefore, the gap between tourists' expectation and perception needs to be closed.

Table 2 Performance-importance analysis on transportation between Pattaya and Koh Lan

Factor	importance	Perception	GAP
1. Convenience and frequency of speed boat from Pattaya to Koh Lan	3.81	3.64	0.17
2. Service Charges of speed boat from Pattaya to Koh Lan	3.79	3.36	0.43
3. Safety of speed boat from Pattaya to Koh Lan	3.88	3.51	0.37
4. Speed boat crew's behavior	3.77	3.52	0.25
5. Convenience and comfort of ferry from Pattaya to Koh Lan	3.78	3.53	0.25
6. Service charges of ferry from Pattaya to Koh Lan	3.90	3.75	0.15
7. Safety of ferry from Pattaya to Koh Lan	3.95	3.71	0.24
8. Ferry crew's behavior	3.77	3.63	0.14
9. Overall score related to transport system from Pattaya to Koh Lan	4.07	3.86	0.21

To improve transport systems between Pattaya City and Koh Lan, it would improve in two ways. First, reengineering existing transport systems by focusing on hardware (i.e. vehicle and harbors), software (i.e. information to tourists) and peopleware (i.e. training crew with service minded). Second, new efficient and friendly environmental transport system (i.e. cable car and underwater car) would be considered. The result shows the levels of importance and satisfaction tourists have for travel destinations within Koh Lan. Surveyed tourists revealed they had high expectation for travel destinations in respect to beauty and atmosphere, cleanliness and safety, and that they were satisfied with these aspects of the island. However, they indicated some dissatisfaction with cleanliness and sanitary system, as well as some concern for the safety of security systems used at some travel destinations.

Managing tourism logistics in term of existing travel places is not considered only lower costs and higher services level, but it also means to manage all travel destinations in routes and vehicles. Unseen travel places would be effectively established and promoted. Obvious and clear signs between destinations become a source of satisfier. When considering the levels of importance and satisfaction tourists place on transport (and related logistics) while visiting on Koh Lan. This study asked the tourists to rate the transport systems from Pattaya City to Koh Lan, as well as the transport systems within Koh Lan, in various relevant areas. Most of the tourists indicated high expectations related to safety and the expense of transportation. The study also found that they were mostly satisfied with the availability and comfort of transport systems to Koh Lan. However, they were somewhat dissatisfied with the safety of transport systems to Koh Lan. When considering the transport system within Koh Lan, tourists had high expectations for price standardization, as well as for comfort and availability of transport. But, they were dissatisfied to actually find a lack of price standardization of transport within Koh Lan. Logistical implication would consider in a whole system, and then set standard prices in each destination. The difficulty is how to communicate and motivate to local people for following to same standard without their resistance and conflict. The interesting issue for infrastructure required for supporting tourism on the island, it included electricity, road, water, and telephone systems. Survey results revealed that most of the tourists (more than 75 percent) did not stay overnight in Koh Lan, but rather returned to stay overnight in Pattaya City. The question is that why tourists did not stay overnight on Koh Lan. the interviewed results showed that most of tourists identified to unavailability and inconvenience in term of shortage, including high prices compared with earned services. They had high expectations for the costs and availability of tourism infrastructure in Koh Lan. But, they were dissatisfied with the actual fees charged for services and the availability of infrastructure. These results reflect that there is a need to think and analyse a whole system. It would commence with forecasting future demand to provide properly infrastructure and facilities. The study examine an appropriate methods and found that seasonal time series would be the demand forecasting model which fits to tourism on Koh Lan. One of serious problems is garbage and pollutions occurring from tourism (appropriate 6-12 tons a day). Nowadays, the garbage is moved by 2 boats to Pattaya for disposal. Now the issue is increasingly becoming serious problems to friendly environmental tourism. It needs to apply concept of effective reverse logistics for creating and enhancing sustainable, eco-friendly tourism on Koh Lan.

6.0 CONCLUSION

The results show that using a logistics concept for tourism, especially on an island, would increase effective, sustainable, eco-friendly tourism. A demand forecast of tourism for the next ten years must be considered to effectively design and develop smooth flow patterns for future tourists, along with providing sufficient and appropriate infrastructure and facilities. It points out that a seasonal time series would be an appropriate model of demand forecasting. It revealed that in the next decade, tourism in Koh Lan would increase to twice its current level. This result must be taken into consideration for designing transport (and related logistics systems) from Pattaya City to Koh Lan. As rapidly increasing garbage has become a problematic issue related to the logistics of maintaining a green, eco-friendly environment.

It provides valuable information for stakeholders, especially top management of Pattaya City and the Tourism Authority of Thailand, as to the planning and development of infrastructures and facilities for islands, and specifically Koh Lan. Logistically planned transport management can facilitate growing tourist travel to and from Koh Lan, providing hotel, resort and residential-accommodation owners with consistently increasing demand, while also preventing the unrestrained destruction of natural resources and environments on the island. This study leads to the conclusion that strategic and integrated logistics management is required, with active participation from all relevant stakeholders.

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SECTION 7 – OUTSOURCING AND CUSTOMER-SUPPLIER RELATIONSHIP MANAGEMENT

DEVELOPING PURCHASING & SCM IN SMES – A FRAMEWORK TO TACKLE CHALLENGES AND OPPORTUNITIES

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ABSTRACT

This paper discusses the challenges and opportunities of purchasing in SME context. Main finding is that naturally limited SME resources are even more limited when SME purchasing resources are in question. There is a need for building confidence in SMEs to invest in purchasing and sourcing development. The paper presents a framework to support the practical purchasing and SCM development efforts in SMEs. The framework consists of three elements: 1) Strategy & management, 2) Organization & resources and 3) Processes & practice. Considering these areas systematically a SME can get an overall view on its operations and how to develop purchasing as a part of it.

INTRODUCTION

Global competition faces industrial SMEs as well as large companies. This can be both a threat and an opportunity for SMEs. On the one hand competition threatens SMEs' position towards their existing customer companies. On the other hand SMEs can take advantage of new emerging international supply possibilities in their own operation. Whatever the situation, SMEs are required to adjust to the new setting in the marketplace. Purchasing function has been traditionally quite limited in SMEs especially due to limited resources. However, in order to survive the new dynamics in the marketplace, developing purchasing function may be one key area to improve competitiveness (Ellegaard, 2006).

As companies grow and the proportion of purchases of the revenue increases, the importance of purchasing in making profit grows as well. Purchasing either creates or destroys the competitive advantage of the company. The question is not only about purchase prices but about systematic purchasing methods and practises also. The challenge for SME suppliers is how to apply efficient purchasing methods when business environment demands flexibility and management of large variety of purchase items. Developing appropriate purchasing methods and practises is important for a single SME as well as whole industry (Quayle, 2002).

Quayle (2002) suggests that research is necessary to establish key elements and disciplines of continuous improvements with a particular focus on the purchasing functions. However, it has to be taken into account that there is high variation in SME purchasing practises and contexts (Pressey et al, 2009). That implies that there is no single model to develop purchasing in SMEs. This paper aims to provide support for purchasing and SCM operations developers and managers in SMEs by providing a general framework which can be utilized in the analysis of the company's purchasing function and practices.

RESEARCH APPROACH

The paper is based on one case study and additional interviews with 4 other industrial SME companies. The case study data was gathered from one SME's purchasing development project in which the researchers participated. The company operates in the metal products manufacturing sector having about 10M€ turnover and personnel about 100. The company has one dedicated purchasing person. To broaden the data source additional interviews with 4 other SME companies were made. The interviews were carried out as semi-structured interviews and focused especially on the development needs and plans for purchasing operations. The interviewed companies operate in the machine and equipment manufacturing sector. Their turnovers were in the range of 20 to 50 Million euros. The interviewees were the CEOs and purchasing and production managers of the companies. The conclusions and framework elements presented here are based on qualitative analysis of the research material.

RESULTS

Our case results support the findings from earlier studies on SME purchasing. Ellegaard (2006) identifies following research need areas in SMEs which can also be defined as key challenges for managing a SME purchasing:

- The lack of resources of the small company owner
- The limited supply market knowledge and experience of the small company owner
- The small company owner as a relationship and network manager
- The functional and managerial diversity of the small company owner

Ellegaard (2006) emphasizes the SME owner point of view. Our findings from the case studies were quite similar without making the owner emphasis. Perhaps this is because our case companies all had at least one dedicated person for purchasing. However, e.g. in our case development company the dedicated purchasing person still had a wide variety of tasks and responsibilities from everyday buying to developing supply base and making supplier audits. Based on this case study we would suggest that the overall challenge in SMEs is the amount of resources vs. the amount and variability of the tasks in the SME organization. SMEs have to do almost the same tasks as larger companies to run their business, but with smaller resources. One finding that seems to come up with all the cases was that when considering their development needs the SMEs tend to focus on relatively specific and practical subjects such as developing employee language skills when implementing international purchasing.

Our studies have given us an experience that it is challenging for SMEs to get an overall view of the importance of the purchasing function to their business. Companies can purchase even 70% of their revenue outside yet they focus their resources almost totally to the in-house processes. Supplier interface is managed rather reactively, often fire-fighting the practical problems.

To overcome the lack of ability to consider the overall management of purchasing and its relationship to the company operation has lead us to develop an analysis framework to support the purchasing operations planning in SMEs. The developed framework consists of the following three main elements (Fig 1):

- Strategy & management
- Organization & resources
- Processes & practices

All sub-elements of the above three main elements of the framework are depicted in the figure 1. Under the sub-elements we have defined questions which guide the users in their considerations. It has to be noted that different elements are interconnected, i.e. making decisions on organization may have strategic effects and thus the strategy must be reviewed in parallel. Respectively, strategic decisions must have implementation effects in the organization and process elements. This way of considering the framework is analogical to the strategic development approach presented by Vos (2002).

The strategy and management element in the framework concentrates on the purchasing strategy of the company and the position of purchasing function in the organization.

The resources element discusses the resources of the own organization, suppliers' resources and also the supporting systems of the company, e.g. IT-systems and other supporting functions.

The third element, processes and practices, considers how things are done in practice in the organization. This element consists of task descriptions, process models and responsibility definitions which describe the way of working in the organization. These models are the most practical part of the framework. Typically purchasing management, order-delivery practises and demand & supply management are at focus in this area. Many companies have implemented quality systems and models created for that purpose can be utilized here, too.

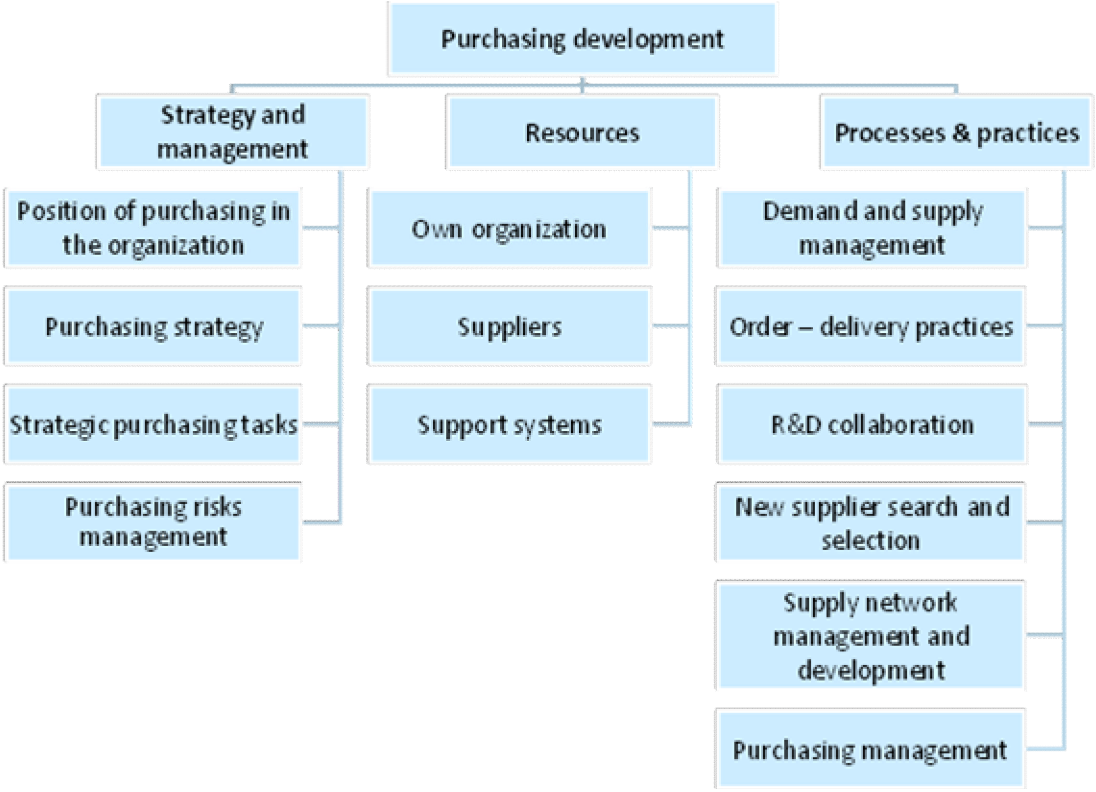

Figure 1. Framework for purchasing development in SMEs.

Perhaps the most interesting finding from the case study was that purchasing can have a role in identifying and developing new offering and sales opportunities for the company. Like sales personnel, also purchasing personnel travel the world scanning the offerings of numerous suppliers and thus can identify new things to be added to the company's sales portfolio. Addressing this opportunity can raise the strategic significance of purchasing operations further.

Concerning the findings from the additional company interviews in relation to our framework, most of the development needs were in the area of processes & practices. Companies prioritize, e.g., demand and supply management, order-delivery practices and R&D collaboration. There is less emphasis on purchasing and supply chain management practices. Companies also had interest in developing purchasing strategy and many of them already had outlined it. Clearly the less considered area was resources relating to own organization. However, concerning the resources the IT systems development ranked high.

The interviews also confirmed the earlier finding that purchasing is developed quite reactively, solving problems case by case basis instead of strategically developing it. However, one company which had a strong relationship with a large and advanced customer had also utilized some of the customer's advanced purchasing models to its own operation.

CONCLUSIONS AND DISCUSSION

There is a lot of unexploited potential in developing purchasing function and operations in SME companies. However, e.g. Quayle's (2002) study shows that SME companies do not put much effort on developing their purchasing. It's not even in the top ten development priorities. Quayle (2002) explains this by the finding that the SMEs have little negotiating power and thus don't consider purchasing a development priority. In this study we have tried to develop supporting methods for SME companies to take the first steps to analyse and understand the significance of purchasing in their overall operations.

Based on our case experiences on the subject area there is a need for building confidence in SMEs to invest in purchasing and sourcing development to exploit its full potential. Our framework supports this by providing a systematic model and tool for company developers to consider how purchasing and sourcing operations relate to the overall company operation. The framework does not prioritize any of its elements. The priorities emerge case specifically as the framework is applied into practice. As mentioned earlier, the strategies, development needs and overall operating contexts vary a lot between SMEs. By carrying out an analysis with the framework it is possible for a company to produce a purchasing handbook for its personnel. Our view is that this kind of a handbook can be a significant practical benefit for SMEs.

The research is based on a limited number of cases. Research on SMEs operating in different industries and contexts is required to validate and further develop the framework. However, from practitioner point of view our framework with the supporting reference and questionnaire material is already applicable to practical use.

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KEYWORDS - Small and Medium Sized Enterprises, Purchasing, Supply Chain Management

DIRECT STORE DELIVERY PRACTICES IN FRONT-END OUTSOURCING; INSIGHTS FROM THE FAST MOVING CONSUMER GOODS MANUFACTURERS OF EGYPT

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1. INTRODUCTION

Effective flow of information is crucial in the operation of an integrated supply chain as it helps in creating an optimal product flow (Lambert and Cooper, 2000). The front-end logistics stage of the supply chain is the phase at which the manufacturer and the customer interface, providing the manufacturer with the optimal chance to gather information from the market. Intuitively, the accuracy of such information would be maximized as the number of intermediaries between manufacturer and end customer is minimized. Direct Store Delivery (DSD) is a direct distribution and selling method from the manufacturer to the Point of Sales or to the Point of Consumption (Kaipia and Tanskanen, 2003; Pramatari and Miliotis, 2008; Otto et al., 2009). In 2006, 80 % of the top thirty Fast Moving Consumer Goods in the world were using DSD and in the same industry, 88% of the retailers and 96% of the manufacturers emphasized having major competitive advantages resulting from DSD adoption (Otto et al. 2009). DSD involves additional services such as information gathering, equipment servicing, category management, merchandizing and payment collection.

By definition, Direct Store Delivery involves no distributor in the distribution channel, however, some manufacturers apply DSD practices while using a third-party logistics service provider to perform and/or manage the distribution of the products on its behalf (GMA 2002). The GMA report (2002) introduced the notion of a 'three-tier DSD model' and compared it to the typical two-tier DSD model. In the two-tier model, the manufacturer is responsible for the overall distribution process and is in full control of the product pricing, loaded items, and the sales force. In the three-tier model, a manufacturer can involve an independent third-party logistics service provider to manage the distribution process on his behalf. However, the report specifies that the distributor controls the distribution process and the manufacturer has minimal involvement. Similar to many other supply chain management areas, theory development has lagged behind the practice of DSD. This paper is structured as follows. In the literature we review front-end logistics, its main processes and activities, literature on logistics outsourcing and the use of IT technologies in front-end logistics. Then we explain our exploratory research methods and share information about our cases. The following section presents our suggested DSD framework followed by a section presenting our qualitative findings. We finally conclude with a brief summary and propose some future research ideas.

1.1 Front-end Logistics

One of the first attempts to define the areas of the front-end logistics function can be seen in the work of Bowersox (1974), where five major areas were listed, namely; Facility location, Transportation, Inventory, Communication, and material movement. Rabinovich at al. (1999) further developed these areas in their model, after which several attempts were made, each adding, a new dimension to Bowersox's definition, and concluded by Hsiao et al. (2010) who provided a broader definition of the levels in a logistics process and classified them into four levels as follows: Basic activities execution (first level), which includes simple activities such as warehousing and transportation. Value added activities (second level), refers to activities that add value to the product like assembling a product and installing it. Planning and control (third level) addresses planning issues like forecasting and inventory replenishment, and Strategic decisions (forth level), which includes strategic decisions in the network design such as management of logistics networks and site selection (Hsiao et al. 2010:397). Key front-end logistic functions include forecasting and planning (Seifert, 2003; Taylor, 2006; Adebanjo,

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2009), route management (Cruijssen, et al., 2007; Solomon, 1987), stock handling (Otto et al. 2009), physical distribution (Thomas et al., 2009), and reverse logistics (Rogers et al., 2001; Ordoobadi, 2009).

1.2. Direct Store Delivery

Mallen (1996) showed a favorable trend towards more direct distribution channels. Where a comparison between the extreme cases of direct (from manufacturer to end customer) and indirect distribution (involving all kinds of intermediaries) showed that absolute direct distribution maximizes sales, channels good will, channels control, while leading to increased cost. Direct Store Delivery (DSD) is a direct distribution and selling method from the manufacturer to the Point of Sales (Kaipia and Tanskanen, 2003; Pramatari and Miliotis, 2008; Otto et al., 2009). Otto et al., (2009) classify DSD in terms of primary and secondary processes[1].

1.2 Logistics Outsourcing

"Logistics Outsourcing" or "Contract Logistics" or "Third Party Logistics" is a business relationship in which an alliance is formed with an external logistics company offering the shipper a bundle of services according to agreed-upon terms and service of level. These services can vary widely ranging from simple transportation activities, up to distribution, warehousing, and information management services integrated altogether (Ellram and Cooper, 1990; Rabinovich al., 1999; Sink at al., 1996; Bolumole, 2001; Knemeyer and Murph, 2004; Hsiao et al., 2010). Logistics activities usually require a company to heavily invest in assets, like vehicles, warehouses, IT infrastructures (Fredriksson and Jonsson, 2009; Hsiao et al. 2010). By outsourcing, a company turns its fixed costs into variable ones and cuts manpower as well as equipment maintenance costs (Abdur Razzaque and Sheng, 1998; Selviaridis and Spring, 2007). Moreover, outsourcing is the optimal solution for a company whose objective is to focus on its core business and promote its core competencies, especially if the logistics activities do not add significant value to the company (Abdur Razzaque and Sheng, 1998; Hsiao et al, 2010). A company may resort to outsourcing if it finds difficulty in coping with the fast pace change in the market, or in developing a good image and presence in the market (Selviaridis and Spring, 2007). Logistics service providers are usually more regionally experienced and can help penetrate new markets where long term relationships with the customers are important (Abdur Razzaque and Sheng, 1998). In addition, outsourcing would allow the manufacturer to reduce its inventory levels (Abdur Razzaque and Sheng, 1998; Fredriksson and Jonsson, 2009; Selviaridis and Spring, 2007)[2].

Against the above mentioned gains, the main concerns reported with outsourcing the logistics function relate to compromising the level of service performance in terms of 'reduced or no control' over the outsourced activities, and 'loss of communication with customers' (Abdur Razzaque and Sheng ,1998; Selviaridis and Spring, 2007). Loss of control over assets and employees to the third party needs to be replaced by control through contractual agreements (Lankford and Parsa, 1999; Lonsdale, 1999; Barthelemy, 2003). Also, a manufacturer has to be aware that it is reducing its contact with its customers, and hence risking loosing valuable customer information (Abdur Razzaque 1998; Sleviaridis and Spring 2007). This study will delve deeper in analyzing the effect of different levels of outsourcing on 'control' and 'information sharing'.

2. RESEARCH METHOD

This study is exploratory because it seeks new insights of direct distribution in the Egyptian

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[1] There are two types of DSD; one is Route Sell (also known as van sales or route sales) and the other one is Pre-sell. Differences between both types are mainly in the areas of order generation and order fulfillment (GMA 2002a:21, Otto et al. 2009:15).

[2] Sink and Langley (1997) present a comprehensive framework for setting the criteria and processes for acquiring third party logistics.

Market. The study is also descriptive because it describes the DSD process in the Egyptian market and reported on specific cases from the market. Multiple cases were studied to reduce the observer bias in the results, and to allow for richer data. Semi-structured interviews with open-ended questions were used to collect data (Voss et al., 2002). First, preliminary interview questions were set to conduct a pilot study to get the first insights from the market. They were used to conduct the first four interviews, (two interviews with two manufacturers, one with a distribution expert, and one with an IT expert[3]). The results of the preliminary interviews were then used to modify the questions and add some more to reach the final version of the interview questions. As the interviews were conducted and analyzed, it became apparent that many FMCG manufacturers in Egypt outsource part/the whole of the distribution function to specialized distributors and still receive the benefits of DSD. This is because many available distributors offer DSD-like services, including information gathering, product placement, and merchandizing. To further investigate the offered DSD-like services by distributors and understand the different contractual agreements another interview was conducted with another distributor working in the FMCG industry. The researcher then moved on to interview six other manufacturers and another IT expert.

Table 2.1 presents the different arrangements that took place with service providers in terms of asset ownership, employment affiliation, contractual agreement, the role of the manufacturer in management.

Table 2.1. Comparison of Outsourcing Agreements to DSD

	Pure Direct Store Delivery (DSD)	Distributor as Service provider (DASP)	Outsourced DSD (ODSD)	Indirect Store Delivery (ISD)
Assets	Owned by the company	Leased from the distributor, managed by the manufacturer.	Owned and managed by the distributor.	Owned and managed by the distributor.
Sales Representatives	Employed by the manufacturer	Employed by the distributor, selected & managed by the manufacturer.	Employed and managed by the distributor.	Employed and Managed by the distributor.
Contractual benefits	All benefits/profits fully go back to the manufacturer	All benefits/profits go back to the manufacturer. The distributor is only paid the fixed cost of leasing the vans and sales representatives.	The benefits are shared between the manufacturer and the distributor, where the manufacturer receives services as per the contractual agreement and the distributor; either gets a margin of the profits that come from his sales to the retailers OR buys products at a discount from the manufacturer and benefits from the	All the benefits/ profits go back to the distributor: The distributor whether buys the finished goods from the manufacturer at a discounted rate and then takes full responsibility of selling the products and taking the profits OR sells for the manufacturer and then gets a margin of the profit. The manufacturer only gets the benefit

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[3] The first IT interview was with the technical solutions architect of company providing the hand-held devices used by sales representatives in the DSD process, while the second interview was with the managing director of a company providing the software applications that run on these hand-held devices and applications that transfer information to and from the company server.

			profits.	of bare product distribution.
Level of manufacturer involvement	The manufacturer is fully involved in the management of the process	The manufacturer is mostly involved in the management of the process, but doesn't own the assets or the sales representatives	The manufacturer is partially involved in the management of the process This can happen in two ways: First: The manufacturer can have a manager for the process working at the distributor's premises to manage the process Second: The manufacturer can be less involved and the distributor takes control of the whole process while the manufacturer only dictates the process to be followed.	The manufacturer's role ends at the point of setting target sales for the distributor and selling him the products.

From the eight companies and according to the classification above, information was gathered regarding six cases of pure DSD, one case of Distributor as a service provider (DAAP), five cases of Outsourcing the DSD functions (ODSD), and one case of Indirect store delivery (ISD).

3. SUGGESTED THEORETICAL FRAMEWORK

Figure 3.1 indicates that the comparison of DSD to ISD is not black and white, but that there are different levels (shades) in the spectrum of relationships between the manufacturer and retailer. It also illustrates the degree of 'directness' in each approach, with DSD and ISD at the ends of the scale. The second and third approaches, represented by the grey shades, both fall under the two-tier model and are used to divest the assets and the investment in head counts to the distributor, thus getting rid of the hassle of having all assets and sales representatives on the books of the manufacturer while getting the majority of typical DSD benefits.

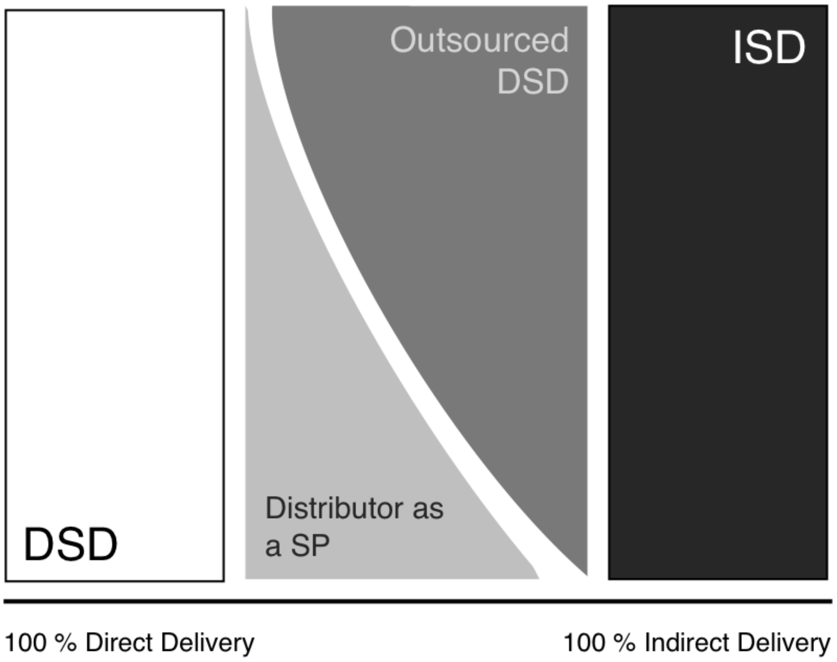

Figure 3.1. Framework for DSD Categorization

The first approach Direct Store Delivery (DSD) represents a typical two tier model where the manufacturer distributes directly to the retailer with no intermediary. In the second approach Distributor As Service Provider (DASP) the manufacturer runs the distribution process himself while using the distributor only as a service provider, leasing the vans and the sales representatives to the manufacturer. This approach still involves a high percentage of directness in the distribution process making it very similar to a two-tier model. In the third approach Outsourcing Direct Store Delivery (ODSD) the distributor runs the actual process, but still under the management of a manager employed by the manufacturer, who controls the process and the sales representatives in the distributor's premises. Such a manager would act as the decision maker for the distribution of his company's products, forcing a specific process to be followed while monitoring it. This approach can also be viewed as an extension to the two-tier model. The fourth approach titled In-direct store Delivery (ISD) represents a typical three tier model, where the manufacturer outsources the whole distribution process to the distributor, with no monitoring over the process and where communication between both parties ends at the point of transferring the products to the distributor and collecting the cash/credit from him.

4. FINDINGS AND DISCUSSION

In some cases the decision to apply DSD is one forced by the nature of the product and by market demands. One of the companies indicated that for beverages, 70% of the business is on the returnable side, so it would be difficult to find a third party to sustain such a module with all the hassles involved (vans, sales representatives, glass bottles, and bearing the damages) other than the company itself. Other companies using DSD highlighted the strategic importance of Egypt as a huge consumption market and its growth potential as factors promoting DSD. The threat of new entrants, make those who already distribute using DSD value their advantage, and for cases requiring launching new products, and need for market penetration, companies reported preferring DSD as there is a need to go in person and explain to retailers what the product is about and why they should stock it.

4.1. Preliminary data for the different DSD approaches

It was collectively reported that moving from the first approach (DSD) to the second approach (DASP) can be estimated to save a company about 10-12% of the costs. While moving from the second to the third approach (ODSD) could save a company between 12-15%. Preliminary data was collected with respect to two variables that showed in the literature to be of highest concern to the outsourcing decision. 'Level of Control' and 'Level of Information Sharing' and was collected across the five logistics functions presented in section 1.1.1.

For 'Level of Control' results showed no difference among the first and second approaches (pure DSD and DASP), and variations among companies using outsourced ODSD and ISD. All the companies under the four DSD approaches showed similar and very high levels of control over the forecasting and planning function (all companies reported setting their own demand forecasts as well as promotions for their distributors). Companies using the first two approaches (pure DSD and DASP) showed the highest levels of control over the route management and stock handling functions, while those using the third approach (ODSD) reported a much lower control levels. The company using ISD showed almost no control over the route management and stock handling functions. For the physical distribution phase, companies using the first two approaches (pure DSD and DASP) show the highest levels of control. However those using the third approach (ODSD) also reported an overall high control level over the activities carried out during that function. Again the company using ISD reported no control over that function. For reverse logistics, no differences were reported between the first and second approaches, ISD showed an unusually high level of control over this function. Results were mixed up with respect to the five companies using ODSD ranging between high levels of control and low levels for reverse logistics.

For 'Levels of Information Sharing'; the first and second approach (Pure DSD and DASP)

show the highest levels of information sharing through all five logistic functions. ODSD however, shows moderate information sharing levels in the areas of stock management and route management, full information sharing during the physical distribution function, and moderate levels of information sharing in reverse logistics. ISD, shows the lowest level of information sharing compared to the other approaches, where there is no information sharing in the areas of route management, stock management, and the physical distribution. Again, ISD showed almost full sharing of information in reverse logistics.
It is worth noting that company 'four' applying ODSD has always showed the highest levels of control and information sharing among all the other companies applying ODSD. The company has been using the same sole distributor since it was founded, and the distributor system is connected to the company's ERP and synchronizes with it frequently. The distributor works only for this company and one other. Two other companies using ODSD stated that it is not difficult to reach the same advantages of DSD and DASP through an ODSD approach, especially in cases where the manufacturer is large enough to enjoy a higher bargaining power with respect to the distributer. The interviewees from these companies mentioned that being among the biggest multi-nationals, forces distributors who deal with them to offer the services they request, even if the distributor does not normally provide such services to other smaller less strategic manufacturers.

5. CONCLUDING REMARKS

This research presented an overview of Direct Store Delivery (DSD) as a concept grounded in the literature related to front-end logistics and outsourcing. The study suggested a framework for exploring the different occurrences of DSD practices, and investigated the different arrangements manufacturers have with their front-end service providers in Egypt. The study reveals that many of the favored DSD practices can be applied using a third-party logistics provider, and suggested two further approaches to DSD before considering the arrangement to be an Indirect Store Delivery (ISD), namely, Distributor as a Service provider (DASP) and Outsourcing Direct Store Delivery (ODSD). Manufactures need to weigh the benefits of DSD to the identified challenges when making an outsourcing decision. The study suggested using 'level of control' over the front-end activities, and 'level of information shared' among the activities as key criteria in making that decision. Preliminary results show no differences between DSD and DASP, and some compromise when using ODSD for the above criteria.

Fourteen interviews were conducted with eight manufacturing companies, two distributors, two distribution experts, and two companies providing IT solutions for DSD. The qualitative nature of the study, using convenience sampling, and selecting only among FMCG manufacturers in Egypt, constraint the generalization of the findings creating opportunities for future research.

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DETERMINANTS OF ENVIRONMENTALLY-ORIENTED GOVERNMENT PROCUREMENT IN SINGAPORE

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ABSTRACT
Purpose:
This study aims to identify the critical determinants of environmentally-oriented government procurement in Singapore.

Research approach:
Through extensive literature review, this study has identified four determinants of sustainable procurement: integrated product attributes (IPA), waste management (WM), organisation systems and processes & policies (OSPP) and organisational values (OVAL). A multiple regression using SPSS is employed to assess the relationships between the four determinants of environment-oriented government procurement practices.

Findings and Originality:
Results of the correlation analysis show that all six correlations among the four determinants are positive and significant which broadly support that the determinants should be implemented in combination. Although, the coefficients of correlation between environmentally-oriented procurement practices and each of the four determinants were positive and significant, the results of multiple regression analysis showed that only organisation systems and processes & policies (OPSS) and organisational values (OVAL) have positive and significant relationships with environmentally-oriented practices.

Research impact:
This study contributes valuable insights into the determinants of sustainable procurement in public organizations in Singapore. Both managers and researchers should find it useful that decisions to procure environmentally-oriented products are influenced mainly by organisation systems, processes and policies and organisational values.

Practical impact:
The results suggest that the determinants of environmentally-oriented government procurement practices must be implemented in combination and the degree to which each determinant is implemented is correlated with the implementation of other determinants to achieve holistic and integrated sustainable government procurement practices.

Keywords:
Government procurement, sustainable practices, multiple regression and Singapore

1.0 INTRODUCTION

Procuring environmental products has been a focus of research since it was recommended as one of the measures for sustainable development in the adoption of Kyoto Protocol in 1997 (Grubb et al., 1999). The government, as the single largest buyer of goods and services in any economy, has the capacity to influence the demand for more environmental products (Li and Geiser, 2005; Audet, 2002). Government procurement therefore was identified as one of the policy instruments to achieve environmental sustainability (Crosbey and Cameron, 2008). Along this line, this study aims to identify critical determinants of environmentally oriented government procurement in the context of Singapore.

Review of the literature suggests that research on environmental practices in business organisations is a new development and is rapidly gaining importance, especially in the area of government procurement where there has been limited research. Coggburn & Rahm (2005) studied the nature of environmental purchasing in the US government. Literature suggests that the public authorities have a critical role in procuring sustainable products and services (Walker & Brammer, 2009; Day, 2005). Research into assessing the critical determinants of government procurement from the environmental perspective is rare. Therefore, this study aims to fill this gap.

The remainder of the paper is organised as follows. Section 2.0 provides a review of literature and identifies the critical determinants of environmentally-oriented procurement practices. This is followed by the research design in section 3.0 which outlines the conceptual framework. Section 4 discusses the methodology used to analyse the data and section 5 presents the demography of the respondents. Findings and a discussion of the study are presented in section 6.0. Finally, discussion on the implications is presented in section 7. Section 8 presents the conclusion of this research.

2.0 Literature Review

Environmental orientation of sustainable government procurement is linked to the concept of corporate social responsibility (CSR). Carroll (1979) argued that CSR is an organizational value that encompasses the economic, legal and ethical orientation of organizations. Carter & Jennings (2004), on the other hand, argued that environmental purchasing is a subset of corporate social responsibility. Ciliberti, et al. (2008) extended the corporate responsibility analysis by developing a taxonomy of purchasing social responsibility incorporating managerial practices in organizations that adopt sustainable practices relating to transportation, warehousing, packaging and reverse logistics. Carter, et al. (1998) looked at inter-organizational factors that affect environmental purchasing activities such as those that facilitate recycling, reuse and resource reduction.

In relation to organizational practices, other studies looked at environmental attributes of products. Mojo (2007) focused on the concept of biodegradability. Zheng, et al. (2005), on the other hand, looked at the management of plastic waste disposal. Murphy and Poist (2002) looked at energy conservation. Carter and Jennings (2002; 2004) classified a number of sustainable practices such as recycling, reuse, the use of life cycle analysis and suppliers' commitment to waste disposal. Ciliberti, et al. (2008) studied the sustainable practices implemented in the transportation, packaging, warehousing and reverse logistics. The importance of ISO certification for organizations was investigated by Quazi (1999) and Alan, et al. (1999). Gallastegui (2002) argued on the importance of eco-labelling that creates awareness among consumers. Walther and Spengler (2005) studied the treatment of electronic waste and its legal requirements in Germany. The determinants of environmentally-oriented government procurement are discussed below.

2.1 Integrated Product Attributes (IPA)

Product attributes refer to factors such as energy efficiency (Ashina and Nakata, 2008), energy conservation (Murphy and Poist, 2002), biodegradability (Min and Galle 2001; Mojo 2007) and non-hazardous materials (Thornton, 2001) which contributed to environmental sustainability. Murphy and Poist (2002) stated that energy conservation is one of the heavily researched environmental issues. Dincer (2003) argued that energy conservation achieved through energy consumption programmes and the government plays a major role in developing energy efficiency and conservation efforts. Mojo (2007) argued that biodegradable products are products or packaging that break down and return to nature and procuring organisations need to ensure that suppliers not only claim but also prove their products are biodegradable by providing appropriate information. Zheng, et al. (2005) considered biodegradation as a solution to manage plastic waste disposal in view of the increasing use of plastics in human activities. Drawing from the discussion in the literature review, it is hypothesised that:

> *Hypothesis H_1*: There is a positive relationship between integrated product attributes and the implementation of the environmentally-oriented government procurement.

2.2 Waste Management (WM)

The waste management of products is an important measure to combat global warming (OECD 2008, 2003). Purchasing recyclable and reusable products were found by many researchers as important environmental activities within the purchasing function (Carter, et al. 1998; Carter and Jennings 2002; Carter, et al. 2000). Ciliberti, et al. (2008), Murphy and Poist (2002) and Min and Galle (2001) opined that reverse logistics has an impact on the environment by monitoring and managing waste recovery. Murphy and Poist (2002) also stressed the importance of reverse logistics especially in the areas of salvage and scrap disposal where organizations are making changes to their operations to be environmentally-oriented. Camm (2001) looked at hazardous and non hazardous waste disposal. Min and Galle (2001) considered the scrapping and sorting of non-toxic materials for incineration as important environmental practices for procuring organisations that implement company-wide environmental programmes. Organizations should be committed to waste reduction programmes and ensure that the production processes and products manufactured are environmentally-sustainable (Carter, et al. 1998; Carter, et al. 2000). It is hypothesized that:

> *Hypothesis H_2*: There is a positive relationship between waste management (WM) and the implementation of the environmentally-oriented government procurement.

2.3 Organisation Systems, Processes and Policies (OSPP)

Organisation systems, processes and policies refer to environmental standards and measurements such as ISO14001, eco-labelling, product design and life cycle analysis. They are introduced to ensure principles of environmental management are observed. ISO14001 is an international certification (Alan, et al. 1990, 1999; Quazi 1999; Singh and Perry 2000) which when implemented made businesses more aware on the importance of environmental management. Eco-labelling refers to a label given to products informing consumers that the products are environmentally sound. Li and Geiser (2005) argued for the use of labels on electronic goods which would indicate specific environmental benefits likely to be procured by public organisations.

Environmental considerations are incorporated in the design stage in new product development. Known as design for the environment (DfE), product design has significant impact on pollution reduction, waste management as well as reducing disposal costs. It is also argued that the amount of waste generated is a direct consequence of decisions made during product design (Bowman 1996; Melynk et al. 1996). Product design for disassembly, recycling and reuse is also seen as an important factor in environmental purchasing (Carter 2005; Carter, et al. 2000). Hart (1995) positioned that life cycle analysis considers the life cycle of a product starts from the design stage until the end of life of a product with minimum environmental impact. Kaebernick, et al. (2003) proposed the use of life cycle analysis during the design stage of a product. It appears that in the context of government procurement, the life cycle analysis can be integrated into the procurement process. It is hypothesised that:

> *Hypothesis H_3*: There is a positive relationship between organisation systems, processes and policies (OSPP) and the implementation of environmentally-oriented government procurement.

2.4 Organisational Values (OVAL)

Values in an organisation serve as a guide in decision-making to achieve a common purpose (Sullivan, et al. 2001). In the context of government procurement, organisational values: entrepreneurship, commitment, organisational learning and innovation, can be defined as an organization-wide recognition and commitment on the importance of environment that influences organizations to act in ways consistent with the protection of the environment (Henriques and Sadorsky 1999). Environmentally-oriented organisations are committed to engage in activities such as developing environmental plan, organising regular communication of this plan to employees, training their employees to take a long term perspective on environmental matters by using strategies and policies as well as allocating resources that support this view.

Hypothesis H_4: There is a positive relationship between organisation values (OVAL) and the implementation of the environmentally-oriented government procurement*.*

Literature also suggests that the implementation of the determinants of the environmentally -oriented government procurement discussed above must be implemented in combination. Drawing on this it is hypothesized that:

Hypothesis H_5: The determinants of the environmentally-oriented government procurement must be implemented in combination. Thus, the degree to which each determinant is implemented is correlated with the implementation of the other determinants.

3.0 RESEARCH DESIGN

As discussed above, four determinants of sustainable procurement such as Integrated Product Attributes (IPA), Waste Management (WM), Organisation Systems and Processes & Policies (OSPP) and Organisational Values (OVAL) have been identified and a conceptual framework (Figure 1) is proposed below.

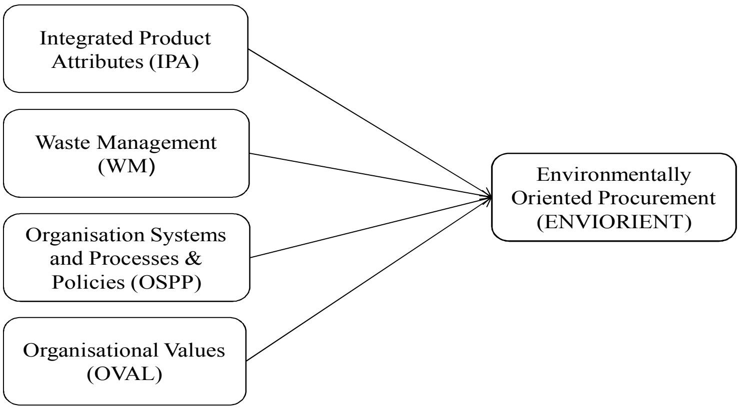

Figure 1: Conceptual framework for Environmentally Oriented Procurement

4.0 METHODOLOGY

The data was cleaned for normality and outliers. On the normality of distribution, the data shows that it was normally distributed. The skewness value of the data is within the range of +1 and -1 (Pallant, 2001). The data also met the requirement of +2 and -2 for kurtosis. The data conforms to tests for null hypotheses for constructs based on early and later respondents. The t-test shows values of above 0.05 which means the null hypotheses are not violated as such non-response bias should not be a problem in this study (Pallant, 2001). In analysing the data, first we used factor analysis for reliability of the determinants. Using SPSS version 18, the reliability of constructs achieved Cronbach α of above 0.8 (Hair et al., 2010). The study then applied multiple regression method to investigate the relationships between the determinants and environmentally-oriented procurement.

5.0 DEMOGRAPHY OF RESPONDENTS

Data was collected using a survey questionnaire with a 5-point Likert-scaled items where 1 = strongly disagree and 5 = strongly agree. The instrument was developed after an extensive literature review followed by a pilot study with the participation of 10 respondents with similar characteristics with the sample population. The sample population consists of government officials responsible for procurement in Singapore. A total of 570 questionnaires were distributed of which 295 (52%) usable responses were received.

Fifty four per cent of respondents comprised of directors and deputy directors, department heads/units and staff holding managerial positions. Around 46% of the respondents were executive officers. Forty six per cent of the respondents had received tertiary education, nearly 38% have attained Diploma/Higher Diploma and the other 15% had received secondary/post secondary education. In terms of working experience, more then 50% of the respondents indicated that they had been working in the organisations for more than 5 years. Data also revealed that nearly 50% of the respondents had experience in procurement-related activities in their respective organisations.

6.0 FINDINGS AND DISCUSSION

The results of the factor analysis showed that the Cronbach alpha (α) values varied between 0.8 and 0.9 which are above the recommended value of 0.7 (Nunnally and Bernstein, 1994). Table 1 shows a multiple regression model which was then run to assess the relationships between the four determinants and environment-oriented government procurement practices.

Variable	Number of items	Mean	Std. Dev.	Cronbach α
IPA	10	3.44	0.559	0.885
WM	8	3.40	0.612	0.905
OSPP	8	3.40	0.623	0.910
OVAL	8	3.45	0.602	0.871
ENVORIENT	6	3.35	0.664	0.882

Table 1 - Descriptive statistics of the scales of environmentally-oriented procurement determinants, environmentally-oriented procurement practices and Cronbach alphas

The correlation analysis is shown in Table 2 and the results indicated that all six correlations among the four determinants are positive and significant (*p = 0.01*). The results broadly support hypothesis H_5 that the determinants should be implemented in combination. Hypothesis H_1-H_4 was first tested using the results of correlation analysis. The coefficients of correlation between environmentally-oriented procurement practices and each of the four determinants were positive and significant (IPA = 0.627; WM =0.692; OPSS = 0.751; and OVAL = 0.771). This provides support for H_1-H_4. However, the results of the multiple regression analysis (Table 3) showed that only Organisation Systems and Processes & Policies (OPSS) and organisational values (OVAL) have positive and significant relationships with environmentally-oriented practices which supports hypothesis H_3 and H_4 (*p = 0.01*)

Constructs	IPA	WM	OSPP	OVAL	ENVORIENT
IPA	1				
WM	0.804**	1			
OSPP	0.750**	0.797**	1		
OVAL	0.690**	0.755**	0.750**	1	
ENVORIENT	0.627**	0.692**	0.751**	0.771**	1

***significant at 0.01*

Table 2 - Correlation between the determinants of Environmentally-oriented procurement

Table 3 shows that multiple regression analysis fails to support hypotheses H_1 and H_2. It is evident that public organisations emphasised the importance of organisation systems, processes and policies (OSPP) as one of the critical determinants in the government's procurement process. Practices of sustainable procurement are reflected in the use of ISO 14001, Life Cycle Analysis, Eco-Labels and Product Design. The other determinant is Organisational Values (OVAL). Public organisations with bureaucratic culture structured on rational-legal approach are not adverse to embrace the values that promote practices of sustainable procurement.

Predictor determinants	Standardized Coefficients B	Std Error	t	Sign
IPA	-0.005	0.067	-0.071	0.943
WM	0.078	0.075	1.039	0.300
OSPP	0.395	0.067	5.922	0.000
OVAL	0.527	0.060	8.552	0.000

Table 3- Results of the regression model

7.0 IMPLICATIONS

This study contributes valuable insight into the critical determinants of sustainable procurement in public organizations in Singapore. Both managers and researchers should find it useful that decisions to procure environmentally sustainable products are influenced by organisation systems, processes and policies and organisational values. These determinants may assist in shaping a public procurement culture towards environmentally sustainable procurement practices vis-a-vis the value for money and cost efficiency, the guiding principle of public procurement in the long run. This role is expected to have an impact on the marketplace where more innovative environmentally-oriented products would be manufactured. Government officers would be well aware that within the established framework of ISO 14001, eco-labelling, product design and life cycle analysis, the values of entrepreneurship, commitment, learning capability and innovativeness could be further enhanced. The adoption of established framework of systems, processes and policies would enable government officers to facilitate their learning capability and shorten the learning curve.

The study also suggests that from the perspective of organisational values, commitment from decision-makers and the implementation levels within the procurement departments of various government agencies are critical, where clear goals and targets are established with an effective monitoring program. Public organisations too should ensure that they provide an open and fair process to identify and procure environmentally-oriented products from manufacturers/suppliers. Environmental consideration is factored in at every stage of the procurement process. The adoption of non ad-hoc strategies that encourages the development of environmentally-oriented products are important to enable for sufficient choice.

8.0 CONCLUSION

This study aims to bridge a research gap in environmental-oriented government procurement. The model proposed in this study provides an integrated and holistic approach of government procurement process. The adoption of environmentally-oriented procurement does not undermine the tenets of government procurement. On the contrary, it upholds the principles of value for money, transparency and accountability. Core competencies of government institutions in delivering quality public services is further strengthened with the emphasis in building bureaucratic culture steeped in sustainability.

Organisation Systems, Processes and Policies, and Organisational Values as methodically measured and validated, are critical determinants not only from the perspective of government institutions in Singapore but also other government institutions in the region that are making initial steps to incorporate environmental considerations in their development plan. Finally, this study suggests that the determinants of environmentally-oriented government procurement practices must be implemented in combination. Thus, the degree to which each determinant is implemented is correlated with the implementation of other determinants to achieve a holistic, integrated and sustainable government procurement practice.

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SECTION 8 – TRANSPORT, DISTRIBUTION AND THIRD/FOURTH PARTY LOGISTICS

TRANSPORTATION AND LOGISTICS OF CARS AND COMPONENT PARTS THROUGH THE PORT OF KOPER

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ABSTRACT

For the Port of Koper distribution of cars (and car component parts) is very important. The first vessel cars entered the Port of Koper in 1990. Since then the vessels have been arriving regularly. Strategic orientation of the management of the Port of Koper is to increase the quantity of handled cars to 1.000.000 till the year 2025 (446.266 in the year 2011). The vision of the management of the Port of Koper is to become the main Car Terminal in Mediterranean.

The area of the Port of Koper has suffered from ecological degradation due to the presence of the port facilities, which is the reason why the port authorities are going to reduce the extent of coal and iron ore cargo and dedicate themselves more to containers and cars.

This paper aims to: (I) introduce the orientation of the management of the Port of Koper to dedicate more to the car business, (II) review the current state of the development of the car terminal of the Port of Koper, (III) introduce recent/new strategies to enlarge car terminal and to build up a more efficient operation and a higher competitiveness.

Keywords: Port of Koper, car terminal, goals, strategies, markets

INTRODUCTION

All major car and also car parts producers, but also many smaller ones as well have invested in the NMS (New Member States of Europe), partly following their main customers but also to take advantage of the qualified and cheap labour force for export production. Car industry is undoubtedly one of the most important industries in Europe. The European car market is by all means one of the most developed as well as one of the most demanding markets on the global scale. The biggest car producers are the USA and Japan, the runner-up being China with more than 5 mio cars produced only in 2004. The estimates say that demand on cars should grow by the year 2015 up to 13.5 mio and by the year 2020 there are supposed to be around 18.9 mio new cars driving the roads of China. It is estimated that China will become the world's second exporter (immediately after the USA) by the year 2020, and its purchasing power will outgrow that of the united Europe.

THE PORT OF KOPER

The Port of Koper is one of the most relevant generators of the development of transport in Slovenia. The economic effects of port activity are multiplicatively reflected in direct surroundings and wider environment. Per one unit of generated value in a direct port activity, eight additional value units are generated in the whole Slovenian economy.

The Port of Koper is some 2000 nautical miles closer to destinations east of Suez than the ports of Northern Europe. From Koper there are regular and reliable shipping lines to all major world ports. Land transport from Koper by road and by railway to the main industrial centres in Central Europe is approximately 500 km shorter then from North

European ports. Some two-thirds of cargo is transported by rail, which means that more than 500 wagons arrive and leave the port on a daily basis.

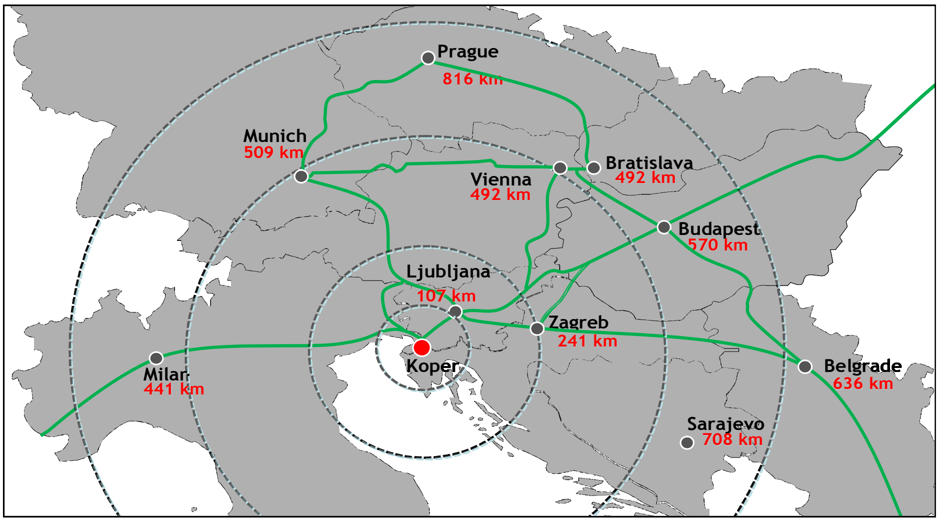

Figure 1: The Port of Koper at the intersection of transport routes
Source: Port of Koper

The entire area of the Port of Koper including the development area extends over 1600 hectares. In addition to investments in technological modernisation, in connection with the further development of container services, the preparations for the construction of a new container terminal (Fig.2) on Pier III are accelerated (enabling total transhipment of 1000000 TEUs).

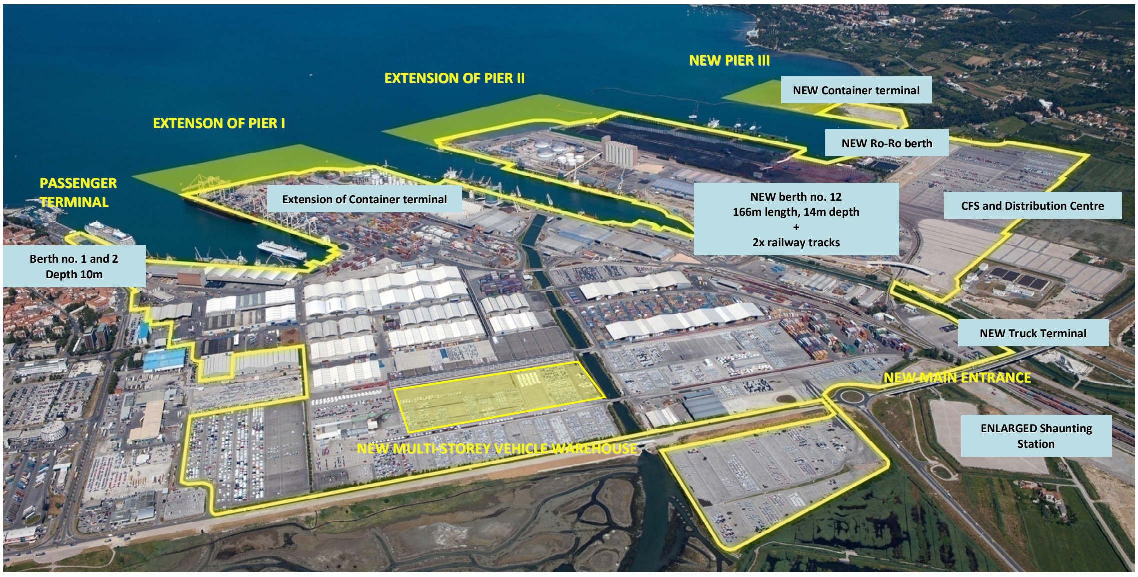

Figure 2: Location of the Port of Koper (Source: Port of Koper)

The Port of Koper is a member of NAPA (Nord Adriatic Ports Association). The five NAPA seaports (ports of Koper, Trieste, Venice, Ravenna (Italy) and Rijeka (Croatia)) combine their strengths in order to promote the Northern Adriatic route and present themselves as an alternative to the North-European ports.

THE PORT OF KOPER CAR TERMINAL

The Port of Koper is qualified for import and export car-handling operations. Besides quick and quality car handling performed by a skilled group of drivers, the Car terminal offers the car storage on controlled asphalted and fenced areas illuminated at night. The high level of security is guaranteed 24 hours per day by an integrate video-system. The operational work is supported by a fully computerised system.

Figure 3: The Port of Koper car terminal (Source: Port of Koper)

Operative shore	800 m
Berths	7
Sea depth	12 m
Ro-Ro ramps	4
Railway ramps	6
Open storage areas	750,000 m2
Covered storage areas	125,000 m2
Open air storage capacity	44,000 units
Covered storage capacity	6,000 units

Table 1: Car terminal capacity figures

Modern workshop is properly equipped for performance of deconservation and conservation of cars, PDI service, optional equipment of cars upon the customers request, various repairing - mechanical, paintwork car-body repairs - of damages occurred during the transport. Close by the terminal are located roofed warehouses offering the possibility of spare parts storage, disassembling and packing of car parts. The transport of cars in the year 2008 was 571273 units (new record), in the year 2009 – 311579 (decline because of the global recession). Increase in car transport followed in the year 2010 - 378224 and in the year 2011 – 446266.The prognosis for the year 2012 is cca 600000 cars.

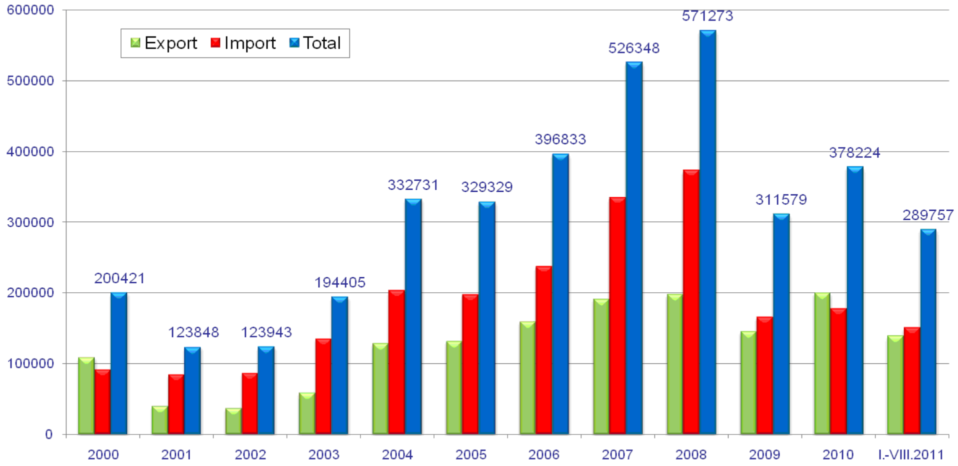

Table 2: Car traffic through the car terminal

Export:
European production and transshipment (VW Group – VW, Audi, Škoda, Seat) to:Albania, Greece, Turkey, Malta, Cyprus, Syria, Lebanon, Israel, Egypt, Libya, Tunisia, Algeria)
Import:
Far East and Turkish production (Hyundai, Kia, GM Daewoo, SsangYong, Toyota, Honda, Suzuki, Nissan, Mazda, Mitsubishi, Toyota, Hyundai, Ford, Renault) to: Slovenia, Austria, Germany, Italy, Hungary, Czech Rep., Slovakia, Poland, Croatia, Serbia and Montenegro, Macedonia, Ukraine

Connections of the car terminal
Hinterland connections:

- Rail (66 % of traffic): well developed rail network of 30 km within the Port area, direct connection to the terminal storage facilities, direct access to public rail infrastructure, efficient collaboration with all main operators: ATG, ARS, Altman, Sitva, Transwagon, etc.
- Road (34 % of traffic): motorway connection to all main target markets,

Maritime connections:
Short-Sea Shipping (SSS): Good connections with various destinations in Mediterranean, Regular lines offered by two major shipping lines – Grimaldi and Neptune.

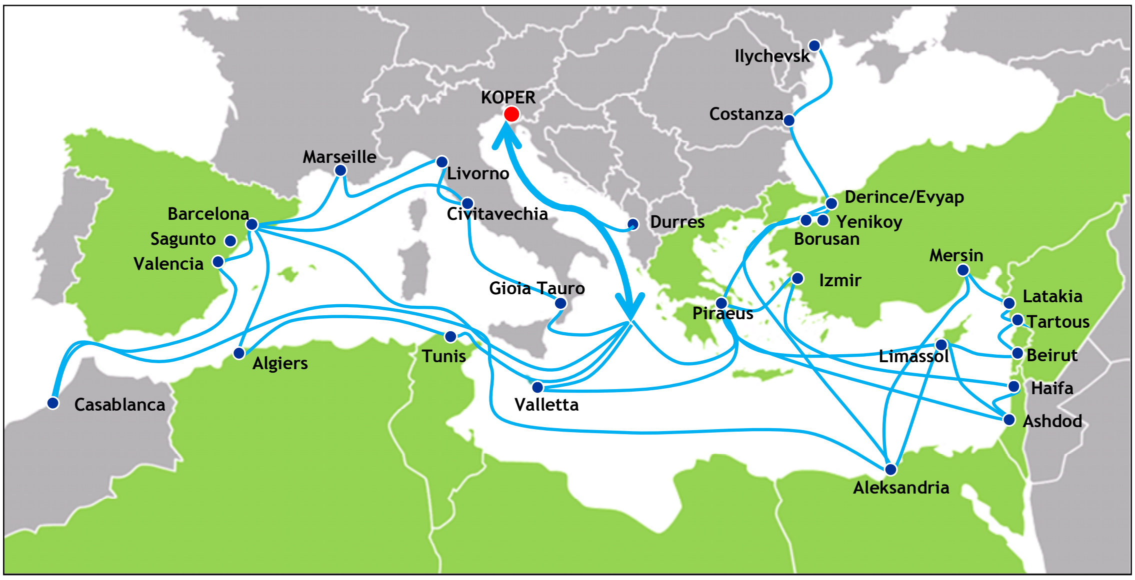

Figure 4: Short Sea Shipping (Source: Port of Koper)

Deep-Sea Shipping: All major deep-see shipping lines are calling Koper on regular basis. Calls to Koper are on route to Northern Europe and /or during the round trip in Mediterranean. Shipowners calling Koper are: EUKOR Car Carriers, Mitsui OSK Lines, HUAL, Wallenius, NYK, K-Line, Nissan, Pan Ocean and others.
On the Figure 5 a newly (from June 2010 on) implemented direct service with the Far East intended for the car industry is shown, which has been established together by the shipping companies MAERSK LINE and CMA CGM. The container line between Asia and the north Adriatic is supplying markets in Slovenia, Slovakia, the Czech Republic, Austria, south Germany, Serbia, Bosnia and Herzegovina, Hungary and Croatia. The ships capacities are from 6200 to 7000 TEUs. The weekly service is maintained with 9 ships between 16 ports - Shanghai, Pusan, Hong Kong, Chiwan, Tanjug Pelepas, Port Kelang, Port Said, Trieste, Koper, Rijeka, Trieste, Damietta, Port Said, Suez Canal, Jeddah, Port Kelang, Singapore in Shanghai.

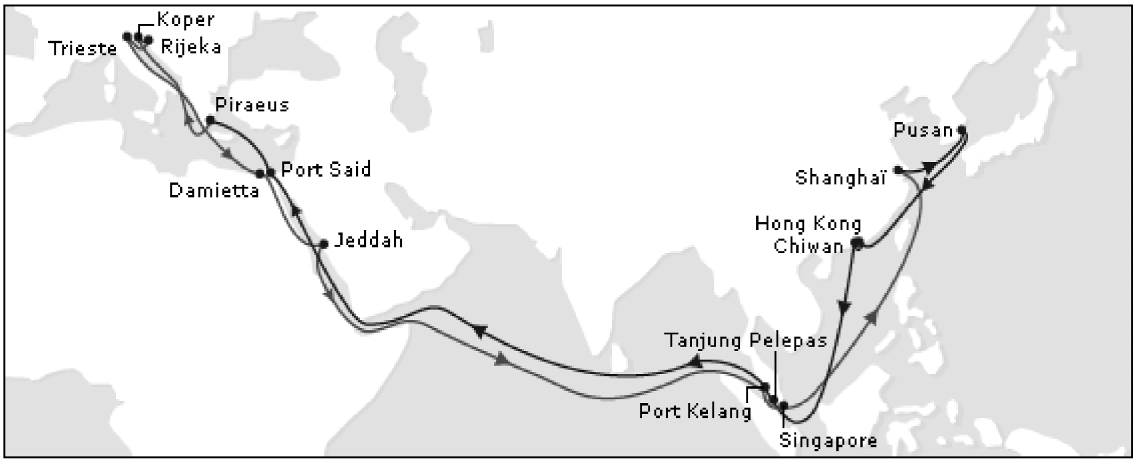

Figure 5: Newly implemented direct service with the Far East intended for the car industry
Source: http://www.cma-cgm.com/eBusiness/Schedules/LineServices/ServiceSheet.aspx?ServiceCode=BEX2

For the container business on this line that is intended for the car industry (JUST IN TIME) is typical that:

- Freight comes from South Korea,
- Freight presents car parts destined to the "Kia" and "Hyundai" factory (Slovakia, the Czech Republic),
- It is approx. 140,000 TEUs on an annual level (approx. 1,250,000 tons of cargo),
- It is 2 ship services (2x a week),
- Containers have priority when unloading from ships holds,
- Freight "starts" from port in a few hours after unloading from the ship – certain containers even in 30 minutes!!!

We can say that the Port of Koper car terminal is Korea's gateway to Europe The first vessel with cars entered the port of Koper in April 1990. From that time the vessels have been arriving regularly. Vessels built in Hyundai's shipbuilding yard in Ulsan, specialised in the transportation of cars can accept around 4,000 and 6,000 cars. The voyage from Ulsan to Koper lasts only 25 days. All the biggest Central and Eastern European markets can be reached in 24 hours.

Competition and cooperation in Mediterranean:
Monfalcone is nearest to the Koper terminal and even shares the same interests. It only deals with the short range shipping. The terminal manager is the well-know ship-owner Grimaldi.

Barcelona is the biggest car terminal in the Mediterranean, undoubtedly more a large synergy potential than a competition to the Koper based terminal. Idea to connect the two fastest growing car terminals in Mediterranean: Koper and Barcelona (KOBALINK Project) was born in the year 2004. The Koper-Barcelona-Link was established in January 2006 thus making it another of the popular and lucrative trend in shifting the goods flow from land to sea. Moreover, it joins both parts of the Mediterranean- East meats West, two powerful fields of production as well as consummation.

Figure 6: Direct shipping line between car terminals in South Europe: Koper-Barcelona (Source: Port of Koper)

FUTURE GROWTH OF THE CAR BUSINESS

Today, the countries of Central and Eastern Europe (CEE) have developed into growing and promising part of Europe. The vision of the NAPA seaports is to form a European logistics platform with regard to servicing these markets as well as the markets of the Far East.To obtain better service the ports of NAPA are going to invest efforts into the coordinated planning of road, rail and maritime infrastructure, as well as the harmonisation of regulations and procedures in the field of port service provision.

Factors due to influence the growth of the car business are as follows:

- The steady growth of the economy and the buying power of countries of the Central and Eastern Europe as well as in the Balkans: the south-Korean trade marks (GM Daewoo, Kia, Hyundai, SsangYong), Subaru, Honda.
- The increase of cars import made in China and bound for the eastern European markets and those of the Balkans.
- Favourable economic situation in Turkey and Greece.
- The increase in car production in the Turkish settlements.
- EU regulations concerning the transport of goods: the shift from land to sea.
- New regular SSS lines for an efficient distribution in all destinations in Mediterranean.
- The establishment of a connection Koper-Barcelona concerning Opel, Škoda, Seat, Renault, Suzuki. Toyota, Chrysler, Audi, VW, BMW, Mercedes.
- New production facilities in Slovakia: Kia, PSA Group
- The increase of production in the Czech Republic: Toyota, Hyundai.
- The increase of production in the Republic of Slovenia: Renault, Adriamobil – Fiat

CONCLUSION

We can estimate a positive development of the car market and thus its increased marketing potential which could in the future lead to a much bigger car flow via the Port of Koper. A part of it ought to be cargo flow on direct shipping line in both ways connecting Koper and Barcelona. The increase in car shipping calls for a larger car terminal with bigger storage capacities (Fig. 2) that the terminal is bound to gain with the construction of the third pier. New projects (extension of the pier I and pier II, the new pier III, new warehouse facilities) and potential investments are important steps within the development of the Port of Koper enhancing it's performance and increasing the market share and stand for the predominant developmental impulse to the development of the Port of Koper car terminal as the south-european gateway connecting Central, Eastern and Western Europe with Mediterranean and Far East Countries.

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SEAPORT RESEARCH IN THE CONTEXT OF SUPPLY CHAIN MANAGEMENT

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ABSTRACT

Ports have increasingly been regarded as part of integrated supply chains. This has led to the movement of research from a tripartite framework (economics, geography, operations research) to a more sophisticated platform embracing a large number of disciplines and subjects. These are arranged in a spectrum where port research is found in a range of locations. This study investigates how seaport research has evolved in terms of both its setting and the methodologies employed. The extant port literature spanning three decades: the 1980s, 1990s and 2000s is reviewed and is categorised under a series of methodological headings which provide the basis for the interpretation of the evolution of seaport research within the context of supply chain management (SCM) during the decades specified. A confirmatory analysis of all journal publications within the SCM field at Cardiff Business School produced from 2001 to 2010 was carried out in order to clarify the fit of port research into the wider SCM literature. A structured review of published port literature was undertaken. Methodological issues have in themselves rarely been studied in the context of port research in contrast to Logistics and SCM where a large number of published studies exist. In order to more clearly understand the context of how port research fits into the wider literature a survey of papers produced by the Logistics and Operations Management section of Cardiff Business School was conducted. This forms a confirmatory study which is consistent with a triangulation approach to research with the aim of increasing the validity of the results.

1. INTRODUCTION

This paper addresses four questions: What have been the primary areas of focus in seaport research in the past?, What are the current areas in seaport research?, How have these areas been addressed?, How has port research changed in an individual institution (Cardiff University) where seaport research is primarily conducted in the wider context of logistics and operations management?; this paper is constructed on the principal that seaport research has diversified to reflect the evolution of seaports in reality as they have responded to changes in the world economy. In addition, it is suggested that plausible answers to these questions can provide researchers with a sense of where they are positioned within the overall range of seaport (hereafter port) research, and the directions they should follow. A more structured, rigorous and comprehensive approach is required to fully understand changing trends and themes in port research. Pallis et al. (2010; 2011) used bibliometric techniques and content analysis to successfully characterise the port research community, identify research themes and analyse their coherence. However, their studies do not clearly show how port research has responded to changing research demands, how the focus of research has evolved and how port research has related to the evolution of the port industry and ports themselves. Against this background, this paper investigates how seaports have been studied during the last three decades (1980s, 1990s, 2000s) using a structured and systematic literature review approach.

2. REVIEW METHODOLOGY

To address the first three questions raised above, an in depth content analysis of papers published in academic journals was conducted. While journal editorials were excluded, comments and notes were included if they had either conceptual discussions or empirical analysis. The target period was the three decades from 1980 to 2009. Thus papers which were available as on-line versions in 2009, but for which the publishing year was 2010, were not considered. All papers relating to port policy, port management and port operations were identified and the tables of contents of the journals in which port studies are frequently published were reviewed. Subsequently the references from these papers were examined to trace the journals and papers which had not been previously identified. In addition, on-line searches were undertaken using various databases such as Scopus, ScienceDirect and Swetswise. The papers selected were classified according to research themes and subjects. This classification process was a primary aspect of this research since category construction is regarded as the area of content analysis requiring the most consideration and having the greatest influence over the results (Cullinane and Toy 2000). First, all eligible papers were intensively reviewed to assess their validity for inclusion. At this stage, a decision on categorisation was made resulting in seven research themes (categories) and forty two research topics (sub-categories) being identified. After further cross-review and assessment, the structure was revised to 8 themes and 38 topics and all papers re-allocated to the revised categorisation.

Concerning the fourth question raised above, in order to contextualise port research at Cardiff University an in-depth survey of 10 years of published output was carried out. In 2000, Cardiff Business School acquired a productive and well known research unit known as the Transport and Shipping Research Group (TSRG). The group was originally located in the Department of Maritime studies and International Transport, also at Cardiff University. When TSRG became part of Cardiff Business School it was integrated with other logistics research groups to form the Logistics and Operations Management Section. The average size of the research group over the period was 11 research active staff vigorously engaged in research, publishing, core teaching, short course programmes and a wide range of outreach / engagement activities. This ensured that output invariably had both an academic and a practical value. The stability of the group enabled ten full calendar years (2001 – 2010) to be captured for the data set. The output from the group was first filtered such that only international journal papers were included; 219 papers were thus identified and these were then attributed up to a maximum of 4 key words generating a total of 656 key words (3 key words per paper average). These were then subjected to an aggregation process (amalgamating, for example, risk and uncertainty, health and healthcare and maritime and seafarers) such that 55 different keywords remained. The main purpose of this exercise was to highlight concentrations of output or, conversely, to identify which research areas within the group appeared on sporadically or rarely. The key words were arranged into four tiers: tier 1 'common' – with equal or greater than 20 appearances; tier 2 'regular' with eight to 19 appearances; tier 3 'irregular' – with five to seven appearances; and tier 4 - 'occasional' – with four or less appearances.

3. OVERALL TRENDS

In addressing the wider context of port research it is clear that there has been a rapid increase in the number of published papers during the last three decades. The greatest number of papers was published in 2008 (=84) and the least in 1980 (=2). On average 28 journal papers per annum have been published over the last thirty years. For the first decade, the increasing trend was not obvious, while during the 1990s there was moderate growth in output, with substantial growth in the third decade, peaking in 2008. Heaver (1993) presented ratios for each topic related to maritime transport among the papers appearing in Maritime Policy and Management (MPM) for the period 1982 to 1991 and the Logistics and Transport Review (retitled Transportation Research Part E (TRpE)in 1997) between 1972 and 1991. It should be noted that, even though 7 port studies appeared in Heaver's list from TRpE, none was identified from TRpE in the second decade in this paper's database, possibly due to a different time frame. Ports were one aspect of Heaver's analysis and he detailed topics including shipping such as liner conferences, charter markets, shipbuilding, and ship costing.

This study, for simplicity, integrated shipping-related topics into 'shipping' and topics other than ports and shipping e.g. shipbuilding, into 'others'. In addition, Maritime Economics and Logistics (MEL), published since 1999, was added to this analysis because it is regarded as one of the foremost journals in the field of maritime economics (Pallis et al., 2010). The total number of papers in maritime transport studies has increased during the period of this analysis. While the difference in the total number between the 1980s and 1990s is not large, the difference between 1990s and 2000s is substantial. When it comes to the proportion represented by each research topic, 'shipping' is dominant with around 60% in the 1980s and the 1990s, and 50% in the 2000s. The proportion represented by 'port studies' increased from 22% in the 1980s to 40% in the 2000s, and although this proportion is still lower than the proportion focused on shipping, this indicates that ports are of increasing importance to maritime researchers. Pallis et al. (2010) showed that more than 70% of port research recorded in their database was published in the top 10 journals identified by the authors, suggesting a high concentration into a small number of core journals. Interestingly, the proportion of papers in each category compared to the overall total number of published works shows a significant change. The proportion attributable to 'Maritime Studies' has decreased while the total number of publications has increased. Transportation' expanded rapidly; in the 2000s, nearly 30% of port studies were published in journals in this category. In contrast, the proportion of port studies papers attributable to the 'Geography' category reduced from 18% in the 1980s to 4% in the 2000s.

At Cardiff University, the results of the institutional survey shed light on the pattern of research persistence of particular research themes and the logical links between the key areas. By far the most common keyword within the 219 papers was supply chain management, appearing 86 times. This can be seen as a broad 'banner' heading that captures much, but by no means all, of what the group has researched over the study period. At Cardiff. port research has clearly moved from being a separate research area (linked closely to ships or shipping) to one that is generally conducted within the much broader field of supply chain management.

4. RESEARCH THEMES

Ports

For the topics based on port authorities/companies, three categories were identified: 'Management and Strategy', 'Competition and Performance' and 'Ports in Supply Chains'. Other categories such as 'Planning and Development' and 'Terminal Operation' are generally regarded as topics which provide governments, port authorities and companies with information used for their decision making, and these are often port specific. 'Spatial Analysis' concerns issues on spatial distribution and change, and is relevant to all port policy and operational activities. For the past three decades, the themes which have been the most extensively researched are 'Management and Strategy' (19.6%), 'Competition and Performance' (19.3%) and 'Planning and Development' (14.9%). Perhaps surprisingly, the category with the fewest publications is 'Ports in Supply Chains' (5.2%). Generally port authority/company-based research themes were more popular than government-based themes.

Port Policy

Studies in this category accounted for 9% of the selected port literature and among them, a sub-group focuses on how national port policy has changed and how the changes have shaped and influenced port development and port-related industry in a particular country (e.g. Pettit 2008; Ridolfi 1995). They also address port development issues within the framework of, typically, national transport policy (Mak and Tai 2001). Supra-national port policy is mostly about the European Union's port policy; a group of studies, focus on the current stance of the EU regarding a variety of issues affecting European ports (Bergantino 2002; Psaraftis 2005a), and the impact of these EU policy actions on a particular country (Pallis and Vaggelas 2005) or the position of a particular country in respect of policy actions (Hinz 1996). The regulatory role of government to market access and state aid have been the main topics within 'Port Policy', especially with regard to promotion or distortion of competition. 'Public involvement' using state aid was widely discussed in the 1980s. 'Regulation and competition' drew researchers' attention throughout the 2000s, and this issue became more important in those countries where privatisation was pursued, generally in the 1990s (e.g. Defilippi 2004; Ferrari and Basta 2009).

Port Governance and Reform and Port Management and Strategies

Port labour reform was researched mainly in the 1990s and this work was led by a few core researchers. The geographical focus was mainly limited to UK and Commonwealth countries such as New Zealand and Australia. Academics and practitioners re-evaluated port reforms in their countries 10 years or more after port labour reforms were introduced (Rayner 1999; Coffey 2009). Port management covers a wide range of sub-topics and accounted for around 20% of the papers. Studies in this category generally discuss managerial and strategic issues at the level of port authorities and Terminal Operating Companies. Emerging managerial issues include environmental management, safety and security management, and information and knowledge management. The former is primarily about how port authorities can or should effectively deal with the challenges and pressures imposed by regulations or institutional changes (Stojanovic et al. 2006; Bichou 2004;) and developing measures to reduce security risks and accidents (Ronza et al. 2003; Price 2004). Port pricing is a traditional research topic in line with port financing for infrastructure and setting of port charges (Dowd and Fleming 1994; Talley 1994b). A clearly discernible trend is the growing attention being focused on the business strategies of Terminal Operating Companies (TOCs) in the 2000s. Rapid development of trans-national TOCs through private investments in the world's container terminals changed the unit of analysis from the port as a whole to TOCs (Olivier and Slack 2006).

Port Competition and Performance, Planning and Development

This category accounted for almost as large a proportion of studies as the 'Port Management and Strategy' category (20%). Advanced methods, analytical tools and new measures helped researchers analyse and assess the complex nature of competition dynamics and relationships among competing ports (Lam and Yap 2008; Notteboom 2009). Bird (1982a; 1982b) revealed perceptions of transport decision-makers in European countries on port development through interviews with the decision-makers. Port selection is a traditional topic analysing shipping liners' or shippers' port choice behaviour, generally using interview or survey (Murphy et al. 1989; Slack 1985). This topic showed an observable advancement with the introduction of a variety of methodologies in the 2000s, such as Analytical Hierarchy Process (AHP) (Lirn et al. 2004), Factor Analysis (Chang et al. 2008), and Multinomial Logit Model application (Malchow and Kanafani 2001; Tiwari et al. 2003). Planning and development includes studies about the planning and development of port infrastructure and the decision making process related to infrastructure extension. Demand analyses are basically forecasting studies covering cargo throughput and growth. Some studies addressed this topic using an exploratory approach (Heikkila 1995; Walker 1985). However, most papers used statistical methods such as regression (Tongzon 1991; Zohil and Prijon 1999), time series analysis (Schulze and Prinz 2009), error-correction methods (Fung 2001; Hui et al. 2004). Several studies were concerned with the supply side of ports infrastructure. Some studies discussed the deficiency in port capacity in particular countries and the necessity for port expansion (Cullinane and Song 1998). However the optimum size and capacity of terminals or ports to meet the demand for port services were most widely researched. Mathematical modelling and simulation were primarily used for research concerning a variety of operational situations such as: vessel arrival patterns (Huang et al. 2008; Noritake and Kimura 1983), construction and operational costs (Musso et al. 1999) and cargo handling systems (Chu and Huang 2005). Researchers also paid attention to institutional aspects of planning and decision making related to port development.

Terminal Operations and Spatial Analysis of Ports

This approach seeks optimal solutions in terminal operations and it appears to be a separate field from port management and policy studies. It is indispensable in the efforts to cope with increasing container transportation and in the drive to achieve ever higher efficiency in seaports. Its importance is also shown by the 11% proportion of total papers in this category even though a number of optimisation studies were classified in other categories such as demand and supply analysis and port selection. Spatial analysis accounted for 11% of the selected papers for the past three decades, a higher proportion was in evidence during the 1980s and 1990s with spatial analysis of the port system of a country or a region being the main topic.

Ports in supply Chains

In the content analysis the papers in this category were separately classified, even though the proportion in all the papers was the lowest (=5.2%) among the 8 categories. The reason for this is that the papers take a different view on seaports from those of traditional studies which see seaports as nodes at the interface between sea and land transport. They argue that seaports should be viewed as parts of supply chains (Bichou and Gray 2005; Robinson 2002) and as an extended system which can interact with other participants in the supply chain such a manufacturing, assembly logistics or retail companies. In this context, a number of papers investigate the integration strategies and practices of seaports along supply chains (Carbone and De Martino 2003; Tongzon et al. 2009) and their impact on performance (Song and Panayides 2008). The total number of papers published during the three decades was 44 with 95% being published between 2000 and 2009 (Table 1).

Table 1. Ports in Supply Chains Research

Research Agenda	**1980-1984**	**1985–1989**	**1990–1994**	**1995–1999**	**2000-2004**	**2005-2009**	**Total**
Redefining ports in a supply chain context	-	-	-	1	3	11	15
Integration along supply chain	-	-	-	-	2	11	13
Land-side Logistics	-	-	1	-	5	10	16
Total	**0**	**0**	**1**	**1**	**10**	**32**	**44**

It is worth noting that the increased level of research output in this area is related to the growing interests of terminal operating companies' and their integration into supply chains, and the activities of container terminals or terminal operating companies, rather than as a result of overall port activity. Further, studies about inland logistics connected to port logistics has grown in number (Rahimi et al. 2008; Walter and Poist 2004) as seaports increasingly rely on intermodal solutions through rail corridors and inland ports to cope with volume growth and the imperatives of global supply chains.

5. RESEARCH FINDINGS AND DISCUSSION

Growth in port research

The past three decades have seen a substantial growth in port research. However this study has shown not only the growth but also the changes and transition behind that growth. The introduction of advanced methodologies played a crucial role in attracting researchers' interest to particular topics. Frontier analysis methods such as DEA and SFA led to an increase in the number of studies on port efficiency in the 2000s. Port selection studies became more popular in the 2000s, using a variety of methodologies such as Multi Criteria Decision Making (MCDM), Multinomial Logit model and Factor Analysis. In addition, there was huge inflow of new authors in the 2000s, in particular from Asian countries. The increasing collaboration practices between Asian institutions and European or North American institutes enhanced their contribution to growth of port research. On the output side, it was observed that the number of journals publishing port research has substantially increased and the subject areas have also diversified. As previously discussed, this may be an outcome achieved through port researchers' efforts to apply new advanced methodologies and to address seaport problems with various approaches and from diverse disciplinary contexts. However, it is true that this diversification has provided more opportunities for new researchers to develop port research and facilitated discussion between port researchers and researchers in other fields or academic disciplines. The trend of research theme transition has been from 'development-led' in the 1980s via 'policy-led' in the 1990s to 'management-led' in the 2000s. This transition pattern primarily reflects the evolution of the port industry: from expansion-era via reform-era to post-reform era.

Ports and Supply Chain Management Research at Cardiff University

Within the tier 1 category eight sub-headings were inferred from the keywords: Group A - modelling, manufacturing, production and information technology; Group B – Logistics, Business, Management and Transport/Shipping. Group A keywords (and hence research papers) are focused primarily on controlled environments e.g. in manufacturing plants; group B keywords are found in papers focused mainly on the macro environments e.g. international / long distance movement of freight. Tier 2 keywords reflect specific foci of the respective papers, and it is in tier 2 that the keyword 'ports' is found. Located below multimodal and linked to both 'environment' and 'policy', it is evident that port research at Cardiff University has historically been part of a multidisciplinary and applied approach to research, and that the link between Supply Chain Management research and port research has mostly been indirect rather than direct. Only very recently have journal papers emanating from Cardiff University tried to capture the operational or economic link between Supply Chain Management (or logistics) and port operations.

6. CONCLUSION

This paper reviewed port literature over three decades, using a decadal analysis and a carefully devised categorisation framework which revealed clear trends in the transition in research themes. This primarily reflects the evolution in port management and operation such as government policy, technology advancement, management strategies, etc. In particular, the emerging aspects observed in the 2000s capture changing management environments which the port industry has embraced, for example the existence of stronger inter- and intra-port competition; integration of ports along logistics and supply chains, increasing involvement of private sector due to port privatisation, andsuggest possible future port research. However it should also be emphasized that such developments in port research cannot be driven only by research demand stemming from the evolution of the port industry, and should be accompanied by the development of appropriate methodologies and theories (Woo et al., 2011). As for theoretical developments, while creation of new theories specific to port management can be sought, the application and adoption of existing theories from other research disciplines is strongly suggested (Stock, 1997).

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IDENTIFYING SCM SUBSYSTEMS TO ANALYSE PORT ACTOR-PORT CUSTOMER COLLABORATION IN SUPPLY CHAIN MANAGEMENT

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Introduction

Supply chain management (SCM) in the context of port logistics has been the subject of various research publications. As one of the first authors, Robinson (2002) describes the need for ports to be understood as elements in value-driven chain systems. Port competition takes place not at individual port level but between chain systems (Robinson 2002, p. 250). Thereby, adding value for port customers and their supply chains becomes a crucial factor. In this context, Carbone, de Martino (2003) identify an extension of a port's traditional customer base: requirements of shippers and consignees become more important (Carbone, de Martino 2003, p. 305), putting ports under pressure to develop capabilities such as external coordination with port customers and exercising control over the whole supply chain. The importance of the customer focus in SCM, which the aforementioned authors postulate for port actors, represents a recurring argument in SCM literature (Mentzer et al. 2001, p. 7). In the context of this paper, this means that SCM strategies of the port customers, i.e. the shipper or a service provider who is responsible for shippers' supply chains, are essential when it comes to logistics strategies of port actors. As a result, business requirements for port actors from an SCM perspective are of great importance. Only when port actors understand which services port customers require in view of their SCM strategies can they gain or maintain a competitive advantage. It is, however, not always apparent from a port actor viewpoint what characterises the SCM strategies of a shipper, i.e. a manufacturer or a trading company. Bichou, Gray (2004) find that members of the port community show a strong interest in SCM and logistics concepts but also a general lack of knowledge about SCM approaches in port logistics (Bichou, Gray 2004, p. 60). Previous research tried to change that and dealt for example with the integration potential of port operators in car manufacturing supply chains (Carbone, de Martino 2003), port performance measurement (Marlow, Paixão Casaca, 2003; Bichou, Gray, 2004), SC integration of port container terminals (Panayides, Song, 2009) and the advantages of port centric logistics (Beresford et al. 2011, Wall 2007). Although this seems to be a fair amount of research, some conceptual shortcomings remain. Especially, a detailed understanding of SCM concepts is often missing and only few papers apply concrete SCM models to the port environment (for an exception see Carbone, de Martino 2003). This insight provides the starting point for this paper, which aims to answer the question what constitutes SCM and to apply findings to the seaport system. Therefore, three SCM reference models are analysed and key elements are integrated into an SCM subsystem framework. Furthermore, this paper provides a brief outlook on how SCM subsystems and port actors can be combined in a single explanatory framework for port actor-port customer collaboration, the SCM-port actor matrix, and what to consider in the developing process.

Analysis of SCM reference models

Different authors have developed reference models/conceptual frameworks of SCM. Reference models represent a conceptual framework, i.e. they have a superior, higher-level character and are comprehensive, more generic in nature (Corsten, Gössinger 2008, p. 134; Stahlknecht, Hasenkamp 1999, p. 237). They make an important contribution in terms of providing transparency, guidance and the ability to communicate for analysing and optimising supply chains (Hertel et al. 2011, p. 103 ff.; Corsten, Gössinger 2008, p. 134 ff.). Three SCM reference models have been chosen for analysis in the context of this paper, the supply chain operations reference model (SCOR), the supply chain integrative framework of Bowersox et al. and the conceptual framework of SCM of Cooper et al. A detailed presentation of these models, however, would go beyond the scope of this paper. Therefore, models are only described broadly with references for further reading. The focus will be especially on those parts of the models that provide the best answer to the question what constitute SCM.

The SCOR model, developed by the Supply Chain Council (SCC), has been included because of its high practical relevance and its broad application in practice. It represents a quasi-idealistic, holistic model of a supply chain applicable across companies and industries that describes, analyses and assesses supply chains in a unified manner (Poluha 2010, p. 81). It is organised in a three-level structure. On Levels 1 and 2 the SC architecture is described. Level 3 specifies best practices in executing Level 2 processes (Zhou et al. 2011, p. 333; SCC 2010, p. 11). Two additional levels include industry- and organisation-specific steps. For this paper only Level 1 management processes – 'Plan', 'Source', 'Make', 'Deliver', and 'Return' (Zhou et al. 2011, p. 333) – are of relevance because it is eventually the interaction of those integrated processes across SC members that characterises SCM in SCOR (Bolstorff, Rosenbaum 2007, p. 2).

The supply chain integrative framework of Bowersox et al. has been included due to its comprehensiveness and its all-embracing assumptions (Horch 2009, p. 42). It aims to identify the range and continuity of collaboration in supply chains required to achieve effective and efficient supply chain flows (Bowersox et al. 2007, p. 366 ff.). Four different supply chain flows form the basis of the framework: the product/service value flow, the (reverse) market accommodation flow, information flow and cash flows (for detailed information see Bowersox et al. 2007, p. 174 ff. and Horch 2009, p. 39 ff.). To increase effectiveness and efficiency of those SC flows, Bowersox et al. (2002) identify six relevant supply chain competencies which, if implemented and integrated between supply chain members, could eventually help to reduce delay, redundancy and inefficiency in the supply chain (Bowersox et al. 2002, p. 174 ff.). Competencies are customer integration, internal integration, supplier integration, technology and planning integration, measurement integration and relationship integration.

The conceptual framework of Cooper et al. (1997) was included because of its broad scope, its inter-organisational focus, and a strong process orientation (Horch 2009, p. 50; Heusler 2004, p. 88). The framework includes three basic interconnected elements: the supply chain network structure dealing with the overall configuration of the supply chain (Cooper et al. 1997, p. 9), business processes, defined as intra- and inter-organisational activities that generate value to the customer, and management components which support and provide structure to business processes across SC companies (Cooper et al. 1997, pp. 5-6). In the following the focus is on the eight business processes as it is their integration across the supply chain what represents SCM in the model context (Cooper et al. 1997, p. 2). Business processes are customer relationship management (CRM), customer service management (CSM), demand management, order fulfilment, manufacturing flow management, supplier relationship management (SRM), product development and commercialisation and returns management.

Development of SCM subsystem framework

Based on the descriptions of the three SCM reference models, a conceptual framework of SCM subsystems is developed to answer the question 'What constitutes SCM'. Therefore, the five Level 1 management processes of the SCOR model, the six supply chain competencies of Bowersox et al. and the eight supply chain business processes of Cooper et al. are thematically clustered and integrated into a single SCM subsystem framework (see Figure 1) as they describe best what constitutes SCM in the context of each of the models. The term SCM subsystem is used to avoid terminological confusion, as the aforementioned core processes, competencies, and business processes from the three models do not always entirely explain the clusters formed. Twelve subsystems assigned to four different SCM layers have been identified. The superordinate layer consists of the subsystems plan, measure and integration. Plan activities are included in the SCOR model ('Plan') as well as in the model of Bowersox et al. ('Technology and Planning Integration'). Whereas Bowersox et al. explicitly stress the importance of information in planning, SCOR applies a more general definition of planning with the matching of supply and demand in the supply chain. Measure is named as an explicit competency in the reference model of Bowersox et al. ('Measurement Integration'), being performance monitoring and benchmarking within and across supply chain members. It is also an important element of the performance segment in the SCOR model (Poluha 2007, p. 58 ff.; SCC 2010, p. 8). Integration can be understood as guiding principle of all three reference models. Bowersox et al. (1999) conclude that a high level of integration in six identified competencies represents a source of competitive advantage for SC members (Bowersox et al. 1999, p. 20). Cooper et al. (1997) define SCM as integration of business processes across the supply chain (Cooper et al. 1997, p. 2). The SCOR model facilitates supply chain integration by its structure of common processes and metrics across all SC members (SCC 2010, p. 5).

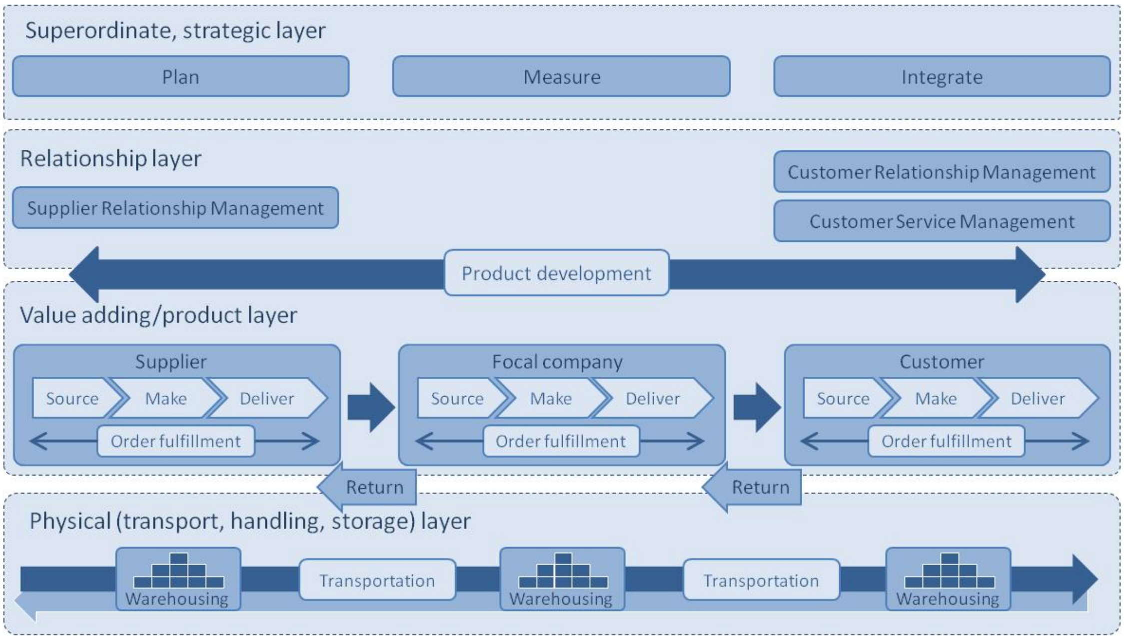

Figure 1: Subsystems of supply chain management (compiled by the author)

The relationship layer encompasses subsystems that are related to the management of relationships in the supply chain. Supplier relationship management represents a business process within the model of Cooper et al. In the same context Bowersox et al. identify supplier integration as an important SC competency. The management of relationships with customers is also part of the models analysed. Cooper et al. distinguish between the largely strategic customer relationship management and the more operational customer service management. Bowersox et al. view customer integration as another SC competency. The value-adding layer includes all elements that are linked to the production process across all supply chain members. Sourcing processes can be found in the SCOR model as one of the basic processes and in Cooper et al. as demand management that aims to balance customer demands with a firm's supply capacity. Make processes, outlined in SCOR ('Make') as well as in Cooper et al. ('Manufacturing Flow Management'), logically follow sourcing activities and deal with all product-related value adding activities across the manufacturing process. Deliver was named in the SCOR model and in Cooper et al. as part of business process order fulfilment. Order fulfilment includes all activities related to and accompanying the customer order and can be found in Cooper et al. Return in terms of reverse flows from the customer to the supplier can be found in the SCOR model ('Return') as well as in the framework of Cooper et al. ('Returns Management'). As return processes also include physical return flows there is a thematic overlap with transportation and warehousing. Product development, part of the model of Cooper et al., includes suppliers and customers in the process of bringing products to market. It is therefore placed at the interface between the relationship layer and the value adding/product layer. The physical layer subsumes SCM elements that are related to logistics functions such as warehousing, handling, and transportation. As a prerequisite for physical SC flows, warehousing and transportation do not represent individual elements in the models but are assigned as sub-elements, for example in the deliver process (transport) and the source process (storage) of the SCOR model.

Applying SCM subsystems to actors of the seaport system: the matrix approach

In the following, it will be discussed how SCM subsystems can be applied to the port logistics system. Before this can be done, it is necessary to develop an understanding of what constitutes a seaport system and which actors belong to it. This, however, cannot be done in detail in the course of this paper. It should however been mentioned that this question has to be dealt with in a case-specific manner, as seaports are complex and heterogeneous entities in many aspects such as assets, roles, functions or institutional organisation. Which actors to include when analysing how port actors are involved in shippers' SCM strategies therefore cannot be decided in general but depends on the SC strategy of the shipper in question. For further insights into the port logistics system and related actors Alderton (2008), Paixão, Marlow (2003), Notteboom (2006), Bichou, Gray (2005) and Talley 2009 can be consulted. As a tool for analysis in the field of ports and SCM, SCM subsystems and relevant port actors can be combined in a matrix with SCM subsystems as row headers and port actors as column headers. The matrix approach can be used as preliminary conceptual work for empirical investigations in the context of SCM and port logistics, e.g. to display respective activities of different port actors or to identify requirements for port actors posed by port customers with respect to their SCM strategies. Overall, the matrix helps to structure empirical evidence and further research in the realm of ports and SCM and by this provides impetus on the ongoing discussion as to how the port logistics system can be integrated in the SCM strategies of shippers.

Conclusions

When analysing SCM in the context of port logistics, two inherently complex systems, SCM strategies of shippers and the multi-actor seaport system, have to be reconciled. As a result, it is not always apparent from a port actor viewpoint what characterises the SCM strategies of a shipper, making it difficult for port actors to offer coordinated services for their customers. Research, dealing with the same challenges, responded by simplifying either the underlying understanding of SCM and/or the seaport system, which impairs the significance and transferability of research results.

This research develops a comprehensive theoretical understanding of SCM by analysing and clustering elements of different SCM reference models into SCM subsystems. Subsystems can be assigned to four different layers which provide a structure of SCM in itself, explaining SCM from different angles. The superordinate layer includes subsystems that have rather general, yet strategic implications for SCM such as planning and measurement. The relationship layer includes strategic as well as operational linkages with upstream and downstream SC members. The product/value added layer includes core business functions which are linked to the manufacturing process and by this add value to the produced product or service. The physical layer includes traditional logistics functions, such as transportation, linking different supply chain stages.

In a next step, with the SCM-port actor matrix, this paper suggests a conceptual tool that combines SCM subsystems with port actors, applicable to support empirical investigation in the context of SCM and port logistics. Fields of application can for example be to display and thematically structure activities in port actor-port customer collaboration or to identify requirements for port actors posed by port customers with respect to their SCM strategies. It thereby provides impetus on the ongoing discussion as to how the port logistics system can be integrated into shippers' SCM strategies.

Further research needs can be identified in different aspects. With respect to the SCM subsystem framework it is important to understand the interrelations between the different layers as it would further improve the comprehensiveness of the framework. Also, as the seaport system is complex in nature, detailed knowledge about system boundaries, relationships between actors, their functions, influence etc needs to be gained. Thereby it is important to bear in mind that collaboration between port actors and customers is case-specific and that the seaport system needs to be analysed on a case-to-case basis.

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LEAN IN LOGISTICS: VALUE STREAM MAPPING - A JOURNEY TO IMPROVED EFFICIENCY AND PERFORMANCE

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INTRODUCTION

Lean can be described either as a philosophy or as an integrated set of tools to improve business practices (Shah & Ward, 2003). The philosophy builds on three basic premises: create value for the customer, eliminate waste and continuous improvement (De Haan et al., 2011a). The basic principles are operationalised using tools and lean bundles such as just-in-time (JIT) and total quality management (TQM). (Shah & Ward, 2003). Value Stream Mapping (VSM) is often mentioned, in relation to lean practises, but mainly as a tool (Hines & Taylor, 2000). Value Stream Mapping (VSM) allows for the identification of value adding and non value adding activities (waste) and allows companies to develop improvement agendas leading to higher productivity, increased quality and lower costs (Hines &Taylor, 2000). The question then is, does it have a 'philosophy' message as well and if so what is this message?

Lean philosophy and related techniques were developed initially for application in manufacturing settings (Shah and Ward, 2003). Nevertheless, lean has also been successfully applied to service organizations (De Haan, et al., 2011a). One such service organization is the Logistics Service Provider (LSP). LSPs are facing increased competition and higher customer expectations. To improve their competitiveness LSPs are forced to reduce delivery times, improve on performance and quality but at the same time drive down costs (Anderson, Coltman, Devinney and Keating, 2011).

The drive to create value and reduce waste is at the core of the lean philosophy (Chen, Li and Shady, 2010). When applied to the analysis of such service organization and their processes allows companies to identify improvement opportunities and establish a culture of continuous improvement. Specific techniques such In the present paper we discuss the efficacy of Value Stream Mapping to support LSPs on their lean journey.

What are the consequences for a tool like VSM if it is applied in other industry, e.g. in LSPs? Unlike manufacturers, LSPs provide a service for their customers to meet the demands of the latter's clients, which the customer outsources to the LSP (De Haan et al., 2011b) In the supply chain the goods move from primary production through processing to manufacturing and the through trading stages to the final customer. LSPs may carry out transportation or warehousing on behalf of a manufacturer or a retailer. LSPs often provide services for many customers (and their clients) as a consequence; the services can become isolated from a supply chain management perspective. Does this influence the 'philosophy message' of VSM?

The remainder of this paper consists of three sections. First a literature review of LSPs as well as of VSM, with an emphasis on the relationship and degree of consistency with the lean 'philosophy message'. In the next section empirical evidence on VSM in LSPs is presented. This data originates from a larger multi case-based study on lean logistics. In this project performance is measured and analyzed at 7 companies in the Netherlands. VSM is one of 4 tools applied at the LSPs during their lean journey. Processes were identified and mapped using a combination of observations, interviews and documentation, and measurements were made by direct observations. Based on the data collected and the theoretical positions taken from the literature a comparison is made. Conclusions are drawn that are relevant for both practice and extant theory.

VSM IN LSPS: THEORY

VSM emerged in Lean as a tool to redesign the productive system, mainly focused on the analysis of disconnected flow lines in manufacturing (Serrano et al., 2008). The outcome would be whether activities are value adding, non value adding or non-value adding but necessary (Hines & Taylor 2000). The VSM process consists of 5 phases; selection of a product (or service), current state mapping, future state mapping, design of an improvement plan and implementation of the improvements. The current state map shows inefficiencies for this particular product (or service). These inefficiencies are the starting point for improvement processes. The role of the future state map is to define a pull-driven continuous flow that is in line with a common takt time rhythm. This creates a leveled production derived from on a 'pacemaker process that improves efficiency. The emphasis in the current and future state map is on numerical data reflected in graphical interface in which standardized symbols are used. Walking the process is an essential element in identifying the value stream (Chen et al., 2010). In particular walking backward through the process as this allows one to see to where the customer enters into the stream. Serrano et al. (2008) stress that VSM is a tool with a focus on the physical and the informational flow but largely neglects the managerial subsystem. However, they also said that this tool did emerge from Lean tradition. As lean is both a set of tools and a philosophy, the question now arises what is its philosophy-message? The emphasis in the 5 phases is indeed on the tool aspect of stream mapping, but the value part is limited to eliminating inefficiencies. What exactly the value is i.e. what the customer demands from the product (or service) is not elaborated on. Hence the reference to foremost fundamentally important facet of the Lean philosophy is neglected. As a result it may be that only inefficiencies are identified for improvement and not deviations from other performance criteria. Exchange of dies, e.g., can be done either in an efficient or in an inefficient way, but the question as to what value this creates is not addressed. This could be corrected if the first step taken would not just be selection of the product family, but what value is required to meet the specified customer performance'. In that case the philosophy message would be clear as well, as well as the tenets in Lean.

LSPs operate in a triad together with their customer (the shipper) and its client (for producers) or its supplier (for retailers) (De Haan et al., 2011b). Logistics is about bridging gaps in time, place and quantity (De Haan et al., 2011a). Hence customers can, in essence, outsource three types of activities and related processes, i.e. transportation, storage and handling. Related activities can be paperwork, planning, value-adding and monitoring and the like. The shipper makes the decision which (parts of these) processes will be outsourced. The shipper and LSP negotiate the content of the operations as well as the conditions under which these have to be carried out and the performance to be met. The shipper dominates these negotiations as the LSP is a 'captive supplier' who has to invest most in the relationship. Logistics is a necessary, but non-core activity for the shipper, but for the LSP it is the core business. Whether the shipper is satisfied with the performance of the LSP, does not only depend on meeting agreed performance levels but also on the satisfaction of the shipper's clients' satisfaction with the overall performance. The LSP is the 'representative' of the shipper in the delivery of the service and thus the goods.

VSMs in LSPs look different from those in manufacturing companies as they reflect the fragmented and isolated processes that the shipper outsources. A traditional value stream map (fig.1) starts with the dispatch of goods at the shippers' supplier and ends with the reception of goods by the shippers' client. Within that map the LSP carries out one or more processes. Transportation from the supplier and/or to the client can be the service that has to be delivered and consists of activities such as loading, driving and unloading (De Haan, 2011a). Warehousing consists of two parts divided by stock keeping: inbound and outbound, each of which consists of a number of activities. A value stream of this service resembles VSMs in manufacturing, especially in case value-adding activities are included in outbound. In all cases where inbound orders differ from outbound orders handling is required as well not only bridging the gap in time, but also that in quantity. Cross docking often implies both transport as well as handling: goods loaded at the shipper or a hub, transported to another hub, unloaded, checked, transported to shipment, loaded, driven to another hub or the client and unloaded. These activities can be mapped in a similar way as in manufacturing firms. However, the requirements that have to be met, i.e. the value to be delivered, are not as clear because of the interests of the shipper and those of its client. These requirements are not always clear to the LSP and even to the shipper (De Haan, 2011b). In the existing VSM literature the emphasis is on inefficiencies or wastes. What a waste is depends, in the end, on the requirements of the shippers' client. 24-hour delivery may be agreed upon with the shipper, but does the client really require this? Consequently, 'late' delivery after 48 hours can still be considered in-time from the clients' perspective. This could imply that trucks could be used instead of vans to distribute at a lower frequency and thus improve the value stream in the eyes of the client and consequently that of the LSP too. Clarity about requirements from all parties involved is crucial to really optimize the services. As a result the underlying processes (De Haan, 2011b) can be improved as well. This involves identifying which of the processes are critical to achieve the real clients' requirements and what performance level is required for that. This kind information is needed to analyze the current state of the value stream as well as to design the future state. This goes beyond the characteristics of the information needed for creating the VSM and using it to identify improvements, as are generally discussed in the literature.

VSM IN LSPS: IN PRACTICE

LSPs provide all kinds of different services for their customers which reflect different aspects of the general VS-picture as presented in the literature. For example, transportation can be either from a supplier to the warehouse from an LSP or from the LSP to the warehouse of a customer('s client) depending on whether the customer is a retailer or a manufacturer. The key processes are loading, driving and unloading. Cross docking combines transportation to and from the LSP and includes rearranging the goods transported. Often goods are regionally collected to be sent in larger quantities to another hub, or the received goods are distributed regionally to final customers, e.g. web shop clients. In warehouses, inbound, storing and outbound processes are distinguished, but value-added activities may exist as well. Both inbound and outbound processes consist of a number of activities, as is explained below. Figure 1 summarizes how the three main services can be shown in the VSM scheme.

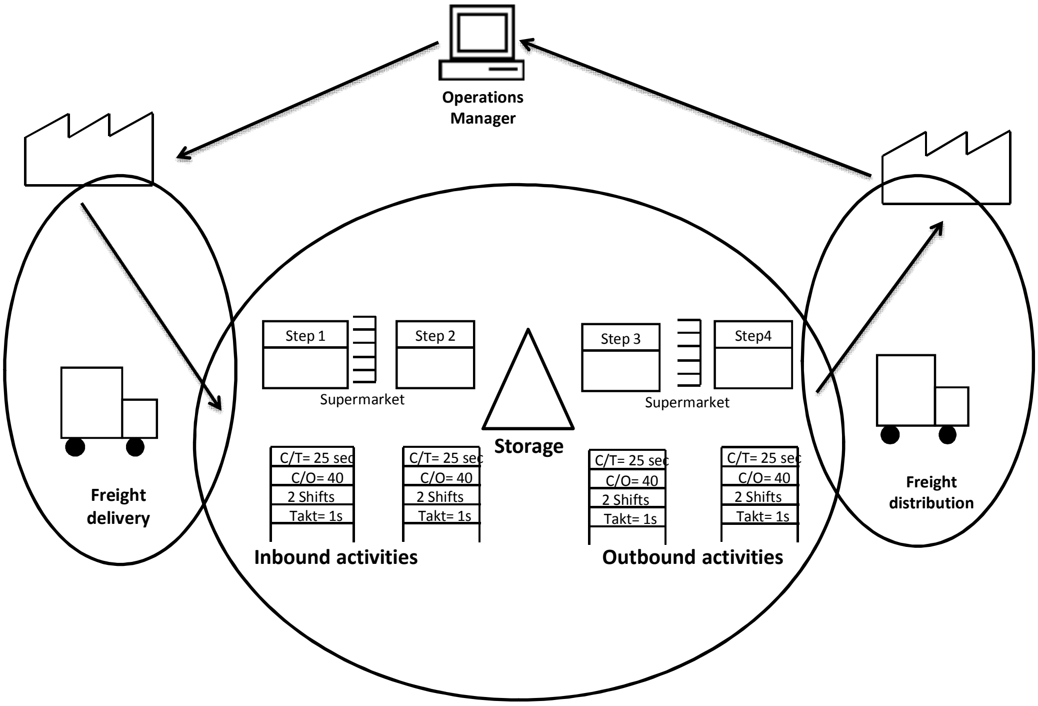

Figure 1: Overall scheme VSM for an LSP

In the remainder of this section we concentrate on the VSM associated with warehousing, both the inbound and the outbound processes of two LSPs are compared to illustrate the content and lean philosophy underpinning of the VSMs as described above. The processes were chosen to compare cases with the richest diversity in terms of company size, type of market (B2B, B2C) types of products, The measurements were stopwatch time studies as well as work sampling (Russell & Taylor, 1995).

Inbound processes

Company K, an SME, focuses its activities on conditioned food and food-related products. For company K the value stream for customer S is analyzed. Customer S produces a semi-finished product that can be used as a raw material for a number of food products. The product is packaged in large bags that are placed in a wooden container. About 20 of these form a full truck load. Much of the production is exported to the US and as customer S has hardly any storing facilities they outsource warehousing activities to company K. Whenever customer S has finished a batch they inform company K, which has to pick up the bags within three days. If K is late, customer S will send e-mail to alert company K. Company K tries to include the pickups in backhauls from other, distribution, drives.

Company N is a larger LSP with about 30 larger accounts, some of which have warehousing facilities on the customers' site which is run by company N, whereas company N also rents warehouse facilities in the close proximity of its clients. Company N has a separate division specialized in transportation for warehouse clients as well as for other clients. Customer H is one of the clients for whom company N provides both

transportation and warehousing. Customer H includes company N in its production scheduling. Hence company N knows in advance when it has to pick up the fast moving food consumer goods from customer H. This facilitates efficient transportation planning for company N as well as planning its inbound activities.
Upon arrival at company K the customer S's products is immediately unloaded and placed in a conditioned docking area. Office is informed after this. After some time, about 3 hours and 40 minutes, the goods will be put away to be stored until an outbound order has been received. Put away starts after an order from the office. Table 1 shows the figures for these two inbound processes company K distinguishes, both total cycle time and time per bag.

	Cycle time		**Time/bag**	
Process	**Average**	**St. Dev.**	**Average**	**St. dev.**
Unload	1118	239	50	19
Put away	1173	190	60	35
Storing time (days)	35	67		

Table 1: Inbound processes at company K (in seconds)

From table 1 we learn that both processes take about the same time. The standard deviation for both cycle time and time per bag of unload is pretty similar: about 20%. This implies that the process is controlled maximally, however compared to the standard deviation of time per bag (almost 70%) the figure is low. Apparently even within one cycle of put away time per bag differs considerably. This may be caused by difficulties of processing these bags. Another problem in this inbound process is the time (and space) the inbound dock is occupied by the bags. This implies wastes (unintended inventory, unneeded movements) and can cause additional wastes for processes for other accounts (e.g. unneeded transport)

Upon arrival at company N the customer H's products will be unloaded immediately. Then they have to wait till the invoice can be scanned. Office is informed when the invoice has been scanned. After scanning the goods have to wait again before they can be put away. Put away is initiated by an order from office. Table 2 summarizes the figures for these inbound processes, both total cycle time and time per pallet.

	Cycle time		**Time/pallet**	
Process	**Average**	**St. Dev.**	**Average**	**St. dev.**
Unload	2630	880	72	17
Waiting for scan	6771	4395		
Invoice scanning	278	208	11	10
Waiting for put away	8571	13803		
Put away	12103	15973	77	20

Table 2: Inbound processes at company N (in seconds)

From table 2 we learn that the average time for put away (132%) exceeds the figure for all other processes and waiting. However, in relative terms the deviation for waiting for put away is even larger (162%). This part of the process is not controlled, although the time per pallet has a moderate deviation (20%). Waiting and unneeded inventory are among the wastes Lean tries to eliminate. Here they may not be caused by the operators involved but rather by people in the office as they are informed when the invoice scanning has been finished, but then it takes another almost 4 hours before put away actually starts. Something similar happens with waiting for scan: about 1 hour are finishing unloading it starts. Although invoice scanning as such does not take much time it shows high standard deviations for both average and time per pallet. As H sourced out transportation to the transportation division of company N, the company could improve quite a lot in the planning and execution of these processes.

Outbound processes

The outbound processes start with an order from the client to the customer, which is then passed on to the LSPs' office. This office will then initiate the outbound activities.
The outbound processes for company K will also be described. The office provides a pick and checking list to start picking and a bill of lading for the loading process. When a process has been finished, office will be informed. In between the two processes the goods stay for 14 hours on the outbound dock. Table 3 summarizes the figures for the outbound processes, both cycle time and time per bag.

	Cycle time		**Time/bag**	
Process	**Average**	**St. Dev.**	**Average**	**St. dev.**
Picking and checking	1087	97	60	60
Loading	1077	315	44	44

Table 3: outbound processes at company K (in seconds)

Company I distributes electronic consumer goods from an extensive assortment in small quantities on behalf of its limited number of clients. Most orders contain only one order line. The number of activities that is distinguished is rather large and some of them have been automated. Its software package informs an office that informs order release and provides labels to box launch as well as communicates with picking and checking and billing and is informed by truck scan. Order release and Box launch start earlier than the other activities. Table 4 summarizes the time per box for the outbound activities, as well as average stock waiting for processing.

	Time/box		**Stock waiting (boxes)**	
Process	**Average**	**St. Dev.**	**Average**	**St. dev.**
Order release	0	0	0	
Box launch	5.9	1.9	132	
Picking and checking	70.9	51.3	721	
Weight checking and billing	3.8	0.6	43	
Packing	8.7	3.8	12	
Truck scan	0	0	3	
Loading			18	

Table 4: outbound processes at company I

From table 4 we learn that order release and truck scan are carried out electronically. Picking is not only the most time-consuming activity; it has also, absolute and relative (70%), the largest standard deviation. In addition to this it has the largest inventory waiting for it. This activity is the bottle neck in company's outbound activities and needs to be improved. Except for the large inventories before box launch and picking and checking, work in process is limited and the processes are quite well balanced as the low and decreasing inventories indicate.

DISCUSSION

This paper addressed the question to what extent VSM reflects the content and philosophical underpinning of value, in particular in the LSPs' triad.

The results of the VSMs in the described cases show that the value streams differ along with whether the focus of the LSP is on one or more activities, i.e. on transportation, warehousing or cross docking. However, in the value streams in all cases waste of unanticipated inventory appeared (for example, waiting time for trucks, buffers in between processes in warehouses); processes are not stable enough to allow LSPs to rely on JIT practices (e.g. high SDs on average process time). Another expectation was that while internal efficiency can be improved, overall effectiveness is often challenged by the other parties in the LSP-triad. However the studies show that in particular the inbound process is not challenged in the LSP-triad and even the outbound processes are hardly challenged by the outside parties.

This research shows that applying Value Stream Mapping in (logistics) service environments is not straightforward. The differentiation between value adding, non value adding and necessary but non value adding is not as clear in practice as it seems to be in the theory. Although the existence of waste could be indicated, the amount to which non-value-adding appeared was not clear from our measurements yet, but would require more detailed analyses. Whether checks and information exchange during the inbound and outbound processes were really needed as necessary but not non-value-adding is not always clear. In company N the office is informed when invoices have been scanned which allows planning of put away. But what if the goods are simply pushed on? Is checking during picking and before billing really needed or is it simply non value-adding? What would make the activities fit in either of the categories? These and other problems with conceptualization need further investigation. Another problem which can been identified refers to the comparison and aggregation of results of individual value streams in relation to improving overall effectiveness. Both company K and company N are informed in advance that goods are due to arrive, or at least could be. Company K knows when a batch has been finished, company N is included in customer Hs' production planning. Yet they don't or can't for some reason or another anticipate adequately to organize the inbound activities in a flow.

With reference to the key question of how this relates to the lean 'philosophy message' it can be said that the application of VSM in service organisations while providing insights into specific quantifiable wastes and inefficiencies it does not ask fundamental questions as to the what Value means for the customer or client or what the right level of value is. Results from this study suggest that logistic companies that want to start a VSM analysis should first conduct a client analysis to understand their customer needs. This analysis at least should allow logistic companies to assess which activities are value adding and which not.

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THE ROLE OF LOGISTICS CENTERS AND THEIR EFFECTS ON CUSTOMERS: THE CASE OF JAPANESE MANUFACTURERS

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Abstract

For manufacturing companies, it is very important to keep due dates when delivering ordered products to customers. But it becomes difficult to bring products in time when customers are located far from manufacturers. For this reason, customer companies build their own logistics centers and keep in touch in order to maintain on-time delivery.

The purpose of this paper is to investigate the most efficient measures to keep adequate stock volumes. The company "Togo Seisakusyo" (Togo) is a Toyota parts supplier which uses the *Kanban* scheduling system. This company receives fluctuating as well as seasonal demand for motorcycle and marine jet components. In 2009, annual sales were about \304M, and there were 830 employees. The main issues at their logistics center are supply and overproduction conditions.

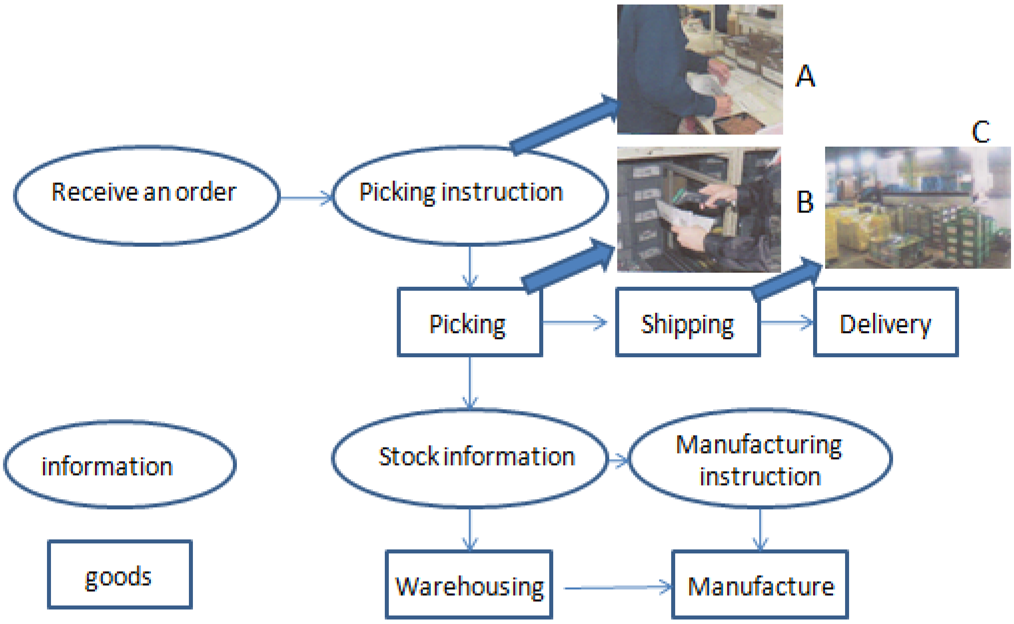
Keywords: logistics center, product inventory, inventory turnover length,

INTRODUCTION

In order to achieve an efficient SCM, companies are trying making efforts to reduce product inventories and spare parts to form good relationship between multi-storied manufacturers and sales company/ shops. According to the sales plan, the company decides on a production plan, but if the accuracy of the production plan is not good, the manufacturing department would produce too much product inventory. In estimating production, a production plan is decided by the supply lead time quantity based on the sales plan. There exist differences between actual sales quantity and planned quantity. Production planners overlook this excess or shortage of stock products, and adjust them to meet the production plan. This system is called push or MTS (make to stock) system. On the other hand, considering production planning of order-made production, it is easier for the system to be stable because makers need to produce products in sold quantities only1). This system is called pull or MTO (make to order) system. In general, companies have both types of products2).

In this study, we deal with one of the Toyota's 1st tier company, The "Togo Seisakusyo Corporation" that manufacture "metal springs and plastic fasteners" to supply automobile related companies. This company is mainly producing MTS products. Togo put their efforts to reduce safety stock, Togo adopted a leveled production policy in the use of past output data. Between 1989 and 1994, Togo developed its own in-house *Togo-Toyota Production Systems* (TTPS). At that time, the *Kanban* supply system was already in use, but in-house needs were being met from lot production, and safety stocks were also large. As a result, large numbers of finished products had to be kept in store. In-house improvements were carried out under the direction of Toyota with a view to reducing lead times. The result was that lot sizes were successfully reduced. For example, a 6 day reserve of finished hose clamp in 1997 could be reduced to a 3.8 day reserve in 2003 3).

After received an order, the goods and information flow is overviewed in Figure 1. According to the picking instruction, operators confirmed inventory, and supplements by manufacturing. *Kanban* orders are classified into picking shelves by picking instruction correctly (A), and products are picked from the shelf and after verification (B), they are shipped after checking order fulfillment (C).



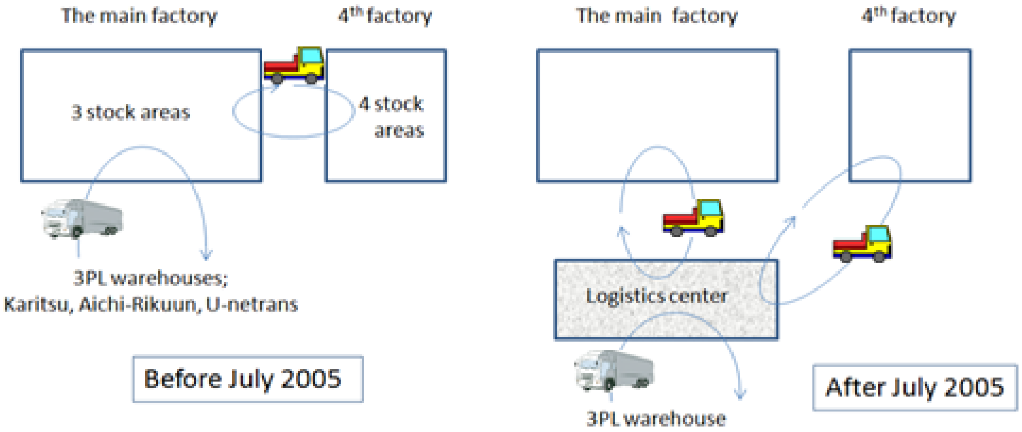
Source: Togo Seisakusyo
Figure 1 Goods and information flow overview

LOGISTICS CENTER AND ITS ROLE

For Toyota's logistics, it has two roles[4]:

(1) Inbound logistics, which is responsible for transporting parts and materials from tier 1 supplier to the OEM plants,
(2) Outbound logistics, which is responsible for the distribution of vehicles from the assembly plants to the dealers.

In this case, Togo logistics transports parts and products to 3PL warehouses of Karitsu Co., ltd., Aichi-Rikuun Co., ltd. and U-netrans Co., ltd., by Togo's trucks and after that these products are sorted according to customers with another makers' parts. 3PLs for Toyota has their warehouses near Toyota's plant. Togo also has an inbound cross-dock logistics center. The network logistics model enables Togo to operate a very efficient and effective inbound logistics operation. Figure 2 shows a Togo model of a logistics network.



Source: Togo-seisakusyo
Figure 2 Togo network logistics model

The 1st model in Figure 1 is the former logistics without a logistics center. In July 2005, Togo built a logics center to unify scattered loads around many part of the factory. Their first aim to build a logistics center is as follows5):

(1) Aim of logistics center construction
- Save production space by summing up finished products in many parts shelves.
- Reduce labor cost by summing up logistics business.
- Visualization ("Mieruka" in Japanese) of inventory management from individual to collection.
- Reduction of loading time by shipment of scheduled service.

(2) Effects of logistics center management
- Shelves can be effectively used by centralization of parts/ products stock control.
- Number of warehousing operators reduced from 45 to 40.
- Depending on the stock location, some shelf space is sometimes full but other shelf space empty.
- Shipping orders were separated into several locations, but in the logistics center, these orders were collected into one place.
- Products can be transported in one place of the logistics center, but in the former system, freights were loaded at the main factory and they were piled up at the 5th factory over again.
- Shipping places were separated from stock shelves, and operators can use these shelves by the products' location address.

Effects of the logistics center were not always suitable but also out of place as well.

These demerits were as follows:
- Transportation between the main factory and logistics center, as well as the 5th factory, was increased. Because of this, the company newly bought two trucks to ply between a logistics center and factories.

REDUCE INVENTORY TURNOVER LENGTH

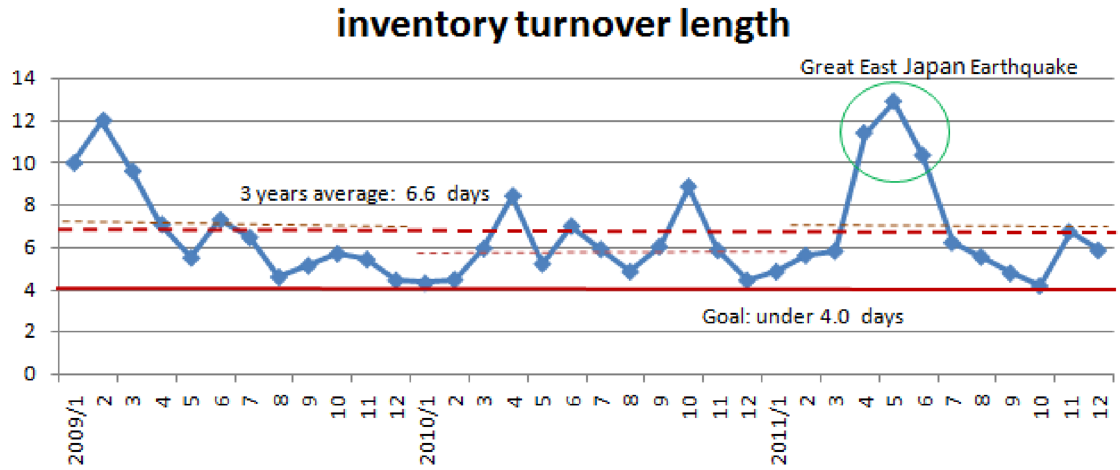
The objective of the firm is to manage inventory so as to reduce systemwide cost. So it is important to consider the interaction of the various facilities and the impact this interaction has on the inventory policy that should be employed by each facility. For this purpose, consider a retail distribution system with a single warehouse serving a number of retailers (in our case, the final assembly maker in general).

An inventory policy based on the so-called *echelon inventory* is an effective way to manage the system. The echelon inventory at the warehouse is equal to the inventory at the warehouse, plus those items ordered by the warehouse that have not yet arrived minus all items that are backordered6).

In order to reduce inventory levels, the inventory turnover ratio was discussed and defined as follows:

$$\text{Inventory turnover length} = \frac{\text{The first day's stock}}{\text{The amount of the first day's shipping}}$$

According to the survey report7) including David, S. L., the turnover ratio in 2001 provided for different manufacturers between 10 and 3, but the parts manufacturers wasn't included. In figure 3, we can see the recent efforts in time series of the company's inventory turnover data at a monthly basis. To exclude the Great East Japan Earthquake during April to July of 2011, the data approached to the goal of 4.0 days.



Source: Togo Seisakusyo
Figure 3 Companywide inventory turnover length

Recently a number of cars lineup rises to about 2 or 3 items. Nevertheless, the number of shelves doesn’t increase at the logistics center. The company is challenging to hold smaller stocks than before.

CONCLUSION

In our case study, we discussed the effectiveness of the logistics center and its evaluation by inventory turnover length. The company reduced the value one by one, and it came to be controlled less than 4 days. Togo’s products are basically manufactured by lot production. Owing to the Great East Japan Earthquake in the last year, companies became aware of being out of stock in Toyota production system or supply chain management. Such risks are captured by inventory issues, but the company decides to decrease its products inventory. Construction of the logistics center has had a great effect on the company, but it is more difficult for managing the **r**eduction of the amount of products inventory.

Acknowledgement

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THE BATTLE FOR THE SEA IS WON INLAND
DRY PORTS AS THE MEANS OF COMPETITION BETWEEN THE SEAPORTS IN NEW ZEALAND

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ABSTRACT

Purpose

A dry port - intermodal terminal with direct rail connection to a seaport - is a potential solution for seaport terminal congestion as well as for better seaport inland access. Competition requires seaports to focus on transport links, on the demand for services in its traditional hinterland and also on development in areas outside their immediate market. The purpose of this paper is to investigate if the implementation of dry ports contributed to competitive advantage of seaports in New Zealand.

Research approach

Data for the case studies on ports of Tauranga and Auckland and their existing intermodal facilities was collected through face-to-face interviews; literature reviews have been carried out in order to accomplish the purpose. In addition, a number of secondary sources were used, such as reports and internal documents.

Findings and originality

The results show that implementation of a dry port brings a competitive advantage to a seaport since it expands the seaport's hinterland, i.e., it improves the seaport's access to areas outside its traditional hinterland by offering shippers low-cost and/or high-quality services. Furthermore, the study identified market-driven Outside-In development of inland intermodal terminals (dry ports) that generates higher level of integration with the seaports. The same is very likely contributing to viability of rail on short distances.

Practical impact

The paper highlights the important role dry ports might play to increase the competitive advantage for the seaports.

Research impact

Seaports expand their hinterland through close links with inland terminals based on a higher level of functional integration that usually results in economically viable short haul rail. Both cases in the study show viability of rail on short distances although the same is heavily argued by the academics; an as such the study opens new area for research.

Keywords: Intermodal terminal, Dry port, Seaports, Competition, New Zealand

INTRODUCTION

As estimated by OECD, container volumes could quadruple by 2030, with the largest throughput rises in China, followed by the US and India; and with today's infrastructure that could hardly handle a 50% increase, let alone doubling or tripling, additional capacity will be required (WCN, 2011). However, capacity increase only at seaport facilities without improvements in seaports' inland access is not enough for the entire container transport chain to function properly. Intermodal (road and rail) transport through dry ports as advanced intermodal terminals would play a key role in enabling the most appropriate mode of transport to be used for different legs of the container transport chain (Roso et al., 2009). With constantly growing container transports, efficiency of rail and flexibility of road are increasingly needed for inland access to/from the seaports (Frémont and Franc, 2011). Slack (1990) discusses the importance the development of inland terminals has on intermodal transportation; in his later research (1999) he emphasizes the inland terminal's role in reducing environmental effects and harmonizing flows as satellite terminals. Transport terminals are of importance not only for the transportation research field, but they are also at the very centre of critical issues in economic, political, urban, and other geographic subfields (Goetz and Rodrigue, 1999). Viability of intermodal transport on long distances is argued by many academics; for example van Klink and van den Berg (1998) state that seaports can generate scale economies to operate cost effective intermodal transport with high frequency to different destinations long distances beyond their traditional hinterland. Furthermore, the authors claim that seaports as gateways stimulate intermodal transport. Frémont and Franc (2011) elaborate that intermodal transport on a short distance of 200 km can be competitive when intermodal operators collaborate and consequently offer prices that are lower than only road transport. Competition requires seaports to focus on transport links, on the demand for services in its traditional hinterland and also on development in areas outside their immediate market. The purpose of this paper is to investigate if the implementation of advanced intermodal inland terminal (dry ports) contributed to competitive advantage of the studied seaports in New Zealand.

The case studies have been done on ports of Tauranga and Auckland and their inland intermodal terminals with dry port characteristics-metropolitan intermodal terminals as they are referred to. Data for the cases has been collected primarily through face-to-face interviews and literature reviews, combined with site visits. In addition, a number of secondary sources were used, such as reports and internal documents.

The paper starts with a brief literature review on intermodal transport and seaports' hinterland access followed by a description of the dry port concept. The two seaports and their inland intermodal terminals (dry ports) are described and then analysed with a focus on what role those dry ports play in competition between the ports. Finally, from the analysis the conclusion is made as well as suggestions for further research.

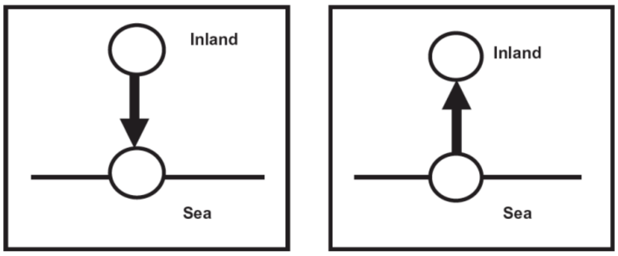
FRAME OF REFERENCE

Lack of space at seaport terminals and/or growing congestion on the access routes serving the seaport terminals are the problems seaports face today. Seaport efficiency is threatened by increased bottlenecks in the landside transportation system serving the seaports. For some seaports the weakest link in their transportation chain is their back door, where congested roads or inadequate rail connections cause delays and raise transportation costs. The strategic decision would be the implementation of rail or improved inland intermodal terminals serving seaports.

van Klink and van den Berg (1998) define hinterland as those places that can be served by the port cheaper than from other ports belong to the port's hinterland. In practice, however, direct monetary costs do not determine the competitiveness of the port towards a certain inland market only; costs related to risks and time should also be considered. As elaborated by van Klink and van den Berg (1998) and McCalla (1999), seaports can generate scale economies to operate cost effective intermodal transport with high frequency to different destinations beyond their traditional hinterland; i.e., to use rail to enlarge their hinterland and at the same time to stimulate intermodal transport. The individual seaports try to attract as much flow as is economically feasible and the size and shape of a seaport's hinterland is not statically or legally determined but varies dynamically due to developments in technology, economy, and society.

De Langen and Chouly (2004) define captive or primary and contestable or secondary hinterlands; primary hinterland is the area where the port is well established and secondary hinterland, with rivalry among ports all regions where one port has a substantial competitive advantage because of lower generalized transport costs to these regions belong to the captive hinterland of this port. The concept of hinterland changes constantly and it is generally accepted today that serving seaport hinterlands is more competitive than before containerisation and intermodality (McCala, 1999). There is a strong interdependency between a seaport's foreland and hinterland, which is particularly apparent in intermodal transportation. Seaports are not competing only with seaports in their local area but also with distant seaports attempting to serve the same hinterland (Heaver et al, 2001; and Notteboom and Rodrigue, 2005).

Today many seaports, as well as shipping lines, integrate vertically to control hinterland transport (see e.g. Wilmsmeier et al, 2011; Notteboom, 2006; and van Klink and van den Berg, 1998). With an increasing level of functional integration, many intermediate steps in the transport chain have been removed. However, the vertical integration must be done cautiously and must respect anti-trust legislation. Wilmsmeier et al (2011) distinguish between two concepts of vertical control of the development process of inland terminal facilities; Inside-Out and Outside-In (Figure 1). In Inside-Out arrangement inland intermodal terminals seek greater integration with their seaports, often driven by public body intervention. Outside-In development is displayed by the conscious use of an inland node as a tool for seaport actors (whether port authorities or terminal operators) to expand their hinterland and capture discretionary cargo (ibid).



(a) Inside-Out (b) Outside-In

Figure 1 Two directions of development (Wilmsmeier et al, 2011)

The increasing container transport volumes handled in seaports requiring efficient inland transport has resulted in some port terminal operators getting involved in developing dry ports (Roso, 2007, 2008; and Ng and Gujar, 2009), sometimes also referred to as extended gates (Rodrigue and Notteboom, 2009). A dry port may be defined as an inland intermodal terminal that has a direct rail connection to a seaport, where customers can leave and/or collect their goods in intermodal loading units, as if directly to the seaport (Roso et al., 2009). Services such as transhipment, storage, consolidation, depot, track and trace, maintenance of containers, and customs clearance are available at dry ports. The basic idea behind the concept of dry port is the shift of flows from road to direct rail resulting in reduction of road transports to/from the seaport once a dry port is implemented in the transport system (Figure 2).

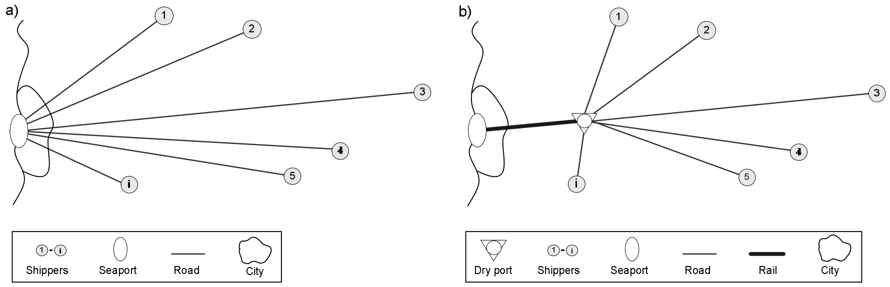


Figure 2 Basic idea behind the concept: seaport's inland access a) without a dry port and b) with a dry port (Roso, 2007)

The quality of access to a dry port and the quality of the road–rail interface determines the dry port's performance. However, the quality of inland access depends on the behaviour of a large variety of actors, such as terminal operators, freight forwarders, transport operators, and port authorities (de Langen, 2004). Scheduled and reliable high-capacity transportation to and from the seaport is the prerequisite. Implementation of a close dry port in a seaport's immediate hinterland increases the seaport's terminal capacity and with it comes the potential to increase productivity since bigger container ships will be able to call at the seaport. With dry port implementation, the seaport's congestion from numerous lorries is avoided because one train can substitute some 35 lorries in Europe (Roso, 2007). With a reduced number of lorries on the roads congestion, accidents, road maintenance costs and local pollution are reduced as well.

Full implementation of a dry port could create a seamless series of physical and procedural links to provide a smooth flow of containers, i.e., smooth transport flow with one interface in the form of a dry port concept instead of two, one at the seaport and the other one at the inland destination (**Error! Reference source not found.**Figure 3). The concept can be compared to the case of an increased level of functional integration of supply chains (Notteboom, 2006), where many intermediate steps in the transport chain have been removed and therefore enabled a so-called one-stop-shop, creating a single contact point. Thus the dry ports are supported by a higher level of integration with seaports than conventional inland terminals. The closer the dry port the higher the degree of synchronization between the port and the dry port (Rodrigue and Notteboom, 2009).

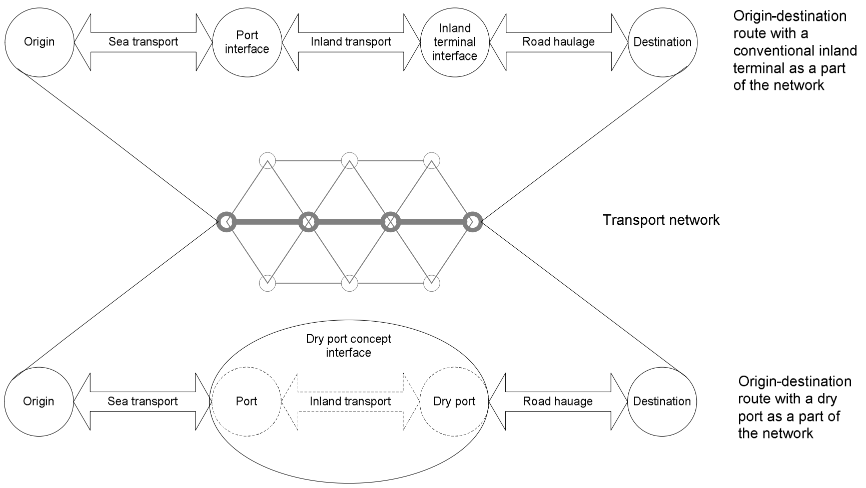


Figure 3 Transport network with and without a dry port (Roso and Rosa, 2012)

A dry port may also serve as a depot, empty containers storage. The benefits from distant dry ports derive from the modal shift from road to rail, resulting in reduced congestion at the seaport gates and its surroundings as well as reduced external environmental effects along the route (Roso et al, 2009). The distant dry port extends the gates of the seaport inland, with shippers viewing the dry port as an interface to the seaport and shipping lines (Roso, 2008; and Wilmsmeier et al, 2011). The implementation of the dry port is not the only factor in relieving seaport congestion or improving seaport inland access; however, it is a significant component in improving seaport productivity. With dry port implementation CO2 emissions should decrease, congestion at seaport terminals and seaport city roads should be avoided, and the risk of road accidents reduced (Roso, 2007). Besides the general benefits to the environment and the quality of life by shifting flows from road to rail, the dry port concept mainly offers seaports a possibility to increase the throughput without physical expansion at the site. Moreover, the dry port contributes to the development of rural areas once implemented in the area as discussed by Höltgen (1995) and Bergqvist (2008), where the authors emphasise the role intermodal terminals have in the promotion of regional development. The regional development is identified through the attraction of new industries to the area, once logistic solutions are available.

THE CASES

Port of Tauranga and MetroPort

Port of Tauranga emerged in the 1950s servicing log export industry and locally produced diary products and fruit. Today, it is New Zealand’s largest port, handling more than 15 million tones of imports and exports annually. The port handled 590 506 TEU in 2011, which is 15% increase from the previous year and now container traffic represents 40.5% of total trade through Tauranga (Port of Tauranga, 2011). With increasing volumes the port has plans to expand not only at inland side but also the port’s side by extending the quay and deepening the channel. The ability to grow to meet customer demands is the key strength of the port.

MetroPort, container-handling facility owned by Port of Tauranga and operated by KiwiRail, handled 138,000 TEU in 2011, which is 20% more from the previous year (Port of Tauranga, 2011). MetroPort started to operate in 1999 with the goal to become integrated intermodal cargo gateway facilitating supply chain efficiency. The facility is a customs bonded area and licensed Ministry of Agriculture and Forestry site, offering services such as empty container storage at MetroBox, storage for refrigerated containers (60 reefer points) and truck and tracing. Rail connection between the terminal facility and the port is provided by KiwiRail as a daily shuttles with fixed schedules. The facility is situated in the heart of Auckland’s industrial, warehousing and distribution area; 220 km from the port. The facility is well functioning greatly due to the advanced IT system used both at the inland facility and the port, allowing efficient rail transport planning, efficient loading/unloading activities as well as short truck turnaround times.

Ports of Auckland and WIRI freight hub

Auckland seaport is New Zealand's largest container port, handling more than 867,000 TEU per year (Ports of Auckland, 2011). In 2010, the seaport handled cargo in the equivalent to 13% of the country's total GDP (Ports of Auckland, 2011). With Auckland region having the dominance in New Zealand, the consequence is road traffic congestion which is considered as a national problem. The port is working on improvements in all areas, recently a new online cargo management system has been launched enabling registered users to order the full range of container services via Ports of Auckland website.

The Wiri Freight Hub, a fully secured 15 ha depot in South Auckland, 25 km from the seaport, close to the major freight routes and in the proximity of manufacturing and warehousing, offers flexibility to its customers. Initially, in 2005, the facility was built to relive the seaport from empty containers and improve the capacity using a truck based shuttle service to the seaport. Nowadays, with its rail link to the seaport, jointly funded by KiwiRail and Ports of Auckland, it is a strategic move to increase competitive advantage as well! Cargo owners are able to leave or collect their units at the facility instead of trucking them through congested central Auckland to reach the seaport. The facility, operated by CONLINXX, Ports of Auckland subsidiary, will be able to offer customs clearance, storage, maintenance, agricultures and food inspections. It is estimated that, once fully operational, the freight hub will save an estimated 100 000 city truck movements per year, resulting in lower congestion and environmental effect. Most of the customers are located within 10 km from the Wiri are importers, by using the rail instead of road for transport to the seaport, CO2 could be reduced by 25%. The ambition is to increase the volumes on the rail and to get more balanced flow.

ANALYSIS

In general seaports are not getting involved in the development of their hinterland connections, i.e. inland access, unless threatened by competition or congestion. New Zealand ports' cases where, in a way, no exception from this rule!

A few years ago, the Port of Tauranga had no issues with either congestion or competition; with no other port in the vicinity to compete with and low volumes handled, the port had to find a way to endure. With the throughput of more than 500,000 TEU in 2010, compared to only 100,000 TEU in 1999, the seaport gained a competitive advantage by establishing a direct rail access to MetroPort in the Auckland area. MetroPort handles about 40% of the port's containers and the direct rail runs three times a day to/from the port with future plans to increase the number of shuttles per day. The success of the terminal depends greatly on the IT system that significantly facilitates coordination of arriving and departing units, making the turnaround of cargo very efficient. Nowadays, thanks to this well functioning inland port, the Port of Tauranga is the main competitor to the Port of Auckland!

The Port of Auckland, with the throughput of almost 900 000 TEU in 2010, was firstly more threatened by its central location and due to that congestion, than came competition. Being centrally located, literally on the waterfront of the city centre, the port was seen as a hurdle by the community, i.e., as an obstacle between the city and the sea. The community seems to forget that if there was no port there would be no city and certainly no community. Urban growth has put pressure on the city's infrastructure and this same community has demands for transport which naturally goes through the port. The community wants shops full of goods but does not want to see the traffic. Still, one has to go with the other and therefore the port tries to explain to the community its contribution to the city and the region as well. Regarding environmental improvements the port is working on noise reduction since a large portion of goods is transported by trucks through the downtown area. One way to solve the truck related problems is movement of goods from road to rail and the port has done that recently by developing their inland intermodal terminal, Wiri, in the south of Auckland, into a dry port with all necessary services. However, the other reason for the development of Wiri is strong competition with Tauranga's MetroPort – inland terminal in the same area; that has taken over a great portion of the Port of Auckland's volume. MetroPort was functioning so well that the biggest customers to Auckland Port have moved to Port of Tauranga. Good inland access has made Tauranga more attractive also on the sea side and new shipping companies started to call at the port.

The direction of development, whether Inside-Out or Outside-In, depends on the existence of policies promoting proactive behaviour (Wilmsmeier et al, 2011). In the both studied cases the inland intermodal facilities have been developed by the belonging port authorities/port terminal operators, so called Outside-In arrangement as explained by Wilmsmeier et al (2011). Either as action or reaction to the competition, both seaports are vertically integrating inland through their inland terminals in order to expand or secure their hinterland, case of MetroPort and case of Wiri respectively. This high level of integration with a seaport is what distinguishes dry ports from conventional intermodal terminals. In this Outside-In arrangement all actors in the transport chain have the same goal and there is no fear of competition between them. Dry ports are to some extent extensions of seaports inland and as such are part of the process of regionalization of seaports characterized by Notteboom and Rodrigue (2005). In that process, and due to the importance of inland distribution, seaports expand their hinterland through a number of strategies including close links with inland terminals based on a higher level of functional integration that usually results in functional short haul rail.

Port of Tauranga is a good example of a seaport competing with a distant seaport attempting to serve the same hinterland, forcing the competing seaport to act by implementation of a dry port in its natural/immediate hinterland. Apart from increasing its competitive advantage by reaching deeper into the hinterland, Port of Tauranga with MetroPort, has provided efficient customer service at inland facilities. By using MetroPort shippers could save time and money by bypassing congested Auckland's roads which also created smooth intermodal transport chain. Port of Auckland is reacting to this by creating a dry port like facility at Wiri with extra value added service in order to offer better customer services and attract new customers.

Inland terminals fit within development cycles where various actors intervene for their siting, design, establishment, expansion, maturity and even to mitigate their eventual decline (Rodrigue et al, 2010). Another dimension of this cyclic behavior concerns competition as a successful commercial idea often leads to many imitators and attempts at differentiation (ibid). Competition from other inland terminals can substantially change their business model and with changing hinterland the viability of certain inland terminals can be questioned, as was the case with Wiri. However, all the improvements, whether on seaport terminals or inland access, usually result in increased capacity and the potential for increase productivity so that bigger container ships may call at the port. Bigger container ships have higher fuel efficiency and lower operating costs which increases the competitiveness of the exporters and provides lower freight costs for importers. All together affecting the companies' port choice.

CONCLUSION

Although the Ports of Auckland has received substantial financial support, which was largely spent on equipment improvement, such as on large quay cranes and straddle carriers, it still under-performs (WCN, 2011). The Ports of Auckland estimated crane productivity is 19.9 moves per hour compared to 31.8 at Port of Tauranga (ibid). Improvements only at seaport terminals are not enough for the success of the entire transport chain; nor do those improvements solely attract new volumes. Therefore functional inland access to seaports is becoming an important decision making factor in the development strategies of seaports; as well as a significant factor that affects shipping companies' port choice. A seaport's natural or immediate hinterland is no longer defined only by geographical distance but by competition with other seaports, i.e. by the quality of the service at the seaport terminals as well as at their inland facilities. Simply, the battle for the sea is won inland!

Both studied cases identified market-driven Outside-In development of their inland intermodal facilities with the aim to increase market share. Furthermore, the results showed that rail could be viable on short distance, likely due to this Outside-In development that generates higher level of integration between the seaports and their inland intermodal facilities – dry ports. The ultimate goal of cooperation strategies such as this is to decrease costs and that might be crucial for short haul rail. However, viability of rail on short distances is very market dependent; there is a hardly one system configuration suitable for all. Or, maybe, there is?!

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FROM CHEAP LABOUR TO LOGISTICS COMPETENCY: THE NEXT MOVE FOR CHINA?

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ABSTRACT

Through a comprehensive desktop research reviewing the relevant literature and analyzing secondary data, this paper reports the current status of logistics competency in China in comparison with that of developed countries and identifying the challenges and the obstacles the industry is facing. The findings show that although logistics expenditure in China increased significantly in the last decade as a result of rapid economic growth, this expenditure is unnecessarily high (up to 18% of Gross Domestic Product (GDP) which is twice that of most developed countries) suggesting the presence of operational inefficiencies. Fragmented markets, transportation bottlenecks, regulatory constraints, and local barriers to entry are some of the major obstacles hindering the development of an efficient logistic industry leading to a continuous rise in logistics cost. Possible measures to enhance logistics competency include investment in logistics infrastructure and technologies, regulatory reform to open up market and to quicken logistics development at national level, promotion of third-party logistics (3PL), and cross-organizational as well as industry-government collaboration to standardize industry practices and provide logistics information sharing platform.

INTRODUCTION

Increasing labour cost has emerged as a major challenge to continuous economic development of China in recent years. In 2010, massive strikes organized by workers of foreign companies in China such as Foxconn and Honda quickly made international headlines (Reuters, 2010; Yew, 2010). These industrial actions finally developed into a nationwide demand for higher wage and better welfare for workers. In the end, manufacturers were obliged to raise the minimum wage by a large amount. Soaring worker wage has resulted in significant labour shortage to many firms particularly the small and medium-sized manufacturers, which are not able to offer salary packages as attractive as that of the big corporations. Attaining and retaining skilled workers is now the biggest concern of the manufacturing industry due to competition. Berthelsen (2010) reports that labour wages in China have increased by an average of 25 per cent a year in more than 20 regions and areas. This has made labour cost in the country much higher than before and that of its Asian neighbours. Although on average Chinese workers are still earning less than US$1 per hour, such an income is still a lot higher than that of their counterparts in other developing countries such as Vietnam in which the average monthly salary of a worker is only about US$50 (Bradsher, 2008). As such, outsourcing or off-shoring to China to reduce production cost by hiring cheap labour is no longer attractive to many foreign investors. The obvious wage difference has prompted multinational corporations to shift part of their production capacity from China to nearby countries such as Vietnam, India, and Indonesia to take advantage of the low labour cost there. It can be seen that increasing production cost has posed a considerable challenge or even a threat to further expansion of the Chinese economy, which is very much dependent on manufacturing. Apparently for China, the days of using cheap labour as a competitive edge are numbered. To maintain its leading position as a global manufacturing base, China needs to explore other avenues to improve its competitiveness so as to retain the foreign investors. While there is little scope for China to continue to compete in labour cost in view of the current soaring wage, there is a large scope for efficiency enhancement in logistics operations particularly when the logistics industry in China is currently still underdeveloped. As such, many scholars and government officials have shifted their focus on logistics competency as a new competitive edge for China, believing that it could be the next major source of cost reduction for the manufacturing industry.

The purpose of this research is to explore the possibility of leveraging logistics competency to reduce total production cost so as to negate the effect of soaring labour cost in China. Zeng and Rossetti (2003) point out that logistics procedure is part of the critical loop of order-to-cash process. Logistics expenditure forms a large portion of the total production cost which is incurred in logistics activities such as transportation, warehousing, inventory holding, packaging, customer service and administration. It is also affected by the proficiency of logistics managers, business culture, and government policy (Ruamsook, 2009; Song & Wang, 2009). Therefore, to reduce logistics expenditure will involve not only optimization of logistics processes and activities but also strategic fit and alignment, cross-organizational collaboration, as well as industry-government cooperation. While firm-based optimization endeavour may help individual company to cut cost, industry-government joint effort can allow the entire manufacturing industry to benefit from enhanced efficiency in the long run, thereby maintaining China's competitive position as a global manufacturing base.

This paper is structured as follows: First, a literature review is given on the benefits that logistics competency can bring to a firm and the whole supply chain. The various elements of logistics competency and how they contribute to superior firm performance are also examined. Then, the methodology of the study, which is primarily a desktop research with secondary data, is discussed. After that, the findings of the analysis are presented. The current status of logistics competency in China is reported in comparison with developed countries such as the US. The causes for the gaps in performance are analysed followed by a thorough discussion on the implications. Finally, limitation of the study is discussed and directions for further research are also suggested.

LITERATURE REVIEW

Competency is generally regarded as the ability or capability to perform or act. Porter (1979) uses the term "distinctive competence" to refer to the capability of a firm to generate customer satisfaction hence competitive advantage that differentiates it from its competitors. The term competence is also defined by Dosi and Teece (1998) as a bundle of skills, assets, and organization activities to be synchronized to achieve winner position for businesses. In short, from a resource-based perspective, competence is a unique and valuable ability for organizations to obtain competitive advantage (Barney, 1991; Collis, 1994; Day, 1994; Grant, 1991; Wernerfelt, 1984).

Logistics competence has been widely investigated in previous logistics research. Many studies drew the conclusion that logistics competences underlie competitive advantage pertaining to strengthening customer service and firm performance (Esper *et al*., 2007; Mentzer *et al*., 2001; Defee & Fugate, 2010; Prajogo & Oihager, 2012). For example, Zhao *et al*. (2001) contend that customer-focused and information technology-focused logistics capabilities strengthen firm performance significantly. Tracey (1998) also opines that logistics practices have a positive effect on firm performance when implemented in a manner contributing to customer satisfaction. Table 1 summarizes the benefits that logistics competency can bring to a firm and the whole supply chain. It can be seen that logistics competency enhances firm performance mainly through slumped cost and maximized revenue.

Table 1 Benefits of logistics competency

Dimension	Benefit	Studies
Higher customer satisfaction	Customer focused practices with enhanced flexibility	Chen & Wu (2005); Zhang, Vonderembse & Lim (2005)
	Differentiated and value-added customer services through different supply solutions	Bowersox & Daugherty (1992); Lynch & Keller (2000)
	Better service quality	Han, Trienekens & Omta (2009)
Better firm performance	Enhanced profitability through improved marketing performance supported by logistics	Everaert *et al*. (2008); Green, Whitten & Inman (2008)
	Greater internal integration between logistics and marketing functions	Birou, Germain & Christensen (2011); Sezen (2005)
	Expedited IT advancement to meet logistics needs	Savitskie (2007)
	Cost reduction through removal of inefficiencies and wastes in the supply chain which may include: ▪ reduced redundancies; ▪ dropped inventory; ▪ lower warehousing costs; ▪ lower transportation costs; and ▪ increased productivity.	Closs, Goldsby & Clinton (1997); Randall, Nowicki & Hawkins (2011); Stainer (1997); Song & Wang (2009); Wang (2010); Wang & Chen (2009); Wu (2002)

As regards the factors contributing to logistics competency, Morash (2001) advocates that they can be analysed from two major perspectives including customer closeness and operational excellence. Customer closeness demands capabilities including flexibility, value-added customer service, and responsiveness. Operational excellence is supported by competences such as low logistics cost, speed, standardization, availability and dependability. From an operational efficiency development point of view, Esper *et al*. (2007) divide logistics capabilities into five areas: supply management, customer focus, integration, information exchange and measurement. In this research, logistics competences are grouped into managerial, operational and technological dimensions with multiple underlying elements to facilitate identification of challenges and corresponding improvement measures. Table 2 summarizes the classification.

Table 2 Elements of logistics competency

Dimension	Element	Studies
Managerial	Corporate culture	Ambroz (2004); Booth & Hamer (2009); Tseng (2010)
	Strategic management	Sandberg (2007); Tan, Lyman & Wisner (2002), Sum, Teo & Ng (2001)
	Human resource management	Gibson & Cook (2001); Lieb & Randall (1996); Santos (2000)
	Integration	Bowersox, Closs, & Stank (2003); Stank, Davis & Fugate (2005)
	Collaboration	Kahn, Maltz & Mentzer (2006); Matopoulos *et al*. (2007); Sandberg (2007)
	Learning	Defee & Fugate (2010); Halldorsson & Skjott-Larsen (2004)
	Quanxi or relationship	Chen *et al*. (2010); Jiang & Prater (2002)
Operational	Flexibility	Kumar *et al*. (2006); Kumar, Shankar & Yadav (2008); Stevenson & Spring (2007)
	Responsiveness	Catalan & Kotzob (2003); Stank, Daugherty & Ellinger (1996); Willis (1998)
	Reliability	Defee & Fugate (2010); Forslund (2007a); Tofen & Rustad (2005)
	Availability	Christopher & Towill (2000); Corsten & Gruen (2003); Grant & Fernie (2008)
	Timeliness	Mason-Johns & Towill (1998); Varila, Seppanen & Suomala (2007); Wilding & Newton (1996)
	Cost reduction	Fawcett, Calantone & Roath (2000); Keebler & Plank (2009); Wu (2002)
	Customization	Jitpaiboon, Dangol & Walters (2009), Liao *et al*. (2011); Stank & Lackey Jr. (1997); Wang & Lalwani (2007)
	Quality	Forslund (2007b); Hsu *et al*.(2010); Juga, Juntunen & Grant (2010); Kersten & Koch (2010)
	Convenience	Hsu *et al*. (2010)
Technological	Innovation	Busse & Wallenburg (2011); Chapman, Soosay & Kandampully (2002); Grawe (2009); Richey, Genchev & Daugherty (2005)
	Standardization	Aronsson and Brodin (2006); Mollenkopf & Dapiran (2005); Morash (2001)
	Information sharing	Fawcett *et al*. (2007); Hsu *et al*. (2008); Li *et al*. (2005); Tai & Ho (2010)
	Information technology	Closs & Savitskie (2003); Hammant (1995)
	Logistics infrastructure	Goh & Ling (2003); Jiang & Cheng (2009); Vijayaraghavan (2001)

In general, the relationship between logistics competency and competitive advantage can be depicted as shown in Figure 1. Each of the elements generates a positive impact on logistics competency in terms of higher efficiency and effectiveness, greater responsiveness, flexibility and reliability, as well as improved quality and availability to customers. Strengthened logistics competency enhances customer satisfaction and improves firm performance, which in turn provides a competitive advantage for the company. The concept can be easily extended to cover the entire manufacturing sector as logistics competency for the industry can be improved through cross-organizational collaboration and industry-government cooperation.

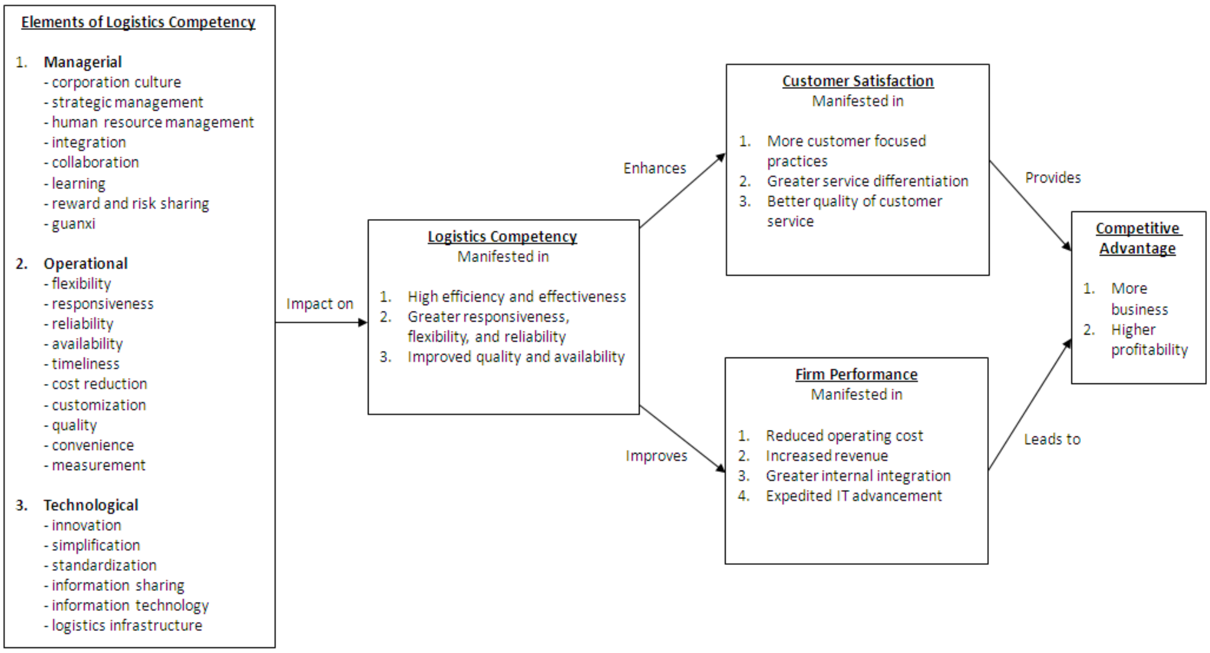


Figure 1 Relationship between logistics competency and competitive advantage

METHODOLOGY

This study uses a desktop research to review the literature comprehensively on the current status of logistics competency of China in comparison with that of developed countries such as the US, Europe, and Japan. Desktop research, which is similar to the case study method, is appropriately for preliminary exploration of a problem which is not yet clearly defined or fully understood. It provides the required flexibility for investigation when a "how" or "why" question is being asked about a phenomenon (Yin, 1994). To provide a preliminary in-depth investigation of a problem, the approach is also considered suitable for studying issue on which relatively little research has been conducted (Benbasat et al., 1987; Walsham, 1995). This approach is often used in exploratory studies in logistics and supply chain management research (see for example Goh & Ling, 2003; Sachan & Datta, 2005; Simatupang & Sridharan, 2008).

To obtain a holistic picture of the current logistics competency on China, secondary data published by the government and non-profit making industrial organizations, such as the China Federation of Logistics and Purchasing (CFLP) and the Council of Supply Chain Management Professionals (CSCMP) in the US, as well as consultancy firms, such as KPMG International and Li & Fung Research Centre under the Li & Fung Group, were used for analysis. The findings of the investigation and the causes for the gaps in logistics performances between China and the developed countries were investigated. Possible improvement measures to close the gaps are also explored and discussed in the following section.

FINDINGS AND DISCUSSION

With the accession of China to the World Trade Organization in 2001, China opened its market to foreign investment and became the world's largest manufacturing base for the developed countries because of its cheap labour supply. China's GDP experienced a double-digit growth annually in the last decade (Knoema 2012). The rapid expansion of the industrial sector and the rise of the domestic consumer markets as a result of the new affluence have stimulated the growth of the logistics industry. According to the figures published by China's National Development and Reform Commission (NDRC), China Federation of Logistics and Purchasing (CFLP), and National Bureau of Statistics of China (NBSC), the logistics market has grown annually by an average of 17.3% over the five-year period from 2006 to 2010 with a total value of RMB2,100 billion in 2010. This represents a share of 6.8% of the GDP on average (see Table 3). Given the current stage of China's economic development which is mainly based on manufacturing and increased consumption, the majority of business for the logistic companies in China comes from the movement of industrial products (90.2% of total value of goods moved in 2010) and imported products (7.5%). However, expenditure on logistics services, which include transport (54% of total cost in 2010), storage (34%), and management function (12%), amounted to RMB7,100 (or USD1,050) billion in 2010 which is equivalent to 17.8% of the GDP (compared to USD1,211 billion and 8.3% in the US according to CSCMP's 22nd Annual State of Logistics Report). The big discrepancy in the total value of the logistics industry and the logistics expenditure indicates that a significant amount of logistics activities were conducted in-house. Based on NDRC's survey, the logistics outsourcing rate of the industrial and commercial enterprises in China is just over 60% (2009 figure) whereas in the US this figure has already exceeded 80% in 2004 (Li & Fung Research Centre, 2011). The majority of the services outsourced are traditional functions such as transportation, distribution, and warehousing. This implies that the 3PL industry in China is still not fully developed and there is scope for consolidation hence greater operational efficiency.

The high logistics expenditure to GDP ratio reflects another problem. Although this percentage has decreased gradually from 18.8 in 2004, it is still twice the percentage of most developed nations. The figure implies significant operational inefficiencies and suggests that the efficiency of China's logistics industry should have much room for improvement. In fact, according to the study of World Bank (2010), China is ranked 27th in logistics performance in 2010 among the 155 economies assessed. It is far behind developed countries such as Germany (1st), Singapore (2nd), Japan (7th), and the US (15th). Table 4 shows a comparison of logistics expenditure as a percentage of GDP in 2007-2008 among selected countries.

Table 3 Logistics industry of China

Year	Total value-added (RMB billion)	Annual growth	Share in GDP
2006	1,412	15.1%	6.7%
2007	1,793	27.0%	6.7%
2008	2,153	20.0%	6.8%
2009	2,310	7.3%	6.9%
2010	2,700	16.9%	6.9%

Source: CFLP

Table 4 Logistics cost to GDP, 2007-08

Country	Logistics cost as a % of GDP
EU	8.2%
US	9.4%
Japan	11.0%
India	13.0%
China	18.1%
Vietnam	25.0%

Source: KPMG, 2010

Albeit that fact that the importance of logistics development in China is well acknowledged by the business sector, government, multinational companies, as well as domestic and foreign service providers, the logistics industry is widely regarded as immature (Byrne, 2006). There are many hurdles to overcome in order to develop a nation-wide efficient logistics systems to match the fast pace of economic progress (Kerr, 2004; Trunick, 2007). Previous studies have identified certain logistics obstacles and challenges in the Chinese market. According to research carried out by Jiang and Prater (2002), Jiang (2002), Kerr (2004), and Trunick (2007), inadequate physical infrastructure, fragmented distribution system, in-house mindset and regional protectionism are the major barriers to limiting competitiveness of the Chinese logistics market. Unavailability or inadequate capacity of interstate highway, railway and port facilities have resulted in transportation bottlenecks. Lack of consolidation in distribution system has led to inefficiency and high distribution cost. Many state-owned businesses handle their own transportation as an in-house function. Outsourcing to 3PL providers is limited. The logistics market is highly fragmented in terms of the number of operators and their geographical remit. Most state-owned transport companies still only operate in their immediate regions and have little incentive to develop more comprehensive regional networks (KPMG, 2008). Even though there are more than 18,000 logistics companies in the country, nation-wide distribution service is currently not being offered by any logistics service provider as no firm has occupied more than 2% of the market share (Jahns, 2007; Byrne, 2006). Obviously, improved coordination at the national level between transportation, storage and inventory control will help operators achieve greater efficiency hence competitive advantage. Tables 5 and 6 show the comparison of logistics cost and infrastructure between China and the US. It can be seen that logistics management takes up a much larger share in the total logistics cost in China than the US suggesting that this is a major area for improvement. The infrastructure figures also show that while China has exceeded the US in the total length of expressways, it is still far behind in development of the railway network. The significant amount of investment in fixed assets (of which 75% is in transportation) in 2010 by the Chinese government also reveals its acknowledgement of and concern for the presence of transportation bottlenecks in the country, particularly in the middle and the western part, which is one of the major causes of logistics inefficiency.

Table 5 Comparison of logistics cost

Year 2010	China	US
GDP (trillion)	USD5.9	USD14.5
Logistics cost (trillion)	USD1.1	USD1.2
Logistics cost / GDP	17.8%	8.3%
Share in logistics cost		
Transportation	54.0%	62.7%
Inventory	33.9%	32.7%
Management	12.1%	4.6%

Sources: NBS, CFLP, CSCMP, Wikipedia

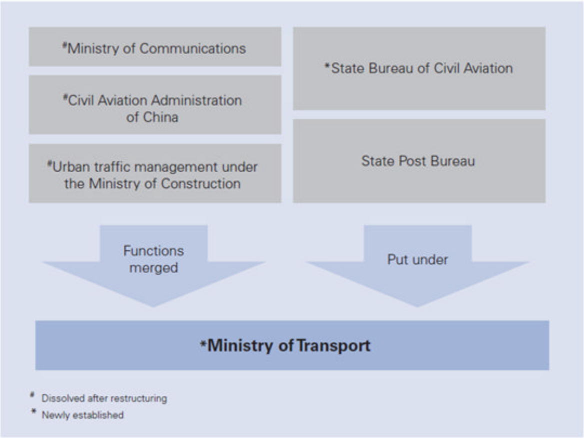
Table 6 Comparison of infrastructure

Year 2010	China	US
Expressway ('000 km)	74	72
Navigable inland waterway ('000 km)	124	41
Railway in operation ('000 km)	91	240
Investment in fixed assets (trillion)	USD0.5	USD2.2

Sources: NBS, CFLP, CSCMP, Wikipedia, US Department of Commerce

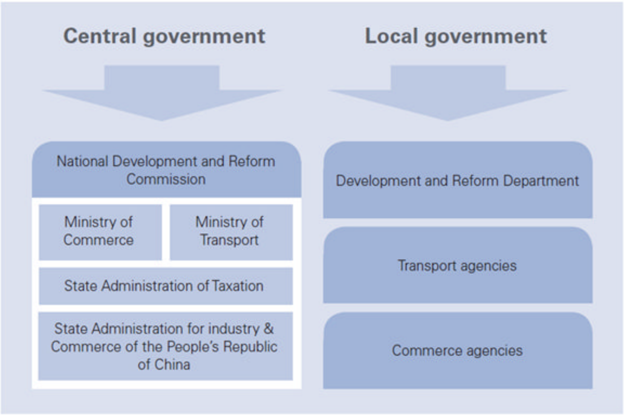
In addition to the lack of logistics infrastructure and fragmented market, regulatory constraints and local barrier to entry also exacerbated the inefficiency. For example, several central government departments were responsible for different aspects of the logistics sector, thereby making formulation of nation-wide policies and coordination of logistics development at the top level difficult. Provincial governments tend to benefit their local economies by setting entry barriers for goods or limiting cross-boundary inter-provincial or national delivery to protect self-interest. Local logistics operators often have secure positions in their specific markets, thus slowing consolidation in the industry and limiting development of national footprints for integrated logistics providers (KPMG, 2008). Hong, Chin and Liu (2007) contend that because of these obstacles, services offered by the Chinese thirty-party logistics (3PL) providers are limited to transportation and warehouse management instead of a wide range of value-added activities or integrated logistics services. This view is also shared by Tian, Ellinger and Zhen (2010). Zhou et al. (2008) point out that the lack of logistics expertise is another factor affecting the comparative efficiency of the domestic 3PL providers. Opening up the market to foreign logistics companies and simplifying the necessary licensing procedures may help as foreign investments tend to bring about operational improvements through the use of better facilities and management skills, richer experiences in the 3PL business, and latest logistics and supply chain technologies. Nevertheless, the need for *guanxi*, which is rooted deeply in the Chinese culture, is vital to the winning or losing of business for both the domestic and the foreign logistics operators (Jiang & Prater, 2002). Building up and maintaining smooth relationship with local governments places extra burden to the management and add to the logistics cost. These reasons have driven many foreign logistics companies to focus on the higher value segments such as express delivery, sea freight forwarding, and specialized logistics services instead of nation-wide integrated distribution (Li & Fung, 2011).

The Chinese government recognized the need for regulatory measures to provide more favourable conditions for both the domestic and the foreign transport and logistics companies to operate. A major reorganization at the ministry level was conducted in 2008 to integrate a number of transport related government bodies to streamline the governance of the transport systems in the country. Under this reform, the functions of a number of government departments regulating civil aviation, postal services, communications and urban public transportation were consolidated into a newly established Ministry of Transport (Figure 2). The amalgamation should expedite the development of the 3PL sector in China and facilitate entry of foreign investments in the logistics market, both of which are considered critical to improving efficiency in the long run. However, other departments are still responsible for monitoring the different aspects of the logistics industry in China (Figure 3). The lack of high level coordination among government departments leads to multiple jurisdictions and limits the development of the logistics industry (Li & Fung Research Centre, 2011).



Source: Li & Fung Research Centre

Figure 2 Formation of Ministry of Transport in 2008



Source: Base on a presentation by Ministry of Transport official

Figure 3 Administration of the logistics industry in China

Obviously, the issue of logistics inefficiencies in China have to be addressed through a combination of improvement measures covering the various elements of logistics competency as detailed in the literature review. These include organizational restructuring and integration (the management elements), adoption of best practices and benchmarking in operation (the operational elements), and investment in supply chain and information technologies (the technological elements). These firm-based efforts will help enhance the logistics competency of operators and reduce operating cost. However, to leverage logistics competency in lieu of cheap labour as the next source of competitive advantage for China, mere firm-based efforts will not suffice. A favourable environment to standardize logistics operational practices across the nation, nurture healthy competition to encourage continuous improvement, and facilitate collaboration in the industry to achieve global optimization has to be provided. This can only be achieved through government support in terms of regulatory reform to remove entry barriers and local protectionism, management education to change the in-house mindset of state owned enterprises, deregulation to open up markets to encourage 3PL development, investment in training to produce logistics professionals to meet market demand, investment in infrastructure and intermodal transportation to remove transportation bottlenecks, investment in logistics information technologies and platform to facilitate information sharing, collaboration, and standardization of processes. That is to say, in addition to the three categories of elements of logistics competency to improve firm performance, a fourth category of elements, collectively grouped under "government support", has to be added to encourage healthy competition and collaboration in the logistics sector so as to improve efficiency of the entire industry.

CONCLUSIONS AND FURTHER RESEARCH

Through a comprehensive desktop research with analysis of secondary data, this study has investigated the current status of logistics competency in China in comparison with developed countries such as the US. The causes for the operational inefficiency have also been examined. They have been found to be related to the presence of transportation bottlenecks, in-house mindset, local protectionism, fragmented market, constraints on management skills and technologies, as well as the lack of high-level coordination in the governance of the logistics industry to facilitate competition and collaboration. The study reveals that the logistic industry of China is still immature at this stage with many of the commonly recognized elements of logistics competency not adequately considered. Basically, improvements in all the three categories of elements, namely managerial, operational, and technological, have to be made in order to enhance firm performance. To leverage logistics competency as a competitive edge for the entire manufacturing industry to replace cheap labour, government support in terms of regulatory reform and infrastructure investment is critical. In fact, the Chinese government does recognize the importance of the logistics industry and its impacts on the wider economic growth. According to NDRC, the central government has set out in its 12th Five-Year Plan (running from 2011 to 2015) a number of directives to expand the logistics industry. They include development of the following: (1) third-party logistics; (2) high-quality, efficient, scalable, and diversified logistics service; (3) intermodal transportation; (4) integrated logistics infrastructure; (5) logistics information sharing platform; (6) e-logistics; and (7) standardization of industry practices. These are all positive moves towards industry-wide collaboration and efficiency enhancement to improve logistics competitiveness of the industry in the globe.

This study is a preliminary research to examine the current logistics competency of China and investigate the possibility of leveraging logistics competency as a competitive advantage for the manufacturing industry to negate the rising labour cost. Although it does have contributed to knowledge by providing a snapshot of the current situation, the use of secondary data has prohibited the gathering of more in-depth information to explore how the various elements of logistic competency should be used to improve operational efficiency in the case of China. Although various challenges and obstacles have been discussed, a systematic approach to generating feasible solutions to address these challenges has yet to be developed. Future research may employ questionnaire survey or in-depth case study to collect disaggregated data for analysis to facilitate formulation of improvement strategy.

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NOTE: A full list of the references can be obtained from the authors.

THE FUTURE OF FOOD SERVICE LOGISTICS – INSIGHTS FORM MULTIPLE DELPHI EXPERT PANELS

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INTRODUCTION

In the context of long-term strategy, uncertainty is often high and decision makers seek advice in order to increase decision accuracy, to increase justification for their decisions, and to share responsibility (Yaniv, 2004). This obviously holds also true for the decision makers within the Food Service Logistics industry. The food service industry constantly increases and in 2010 approximately 53 % of customers' expenditure on food were expected to be spent in food service establishment, that means in restaurants etc. (Friddle et al., 2001). Currently especially in this industry the logistics service providers are in the focus of strategic decisions, as the potential of cost reduction from optimization in food service logistics has not been fully exploited yet. So for decision makers from food service logistics providers accurate decisions for future actions are of essential importance. One valid method to provide both decision support and foresight in uncertain environments is the Delphi methodology, an anonymous expert based survey process (Landeta, 2006).

In our research we applied the Delphi technique in order to generate data on which future scenario development can be based. Logistics experts evaluated a set of projections and reassessed their evaluations based on other experts' assessments. Thereby we retrieved evaluations of different issues regarding the long-term logistics future. These evaluation lay the foundation for the development of scenarios for strategic logistics planning. In fact, an integration of the methods of Delphi and scenario planning has proven to enhance the scenario process (Nowack et al., 2011). The Delphi technique can be applied in different phases of the scenario process and for different kinds of scenarios thereby increasing the scenarios' creativity, credibility, and objectivity (Goodwin and Wright, 2001, Phelps et al., 2001, Visser and Chermack, 2009).

When we were conducting our Delphi survey for logistics scenario development the question arose who should be included in the panel. Delphi is an expert-based survey format. Research that included laymen showed that the laymen provide evaluations that differ in the beginning from what experts say, but during the Delphi process they change their evaluations and adopt the evaluations of the experts which they assume to be better informed (Hussler et al., 2011). So the inclusion of laymen in a Delphi process does not lead to improved results. Furthermore, one can recruit panels with experts from within a logistics company exclusively. Such company internal Delphi surveys gain valuable information from the employees regarding the company's capabilities. Employees can exchange internal information as it is kept confidential and are encouraged to provide evaluations that yield specifically on the logistics company and its respective business strategy. The active involvement of the employees in the strategic planning process creates trust in the management's decisions (Menon and Pfeffer, 2003, Alexiev et al., 2010).

On the other hand, the points of view that can be gathered in such an internal Delphi survey can be limited. This can be overcome by including external logistics experts in the Delphi survey, for instance as an approach to involve the company's stakeholders (Green and Hunton-Clarke, 2003, Preble, 2005). Stakeholders might have different information bases and different professional and personal backgrounds. With this valuable new perspectives they might help the decision makers to make the right decision as they broaden their view (Menon et al., 2006, Menon and Pfeffer, 2003).

Preble (1984) conducted a comparison of two different Delphi panels, where the one included experts from within a company and the other included experts from different companies. He included experts from companies that operated all in the same business area as the company from which the intra-company panel was recruited for the composition of his inter-company panel. He found the both panels to yield similar results and recommended to use intra-company panels for Delphi surveys that exclusively include experts from within the company. The advantages he pointed out are the more convenient survey process and the confidentiality of the reasoning that is exchanged between experts during the Delphi process.

We base our logistics research on this finding and address the question, whether external and internal logistics expert panels lead to different scenario outcomes for the long-term future of food service logistics. We included in our internal panel solely experts from our case company – a logistics service provider in the food sector. Our external panel included competitors, customers, suppliers, and logistics academics.

METHODOLOGY

We apply the Delphi method to develop expert-based logistics scenarios. Therefore we conducted two independent Delphi surveys in which a panel of internal and a panel of external logistics experts evaluated the same set of projections on the future of food service logistics. Both panels were introduced to a set of 18 future theses, i.e. projections, and were asked to evaluate each projection regarding its expected probability of occurrence (EP), impact (I), and desirability (D) until the year 2020. While the expected probability of occurrence is measured on a scale from 0-100 percent, the impact and desirability of occurrence are both measured on a 5-point Likert scale. After inserting their evaluations the panelist receives direct feedback about the assessments of the other experts, that is the median and the interquartile range of the assessments and where his own evaluation is located in relation to the others' evaluation. Furthermore, experts have the option to support their evaluations with written arguments. For each projection and each dimension reasoning could be provided. Each logistics expert had the opportunity to access the qualitative arguments the other experts provided to support their evaluations after his initial evaluation.

The projections were developed in a phase based process (von der Gracht and Darkow, 2010) based on extensive desk and database research, taking into consideration the STEEP factors (social, technological, economic, ecological, and political) and the five forces model by Porter (2008). A subsequent review of the findings aimed to identify the most relevant driving factors for the food sesrvice logistics sector in 2020. These were formulated in clear statements as the final projections. One example is the need of logistics service providers to reduce their carbon footprint. For instance the reduction of the impact of logistics on the environment is one of the major topics in logistics research (Skjoett-Larsen, 2000, Piecyk and McKinnon, 2010), another issue was the demand for flexibility along the supply chain, among others as a selection criteria for the choice of logistics service providers (Barad and Even Sapir, 2003, Naim et al., 2010, Jharkharia and Shankar, 2007).

For the internal panel, leading managers from all over Europe and from the US participated, representing different positions such as President of the European headquarter, Vice President of freight management, Managing Director of environmental services, Senior Vice Presidents for different logistic regions, Senior Manager transport, Managing Directors for different countries. In total 65 top managers were identified as potential participants for the survey and provided with a personalized link to the Delphi survey platform. As the commitment of the management was high for the research project, 57 experts completed the survey. The resulting response rate was 87.7 %.

For the external panel the positions of the invited experts were depended on the company and its internal labels for management positions. From logistics service companies the experts who participated in our panel were for example CEOs, country managers, or senior directors. From customer companies the participants were for example sales directors, supply chain directors, purchasing managers, or food and quality managers of for example hotels and global furniture stores. Supplier experts were likewise CEOs, managing directors, or supply chain directors. Furthermore, we invited consultants who worked either for logistics or for their customer companies as well as academics from supply chain services and the logistics field. Overall, 449 external experts were identified and contacted personally, of which 313 signaled a willingness to participate in the survey and were provided with a personalized invitation hyperlink to the Delphi platform. Of these 313, 122 entered the Delphi platform and 88 of those completed the survey. The final response rate was 19.6 %.

After the Delphi survey scenarios for the food service logistics sector were developed by clustering the Delphi projections according to their expert assessments. First, we developed two probable scenarios, one for the internal and one for the external Delphi panel. Therefore, we conducted a cluster analysis with the ward linkage method along the evaluated probability of occurrence and impact of the projections, as these are the recommended dimensions according to which strategic decisions should be made (Ogden et al., 2005, Akkermans et al., 2003, Rikkonen et al., 2006). The ward linkage method is used for small samples and optimizes the variance of results. We applied square Euclidean dissimilarity measure and transferred the variables into standardized z-scores to take the different dimensions of the variables into account. While EP was measured in percentages on a scale from 0 percent to 100 percent, I was measured on a 5-point Likert scale. Therefore, standardization of equal metrics and weights was necessary.

Second, we developed the desirable logistics scenarios for each of the two Delphi surveys. We selected the projections with average ratings of desirability over 3.8 (desirability of occurrence was measured on a 5-point Likert scale, where 1 meant undesirable and five highly desirable). The desirable logistics scenario can be useful to have a clear vision of what the panellists would like the future of the food service logistics sector to look like. In the strategy development process this kind of scenario can be used to create a roadmap that would lead to the desirable scenario or to identify possibilities how to influence the industry to make the desirable future possible.

RESEARCH RESULTS

In 30 percent of the final results of expected probability of occurrence, impact, and desirability as inserted by the internal and external logistics expert panel deviate significantly. Nevertheless, the obtained clusters for projections with the highest probability of occurrence and impact are rather similar, even though the evaluations for probability of occurrence deviate even in 39 percent. Both logistics scenarios contain five identical projections, but in the external cluster two additional projections are included (projection 14 and 17) (see Table 1). The combination of the projections within the clusters leads to the probable logistics scenario. Based on the input of the set of projections which are regarded to be very likely to become true by the experts, scenarios are created that describe the future of the food service logistics sector under the presumption that the projections of the cluster become true.

The two additional projections that are included in the probable logistics scenario for the external Delphi survey are giving the scenario a slightly richer storyline than the smaller projection set for the internal Delphi, but generally speaking the futures that are expected are rather similar.

Probable logistics scenario for case company’s Delphi panel (internal)		Probable logistics scenario for external Delphi panel	
Projection number in cluster	Strategic issue	Projection number in cluster	Strategic issue
5	Pressure to innovate	5	Pressure to innovate
11	Reverse Logistics	6	Reverse Logistics
12	City Supply	11	City Supply
13	Carbon Footprint	12	Carbon Footprint
14	New Technologies	13	New Technologies
		14	Flexibility
		17	Local Sourcing

Table 1: Probable logistics scenario for internal and external Delphi panel

Using exclusively the most probable logistics scenario for strategy development has been criticized, though. The advantage of scenario planning is its ability to broaden decision makers’ perspectives, to introduce new points of view, and to open the mind to different futures. Taking solely the most probable logistics scenario into consideration can limit the openness for innovative thoughts since the probable scenario might be too narrow and unidirectional to induce creativity. Furthermore, the probable scenario may lead to psychological biases as the logistics strategists neglect that the scenario is based on what the experts expect to become true, but are not the definite future. This might lead to the decision maker focusing on the most probable scenario exclusively and make him disregard other possibilities (Nowack et al., 2011). To prevent this effect, we additionally developed the two desirable logistics scenarios for the future of food service logistics.

To select projections for the desirable logistics scenario we chose those with average ratings for desirability higher or equal to 3.8 (desirability of occurrence was measured on a 5-point Likert scale, where 1 meant undesirable and five highly desirable, 3 can be regarded as neutral (Ecken et al., 2011)). Again we selected the desirable projections for each panel. The internal panel’s set included five projections, while the external panel’s set contained seven projections. Only one projection (New technologies) was common to both sets thereby showing a strong contextual difference (Table 2).

Desirable logistics scenario for case company’s Delphi panel (internal)		Desirable logistics scenario for external Delphi panel	
Projection number in cluster	Strategic issue	Projection number in cluster	Strategic issue
3	Food service logistics providers design supply chain	5	Pressure to innovate
7	In-store logistics	6	Reverse Logistics
9	Distribution Network	11	City Supply
10	Supply Planning	12	Carbon Footprint
13	New Technologies	13	New Technologies
		14	Flexibility
		17	Local Sourcing

Table 2: Desirable logistics scenario for internal and external Delphi panel

MANAGERIAL IMPLICATIONS

The composition of the Delphi panel can have a huge influence on a company’s strategic orientation. A major task of scenarios is to challenge the decision makers’ mental frames (Wright and Goodwin, 2009). As the logistics scenarios obtained from the probability of occurrence ratings are similar for both Delphi panels, we can gain no additional challenge to the decision makers’ mental frame by conducting an internal and an external Delphi survey. On the other hand the desirable logistics scenarios differ from each other, therefore applying two different Delphi surveys provides the decision maker with a new future he can think of. As stated above, the desirable scenario is useful to envision possible activities to influence the future and circumstances in order to make the desirable logistics scenario become true. Circumstances that our logistics company might want to influence are for example customers’ behavior by creating new demands, political developments by proactive innovations, or the development of certain capabilities within the company that might enable the management to maneuver the company’s business into a certain direction. But when the logistics scenario that the company tries to induce is undesired by the other players in the market, it is both unlikely that the company will succeed, as it is not the environment the other parties desire; other stakeholders will either try to change the situation again or are reluctant to act as the case company planned them to do. Therefore the knowledge of the desirable logistics scenarios for both internal and external experts is of interest for logistics strategists.

The difference between internal and external panels could not be observed for the most probable logistics scenario, though. This means that the evaluations of internal and external individuals do not necessarily differ. Nevertheless, it is in general recommended to develop several logistics scenarios, such as (un)desirable or surprising, to ensure that the strategists face several possible futures and remain flexible and open for divergent developments (Goodwin and Wright, 2001). With regard to our research results it seems recommendable to include different logistics expert panels in the data generation via Delphi surveys in order to obtain differing scenarios. For strategists it will not only be of interest to see what the internal experts expect of the future, but also in how far the internal expectations differ from those of the main other players in the market (e.g. competitors, customers, or the government). Formulating descriptive scenario stories helps to imagine the different futures and to emphasize the criteria in which the scenarios, that is the panels, are identical and where they have discrepancies.

CONCLUSION

The logistics experts from our two Delphi panels find it very likely that in the food service logistics sector in 2020 the pressure to provide innovative logistics services will be very high, among others because of the challenges that occur in the city supply and because of the need to reduce the carbon footprint. At the same time the demand for flexibility is expected to increase further compared to 2011 and the usage of new technologies such as smartphones and RFID is expected to be in use in order to increase customer satisfaction. The external logistics experts furthermore see a high likelihood for the provision of reverse logistics services by food service logistics providers. In terms of sustainable sourcing and the reduction of carbon footprint they additionally see local sourcing as one major trend in 2020 that will have a rather high impact on the food service logistics sector.

Besides these major trends for the food service logistics sector, our research reveals significant differences between the two kinds of panels. Especially the question what responsibilities food service logistics providers will have in the future induces disagreement among the two panels. While the management of our case company finds it rather probable that that their customers will purchase as many services from one provider as possible (one-stop shopping) in the future and that they will outsource more tasks such as supply planning to this food service logistics provider, the external experts evaluate these projections differently, as they provide significantly lower estimations for the probability of occurrence.

Above that, external experts see a higher importance of cost transparency and the reduction of the carbon footprint than the Delphi panel of internal panelists does.

Regarding desirability, the differences are largest for the disappearance of one-stop shopping and contracts that have a long runtime, and the reduction of the carbon footprint. For the occurrence of these projections the external logistics experts expressed a significantly higher desirability than the internal experts. On the other hand, the desirability rating provided for the projection that food service logistics providers take over the design of the supply chain is significantly higher than the ratings provided by the panel that includes the entire industry. As the panel of external logistics experts includes customers and potential customers of the case company it is obvious that the expectations of the case company and its main focus group deviate in important aspects. This can be explained as for example the food service logistics provider is interested in expanding its range of services and thereby expanding the possibilities of the company to make profit, therefore the projection that food service logistics providers take over the design of the supply chain is regarded as desirable from the logistics providers' perspective. The probability of occurrence as rated by the experts is higher for the internal logistics panel than for the external panel, too. The effect that projections that are desirable are expected to be more likely to occur by the panelists might be due to desirability bias, that is the panelists are biased in their evaluation of the probability of occurrence by their desirability of the event (Ecken et al., 2011, Landeta et al., 2008).

The external logistics panel on the other hand includes customers of the logistics service providers as well. For them the vision to outsource strategically important tasks such as the design of the supply chain to logistics service providers is not that desirable. Analysis of the evaluations of the customers shows that they find it significantly less likely that these tasks do not remain internal than the food service logistics providers. For them it is unlikely that they will give away such a core competency that is essential for their successful business.

In sum, we can conclude that the Delphi surveys with external experts have benefits from the stakeholder management perspective. The company receives knowledge about their stakeholders' expectations and as outlined above can identify in which aspects the visions of the future differ. Above that, the involvement in the strategic planning process increases the stakeholders' commitment and confidence in the company and as we find huge discrepancies between the evaluations of the company experts and of their stakeholders, the necessity of their involvement for the food service logistics sector becomes more than obvious. Research likewise emphasizes the importance of the relationship between a logistics service provider and his customer. For instance Panayides and So (2005) show, that the orientation of the logistics service provider on his relationship with his customer has a positive effect on supply chain effectiveness and organizational learning. The latter again has a positive effect on innovation, which again enhances supply chain effectiveness. The result of an effective supply chain is improved supply chain performance.

We are aware of several limitations to our research. First, the list of projections presented to the two Delphi panels does not claim to cover the complete range of relevant issues for the logistics service industry. As it is recommended to keep the number of projections limited in order to reduce the drop-out rate and to minimize research fatigue, a pre-selection had to be made. Additional issues that come up in the Delphi process can be used in the scenario writing process as additional food of thought, though, enabling the scenario planner to take further aspects of the industry into consideration.

Second, the logistics experts who participated in our Delphi survey are not necessarily representative for the industry. Though we tried to recruit a broad diversity of experts from different kinds of organizations and from different European countries, it cannot be guaranteed to cover every kind of involvement in the industry.

Third, our research results may not be generalizable. We found out, that the results provided by the two panels differ significantly in 30 percent of the final evaluations. That we find almost identical probable scenarios for the two surveys therefore can be regarded as coincidence. Future research may use the Delphi process already in the scanning phase of scenario development. Using two different panels during idea-generation may reveal further differences as it is likely that the two panels yield a different set of strategic issues. An evaluation of the different sets by each panel would further result in interesting insights regarding the experts' points of view.

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MULTI-STAKEHOLDER SCENARIOS TOWARDS A COLLABORATIVE FUTURE IN MOBILITY SERVICES – INSIGHTS FROM PARALLEL DELPHI STUDIES

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Research Paper

INTRODUCTION

Numerous academic articles and popular science show that mobility accounts for an indispensable part of modern society. Yet, the current mobility system entails a variety of substantial challenges and individual mobility in urban areas is increasingly reaching its limits (Harris & Tapsas, 2006; Schrank, Lomax, & Turner, 2010). Future mobility systems require not only new power train technologies but comprehensive services that involve and affect numerous stakeholders with diverse sets of target systems (e.g. Loose, Mohr, & Nobis, 2006; Oltra & Saint Jean, 2009). Accordingly, as a wide range of different stakeholders is seriously concerned with the challenges to come, collaborative countermeasures become inevitable.

Research found that the types of value resulting from inter-firm relationships changed over the past decades from operational performance improvements towards a stronger focus on integration-based values, such as improved collaboration and partnerships (Terpend, Tyler, Krause, & Handfield, 2008). Furthermore, various empirical findings revealed that vertical integration and horizontal collaboration have a positive impact on a firm's performance. Wilhelm (2011) argues that the most advantageous inter-firm collaboration is where two competitors both cooperate and compete with one another. However, the inherent tension of cooperation and competition is a special challenge in inter-firm relationships as different stakeholders take diverging roles within transition processes (Rotmans, Kemp, & van Asselt, 2001).

To date, only few scientific research articles address the topics of future mobility services and relationship research. Existing publications adopted a rather myopic view, lacking to implement a multi-stakeholder view which simultaneously integrates the prespectives of corporates, public authorities, and end-users to draw a holistic picture.

Consequently, to reflect ongoing discussions and differing perceptions of the stakeholders involved, the purpose of this paper is to develop partially-conflicting multi-stakeholder scenarios for the preferable future of mobility services in Germany. Inspired by future challenges for mobility services and theoretical considerations on inter-firm relations, we study how the mobility services industry should evolve in the long-term until the year 2030 and what the necessary steps are to realize such a desirable scenario. We exemplify a whole scenario building approach along with a backcasting process.

STUDY DESIGN AND SURVEY PROCEDURE

Our research adapts the scientific approach of strategic issue management (Ansoff, 1980), using three parallel real-time Delphi surveys (Gnatzy, Warth, von der Gracht, & Darkow, 2011) for data generation. Thereby, we followed a structured design process supported by cross-impact analysis in developing projections considered to shape the future state of mobility services. For strategy development and implementation of an action agenda, we apply a backcasting approach using multiple focus group workshops to shed light on the way the preferable future for 2030 can become reality. The details of the study and measures are detailed in the following.

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Real-time Delphi Variant

The Delphi method has previously been applied in a wide range of different fields and constitutes a well-established research method. Based on the exchange of expertise in an anonymous format, the technique offers a structured group communication process that allows participants to effectively express individual assessments (van Zolingen & Klaassen, 2003). Building on the work of Gordon and Pease (2006), Gnatzy et al. (2011) validated a web-based real-time Delphi variant, which we used for the research purpose at hand. Conducting a web-based Delphi streamlines the survey process, thus enhancing data validity due to minimizing research fatigue and panel mortality (Geist, 2010; Theodore J. Gordon & Pease, 2006). In addition, the evaluations of comparatively large expert panels can be handled efficiently when applying a web-based Delphi. By consistently applying the real-time Delphi variant, we also ensure standardization and homogeneity across the parallel Delphi studies.

Our study combines insights from three parallel real-time Delphi studies based on diverse target systems (94 corporate, 87 public authorities, 67 end-users, in total 248 participants) to multi-stakeholder scenarios. All of these studies followed the same research design to ensure high levels of comparability and scientific rigor. Invited experts were asked to rate the projections' desirability (D) and probability of occurrence (EP) as well as their expertise (EX) in the field of mobility services, and to provide reasons for all answers. About 3.500 qualitative arguments (corporate-Delphi: 1.322, public authorities-Delphi: 1.246, end-users-Delphi: 924) from expert panel discussions additionally enriched the scenario writing and identification of influencing factors.

Systematic Development of Projections

Previous research has emphasized the importance of Delphi survey questionnaires for a study's success (Loveridge, 2002). Therefore, we pursuit a structured design process in developing projections to unravel influence factors considered to shape the future status of mobility services. To elaborate on the specification of the projections, brainstorming sessions within the research team of four academics were held and intensive scientific database search on influence factors related to the future of multimodal mobility (e.g. ebsco, emerald insight, ScienceDirect, data monitor, etc.) was carried out. Subsequently, the resulting 25 influence factors were transferred into a cross-impact matrix (Bañuls & Turoff, 2011; T.J. Gordon & Hayward, 1968) where each member of the research team rated the mutual influence of each factor. During an adjacent group discussion process, the five key factors with the highest impact on the topic under consideration, i.e. dimensions, were selected for projection formulation. We transformed the influence factors into short and provoking projections for the year 2030. As former research works on the Delphi questionnaire design indicate (Parentè & Anderson-Parentè, 1987), the higher the number of projections the higher the likelihood of a reduced response rate and not properly filled questionnaires. Thus, we set the threshold for the maximum number of projections at 13 which we estimated to represent an adequate time effort for participants. As a final step, the author team consulted four automotive industry representatives (four senior managers from four different German OEMs), two political decision makers, and five frequent end-users of mobility services to further refine the projections in the sense of non-ambiguity and clearness.

Standardized Expert Selection and Survey Procedure

Identifying and selecting appropriate experts is of central importance for the reliability of Delphi research results (Welty, 1972). Yet, no strict rules for right panel sizes can be found in the literature. In order to increase the probability of mapping a high degree of heterogeneous viewpoints within the Delphi studies, we aimed to include at least 30 experts in each Delphi survey, which previous works regarded a scientifically acceptable panel size (Parentè & Anderson-Parentè, 1987). To identify adequate experts, participation lists of topic-related conferences were screened and desk research was carried out. In total, we identified and contacted 721 people who met the criteria proposed by Adler and Ziglio (1996).

Backcasting Appoach

Based on the Delphi statistics and the coding of arguments we conducted a backcasting exercise. Backcasting looks back at the desirable future scenario and defines path ways for involved stakeholders on how this can be achieved, before defining appropriate strategies (Quist & Vergragt, 2006; Robinson, 1988). Backcasting focus group workshops with more than 34 experts from each stakeholder group were conducted in order to discuss measures on the transition to the desirable scenario and the development of recommendations in terms of an action agenda for involved stakeholders. The workshop discussions were based on previously identified dissent topics from nearly 3.500 Delphi arguments. As a result, we were able to assess the way towards sustainable mobility scenarios in Germany for the year 2030.

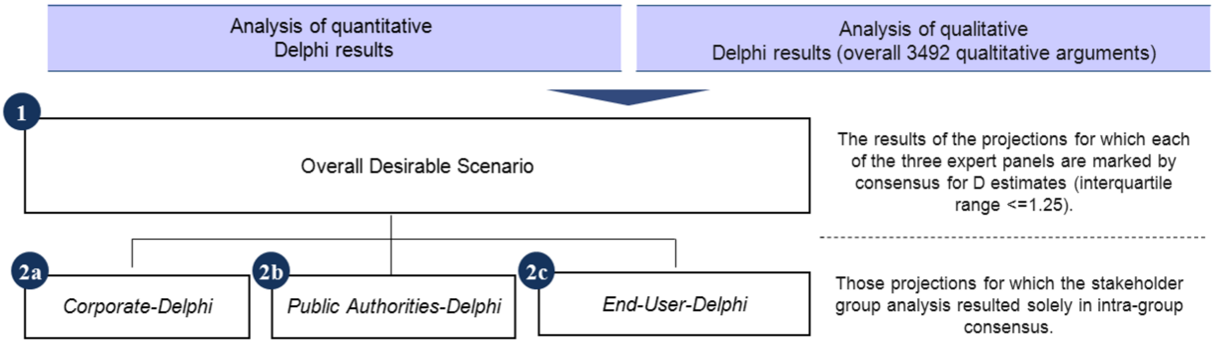
RESEARCH FINDINGS

Delphi Results – Multi-Stakeholder Scenarios on the Future in Mobility Services

Drawing on the results of our real-time Delphi study, we developed four partially-conflicting multi-stakeholder scenarios for the desirable future of mobility services. Building on differences in stakeholder group's assessment, resulting projections showing consensus aided for the development of distinct stakeholder sub-scenarios. At large, the average results of the parallel Delphi surveys are marked by considerable dissent among the participants.

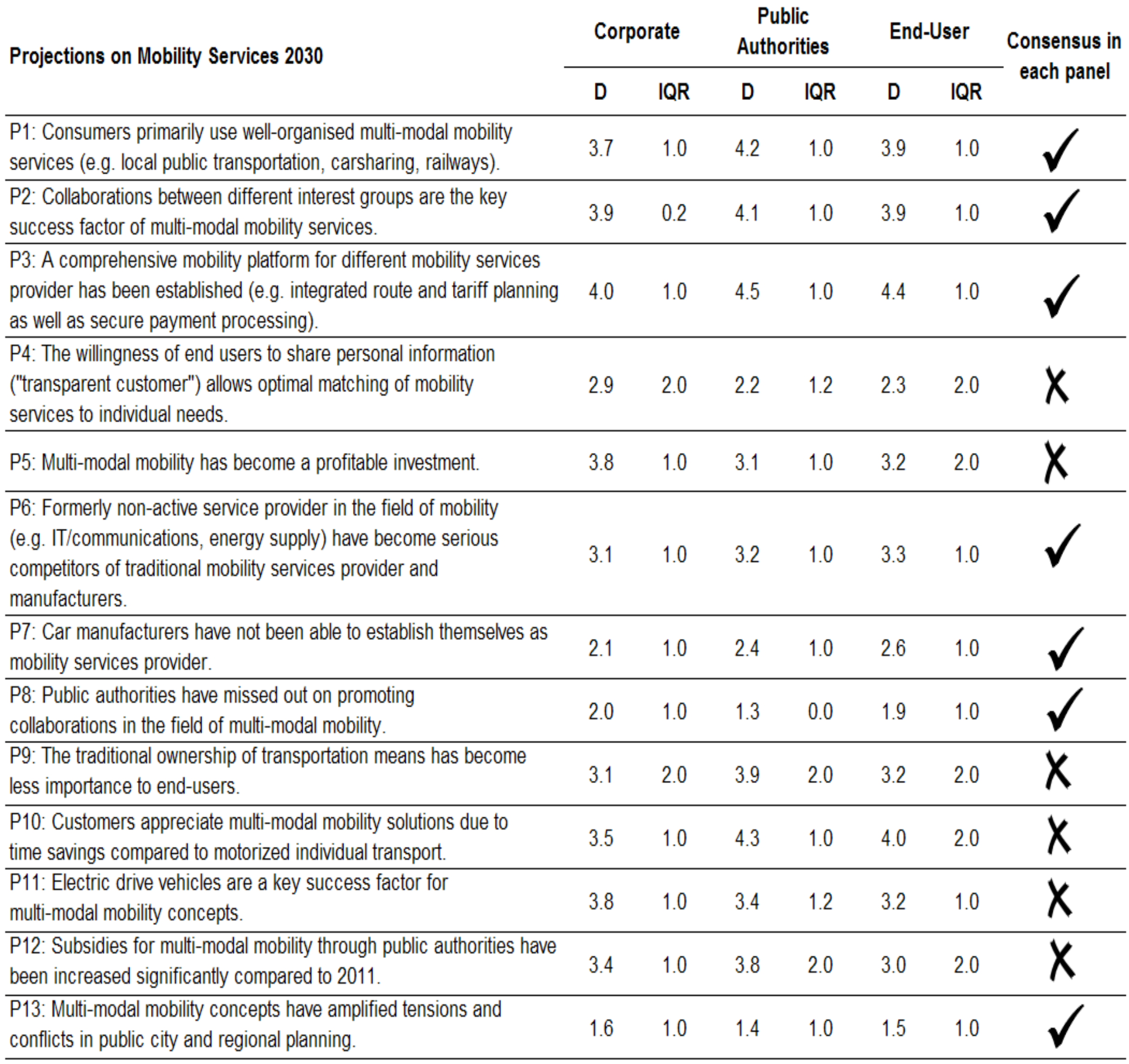
The results of the projections for which each of the three expert panels are marked by consensus for D estimates were used for the first level of the desirable multi-stakeholder scenarios. Thereby we defined consensus by an interquartile range (IQR) of not larger than 1.00 (De Vet, Brug, De Nooijer, Dijkstra, & De Vries, 2005; Scheibe, Skutsch, & Schofer, 1975). **T**hose projections for which the stakeholder group analysis resulted solely in intra-group consensus were used for the second scenario level. Furthermore, by systematically coding the participants' arguments the major influencing factors for the transition paths to the desirable scenario were identified. Figure 1 describes the process of multi-stakeholder scenario development.

Figure 1: Process of Multi-Stakeholder Scenario Development



Seven out of 13 projections (P) describe our overall desirable scenario (P1-3, P6-8, and P13). The resulting projections for which intra-group consensus could be identified provided the basis for our distinct stakeholder sub-scenarios. Table 1 summarises the quantitative findings of our Delphi survey and figure 2 outlines the results of the multi-stakeholder scenario writing process.

Table 1: Quantitative Delphi study results



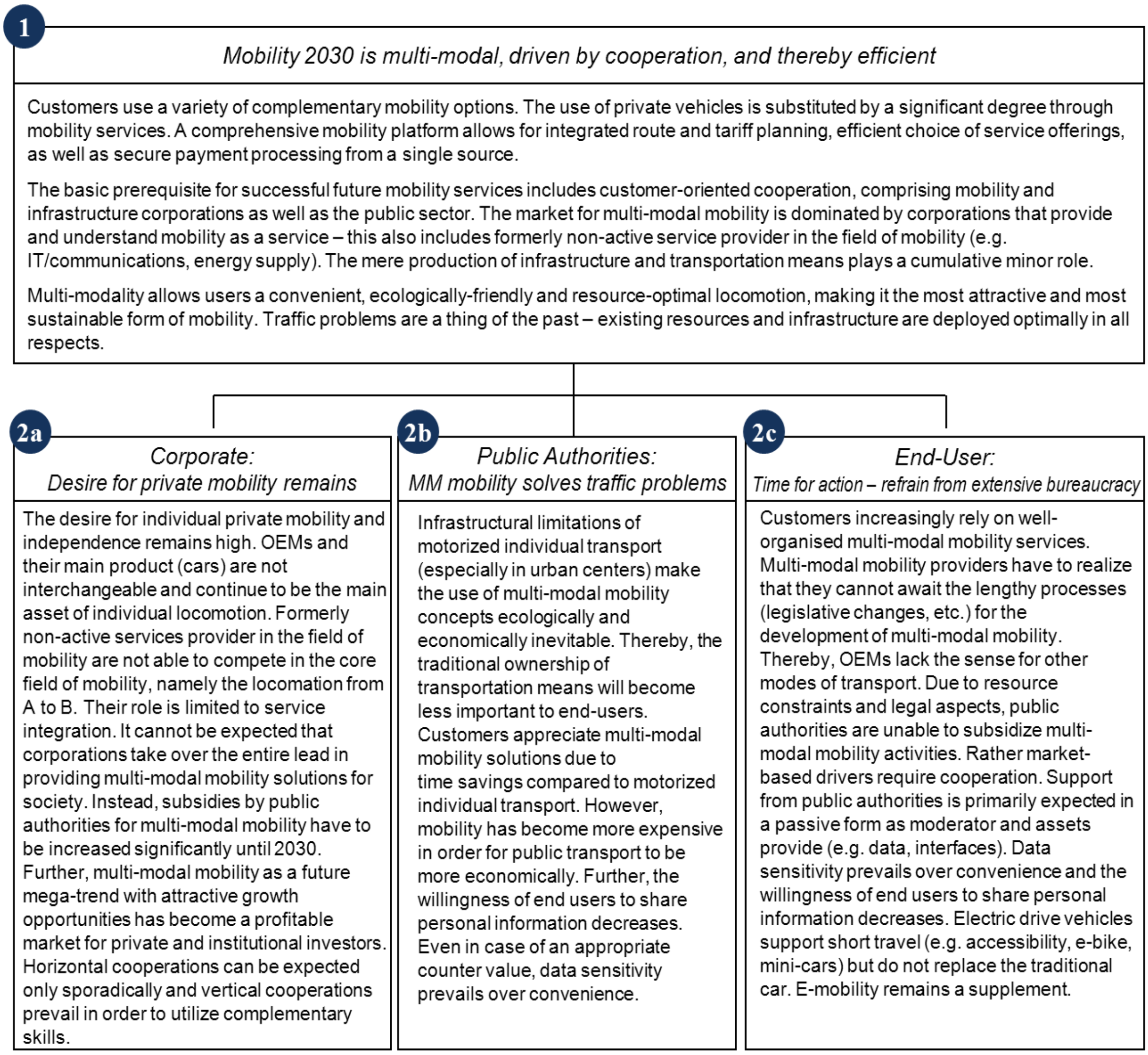
Projections on Mobility Services 2030	**Corporate**		**Public Authorities**		**End-User**		**Consensus in each panel**
	D	**IQR**	**D**	**IQR**	**D**	**IQR**	
P1: Consumers primarily use well-organised multi-modal mobility services (e.g. local public transportation, carsharing, railways).	3.7	1.0	4.2	1.0	3.9	1.0	✓
P2: Collaborations between different interest groups are the key success factor of multi-modal mobility services.	3.9	0.2	4.1	1.0	3.9	1.0	✓
P3: A comprehensive mobility platform for different mobility services provider has been established (e.g. integrated route and tariff planning as well as secure payment processing).	4.0	1.0	4.5	1.0	4.4	1.0	✓
P4: The willingness of end users to share personal information ("transparent customer") allows optimal matching of mobility services to individual needs.	2.9	2.0	2.2	1.2	2.3	2.0	✗
P5: Multi-modal mobility has become a profitable investment.	3.8	1.0	3.1	1.0	3.2	2.0	✗
P6: Formerly non-active service provider in the field of mobility (e.g. IT/communications, energy supply) have become serious competitors of traditional mobility services provider and manufacturers.	3.1	1.0	3.2	1.0	3.3	1.0	✓
P7: Car manufacturers have not been able to establish themselves as mobility services provider.	2.1	1.0	2.4	1.0	2.6	1.0	✓
P8: Public authorities have missed out on promoting collaborations in the field of multi-modal mobility.	2.0	1.0	1.3	0.0	1.9	1.0	✓
P9: The traditional ownership of transportation means has become less importance to end-users.	3.1	2.0	3.9	2.0	3.2	2.0	✗
P10: Customers appreciate multi-modal mobility solutions due to time savings compared to motorized individual transport.	3.5	1.0	4.3	1.0	4.0	2.0	✗
P11: Electric drive vehicles are a key success factor for multi-modal mobility concepts.	3.8	1.0	3.4	1.2	3.2	1.0	✗
P12: Subsidies for multi-modal mobility through public authorities have been increased significantly compared to 2011.	3.4	1.0	3.8	2.0	3.0	2.0	✗
P13: Multi-modal mobility concepts have amplified tensions and conflicts in public city and regional planning.	1.6	1.0	1.4	1.0	1.5	1.0	✓

The findings show that a multi-modal mobility system is most desirable among all experts; that is, the integration of individual and public transport as well as innovative mobility services. In 2030, a comprehensive mobility platform allows for integrated route and tariff planning, efficient choice of service offerings, and secure payment processing from a single source.

Closer cooperative competition among national players is desired in which horizontal cooperation is expected only sporadically due to competitive spirit and difficulties in negotiations. In fact, rather vertical collaborations will increase, leveraging complementary capabilities of market participants. The market for multi-modal mobility is dominated by corporations that provide and understand mobility as a service – this also includes formerly non-active service provider in the field of mobility (e.g. IT/communications, energy supply). The mere production of infrastructure and transportation means plays a cumulative minor role.

Further, in 2030, multi-modality allows users a convenient, ecologically-friendly and resource-optimal locomotion, making it the most attractive and most sustainable form of mobility. Traffic problems are a thing of the past – existing resources and infrastructure are deployed optimally in all respects.

Figure 2: Multi-stakeholder scenarios for mobility services in 2030.



1

Mobility 2030 is multi-modal, driven by cooperation, and thereby efficient

Customers use a variety of complementary mobility options. The use of private vehicles is substituted by a significant degree through mobility services. A comprehensive mobility platform allows for integrated route and tariff planning, efficient choice of service offerings, as well as secure payment processing from a single source.

The basic prerequisite for successful future mobility services includes customer-oriented cooperation, comprising mobility and infrastructure corporations as well as the public sector. The market for multi-modal mobility is dominated by corporations that provide and understand mobility as a service – this also includes formerly non-active service provider in the field of mobility (e.g. IT/communications, energy supply). The mere production of infrastructure and transportation means plays a cumulative minor role.

Multi-modality allows users a convenient, ecologically-friendly and resource-optimal locomotion, making it the most attractive and most sustainable form of mobility. Traffic problems are a thing of the past – existing resources and infrastructure are deployed optimally in all respects.

2a

Corporate:
Desire for private mobility remains

The desire for individual private mobility and independence remains high. OEMs and their main product (cars) are not interchangeable and continue to be the main asset of individual locomotion. Formerly non-active services provider in the field of mobility are not able to compete in the core field of mobility, namely the locomation from A to B. Their role is limited to service integration. It cannot be expected that corporations take over the entire lead in providing multi-modal mobility solutions for society. Instead, subsidies by public authorities for multi-modal mobility have to be increased significantly until 2030. Further, multi-modal mobility as a future mega-trend with attractive growth opportunities has become a profitable market for private and institutional investors. Horizontal cooperations can be expected only sporadically and vertical cooperations prevail in order to utilize complementary skills.

2b

Public Authorities:
MM mobility solves traffic problems

Infrastructural limitations of motorized individual transport (especially in urban centers) make the use of multi-modal mobility concepts ecologically and economically inevitable. Thereby, the traditional ownership of transportation means will become less important to end-users. Customers appreciate multi-modal mobility solutions due to time savings compared to motorized individual transport. However, mobility has become more expensive in order for public transport to be more economically. Further, the willingness of end users to share personal information decreases. Even in case of an appropriate counter value, data sensitivity prevails over convenience.

2c

End-User:
Time for action – refrain from extensive bureaucracy

Customers increasingly rely on well-organised multi-modal mobility services. Multi-modal mobility providers have to realize that they cannot await the lengthy processes (legislative changes, etc.) for the development of multi-modal mobility. Thereby, OEMs lack the sense for other modes of transport. Due to resource constraints and legal aspects, public authorities are unable to subsidize multi-modal mobility activities. Rather market-based drivers require cooperation. Support from public authorities is primarily expected in a passive form as moderator and assets provide (e.g. data, interfaces). Data sensitivity prevails over convenience and the willingness of end users to share personal information decreases. Electric drive vehicles support short travel (e.g. accessibility, e-bike, mini-cars) but do not replace the traditional car. E-mobility remains a supplement.

Backcasting Results – An Action Agenda for a Multi-modal Mobility Future

Subsequent to the multi-stakeholder scenario development, focus group workshops and interviews have been conducted to shed light on how the multi-modal mobility future can become reality until 2030.

Overall, our focus group workshops reveal that involved stakeholder need to realize the benefits of integrating all modes of transport in terms of a cooperative competition and understand such collaborations as a general mission statement. Redistribution from individual mobility towards a cooperative, collective mobility has to be promoted. To manage current traffic problems, individual mobility must decrease and the share of collective mobility has to increase. Thereby, the focus has to be placed on the needs and expectations of customers. Complementary capabilities in terms of system-related and economic strengths of individual transportation means need to be utilized and developed further. For instance, the cooperation between OEMs and the energy industry represents a key prerequisite for the use of alternative drive engines, such as electric vehicles or hydrogen fuels. Stakeholder need to understand that no competition between private and public transport is required, but improvements in the choice of options for end-users is essential.

Corporations – Action Agenda

Our focus group workshops with involved stakeholders reveal that car manufactures need to consider re-framing their business models towards offering innovative mobility services rather than just selling vehicles. Starting from scattered but specific test cases, long-term partnerships will develop from which increasingly comprehensive mobility solutions could be developed.

At present, corporations almost entirely lack comprehensive strategies for integrated mobility with regard to the overall strategy of the company. An integration of the changing mobility business into the current business activities and processes becomes critical for future sustainable success. Corporations must anticipate altering mobility behaviors until 2030, from which changes and key requirements can be derived. Resulting implications have to be taken into consideration in current planning and for the establishment of an action agenda. It can be concluded that fundamental amendment of past business models are required. The adaptation needs to go far beyond a gradual change in the product portfolio. Based on a mobility vision, future business areas have to be deduced. Thereby, corporations depend on a structured analysis of make-or-buy decisions. An appropriate strategy must be aligned to the company's individual market positioning (e.g. premium vs. low-cost vs. entry segment) and must not dilute it. An early positioning of mobility services with specific test cases (trial & error) may provide necessary knowledge to develop comprehensive future mobility solutions.

In addition, the development of a comprehensive network of cooperating partners accounts for a key success factor in the area of mobility services. In the future, skills will be required that go far beyond the original core competencies of current mobility services provider. Based on a company's business model and its individual situation, a comprehensive network of cooperating partners has to be establised at an early stage, including partners within and outside the respective industries. Collaborations on the principle of cooperative competition appear promising, comprising cost-, risk-sharing, and generation of network effects. Building strong vertical relationships that utilize complementary skills with carefully selected partners seem promising: downstream (distribution, service provider), upstream (tier-1), co-branding partners. Horizontal co-operation are to be expected only sporadically.

Public Authorities – Action Agenda

The development of public authorities towards an 'ensuring state' has been stressed among our workshop groups. Thereby, the state is one which safeguards the provision of basic services in terms of organization and control mechanisms (through laws), but leaves the producing to private firms. Transportation and infrastructure must be guaranteed by the state (at least roads and prossibly modes of transport) but implementation and execution fall to the private corporations. Thereby, operating corporations have to cover their costs and take over the maintenance of transport. The commissioning is based on the principles of free market economy with the best companies selected for a service (appointed through tenders). Through tariff arrangement, the state may affect the use of certain modes of transportation. The administration is handled by infrastructure companies, with the state determining the quality management.

Further, public authorities should promote competition and market liberalization in the field of public transport. Although it is expected that a large part of public transport companies are currently not competitive in terms of an open market, it is the only way to increase efficiency and reach the target towards a cost-effective mobility future. The federal government should spur this market opening. States and municipalities are required to campaign for an enhanced bidding of public transport services whereby entrepreneurial skills should be given priority over regulatory solutions. Additionally, efficiency-oriented restructuring is overdue, requiring reductions in operational and administrative overhead as well as economization of management processes.

End-Users – Action Agenda

In future, end-users increasingly need to self-organize their mobility. In order for them to do so, an improved information supply has to be in place. End-users need to be informed on how to improve their individual mobility situation and how they can make better use of available information. Thereby, the catch up by individuals on best offers (price, time, comfort, etc.) has yet to be understood as an obligation to be performed at the place of the end-user. Mobility users will surely be supported by appropriate technologies in their information supply. Though, a support through a comprehensive mobility platform in travel planning for instance requires continuous maintenance of end-user profiles. As mobility in depopulated areas can no longer be provided and secured by public authorities, state-organized regional gathering places need to be strengthened. Thereby, local transportation to these transition points has to be organized by mobility users themselves (e.g. via transportation pooling).

Further, perspectives of the end-users have to be considered already in the design of future mobility services whereby future conflicts are avoided and an optimal satisfaction of needs for all involved parties can be achieved. However, end-users are required to communicate their ideas and get involved as "active citizens" (e.g. during citizens' initiatives).

Finally, end-users' willingness to pay for improved performance has to increase and customers need to realize that mobility is currently too cheap. The mobility user must critically examine and balance his/her demands: On the one hand, customers are reserved regarding demands for standardization. In fact, a continuous increase of individuality and exclusivity is expected. On the other hand, customers need to have the willingness to pay for such required individuality.

CONCLUSION

Transformations towards sustainability in logistics and mobility are very complex phenomena: inherent uncertainty of technological and infrastructural developments and the inherent ambiguity of stakeholders having different value sets and mental frameworks. The public sector, for instance, sets increasingly strict emissions standards and episodic news indicate that a number of cities is about to tighten urban access regulations in the near future (European Comission, 2010). On the corporate level, firms heavily invest in new power-train technologies and alternative fuels in order to contain the most urgent social and economical downturns of mobility. At the same time, car manufactures recognize that alternative ways of vehicle usage such as car sharing are becoming increasingly popular (Loose, et al., 2006). Car manufactures are considering to slight re-frame their business models towards offering mobility services rather than selling vehicles. It is because of these considerable expected changes for a wide range of different stakeholders that we considered a multi-stakeholder analysis on the future of mobility services.

We contribute towards both methodological advancements and practical impact. Our three parallel, web-based real-time Delphi studies in combination with an expert-based backcasting approach represent an innovation for methodology and may serve as a guideline for other researchers. Our holistic approach that involves all major stakeholder groups in the field of mobility services supports strategic decision making and offers guidance for firms, public authorities and end-users on the way towards a desired future in mobility services.

We had to focus on major aspects to keep the level of complexity manageable. Therefore, future research could focus on success factors, impact analysis, and specific requirements for each stakeholder group.

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Keywords: inter-firm collaboration, mobility services, Delphi, scenarios, multi-stakeholder

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FUTURE OF LOGISTICS IN EMERGING COUNTRIES – A DELPHI-BASED SCENARIO STUDY

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INTRODUCTION

Numerous academic articles and popular science have credibly discussed that emerging countries such as Brazil, China, India, Mexiko, Russia, or South Africa represent the new playground for future growth (e.g. Vivanco-Aranda, Mojica, & Martínez-Cordero, 2011; Wu & Pangarkar, 2006). Double-digit growth rates in terms of gross domestic profit have been realised in the past and are expected to prevail in the future. However, in order to operate successfully in these fast growing markets, modern logistics services, intermodal transport, and the application of information technology in materials management and physical distribution have to be in place (Chen, Tian, Ellinger, & Daugherty, 2010; Memedovic, Ojala, Rodrigue, & Naula, 2008). Changing the perspective on this topic, emerging countries have to recognise the need to engage in improving their logistics and transportation capabilities in order to benefit from globalisation and the trend for global supply chains (Memedovic, et al., 2008). In addition, studies have shown that improvements in logistics systems and processes have a tremendous effect on emerging countries' economic growth.

To date only few scientific research articles address the topic of future developments of logistics in emerging countries. Though, several articles that describe various types of foresight activities in emerging markets can be identified (e.g. Chakravarti, Vasanta, Krishnan, & Dubash, 1998; Ribeiro, Brashear, Monteiro, & Damázio, 2009; Vivanco-Aranda, et al., 2011; Wu & Pangarkar, 2006), indicating the strong need for long-term outlooks in emerging countries. Effective decisions are a challenge since emerging countries are characterised by high dynamic institutional change, a lack of transparency of decision-making, and the opaqueness of regulations (Hoskisson, Eden, Lau, & Wright, 2000). Dynamic institutions and frequent changes in the market environment therefore require long-term orientation in order to prepare for future changes to come (Nielsen & Thangadurai, 2007).

Consequently, the purpose of this paper is to study how the transport and logistics industry in emerging countries might evolve in the long-term, elaborating on both managerial and governmental implications.

METHODOLOGY AND RESEARCH APPROACH

Methodology

To study how the future of transportation and logistics may evolve in emerging countries, we conducted a global, real-time Delphi study (Gnatzy, Warth, von der Gracht, & Darkow, 2011) with focus until the year 2030. The Delphi technique is considered as an valuable approach to structure a group communication process and allows expert to effectively deal with complex problems (Linstone & Turoff, 1975). Furthermore, the Delphi method has proven as appropriate in research contexts where insufficient data on a topic is available (Czaplicka-Kolarz, Stanczyk, & Kapusta, 2009; Rowe, Wright, & Bolger, 1991) which appears to be the case when studying the future of transportation and logistics in emerging countries.

Unlike conventional Delphi studies, our real-time Delphi survey was not based on sequential survey rounds. Once experts provided their initial assessments for a certain

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projection, they received immediate feedback on how other peers evaluated the projection and which arguments they provided. Thus, experts could immediately see whether or not they are aligned with the group opinion or deviated from it.

Within the scope of our survey, designated transport and logistics experts were asked to assess 16 future projections with regard to their probability of occurrence (EP), impact on the transport and logistics industry (I), desirability (D), and to provide qualitative rationales for their assessments. While probabilities had to be assessed on a scale ranging from 0 to 100 percent, impact and desirability had to be evaluated on a five point Likert-scale where 1 represented a very low and 5 a very high assessment. Comparable research designs have already proven to be adequate for such foresight activities (e.g. Ogden, Petersen, Carter, & Monczka, 2005; von der Gracht & Darkow, 2010). In addition to these quantitative assessments, experts were motivated to provide rationales for their assessments. To do so, they could fill out corresponding text fields for EP, I, and D.

Selection of experts and participation analysis

The selection of appropriate experts is an important success factor for a Delphi study since panellists significantly influence the reliability of research results (Welty, 1972). Consequently, we paid particular diligence in expert selection and combined various approaches to identify reasonable participants. First, we conducted intensive desk and database research for experts in the field of transportation and logistics in emerging countries. We considered experts appropriate who wrote relevant papers, held key-note speeches or who worked in relevant organisations. Second, we cooperated with one of the world’s leading advisory firm with profound experience in transportation and logistics advisory that activated its network of clients for the survey. Finally, we levered our research institutes network and contacted emerging market experts who exhibited special knowledge on transportation and logistics in emerging countries. As a result of these activities, we identified a set of 846 potential experts for our Delphi survey.

The final expert panel (23% academics, 11% politicians, 56% practitioners, in total 87 participants) comprised top-level representatives from 28 different countries (49% from emerging countries) from around the globe. Identified experts were active in transportation and logistics, subject matter experts in strategy, experts from business associations, and academia. Even though there are not strict rules for the optimal panel size for a Delphi survey, we are confident that an expert panel of 87 participants sufficiently exceeds the recommendation of having at least 30 participants in a Delphi survey (Parentè & Anderson-Parentè, 1987; Skulmoski, Hartman, & Krahn, 2007).

A response analysis shows that the Delphi process was very dynamic. During the survey process of eight weeks each participant took part on average in 2.1 Delphi rounds (i.e. first and second round per projection as well as 1.1 further logins for revision purposes). The maximum number of rounds measured was seven. After conclusion of a full survey cycle, i.e. first and second round screens of all projections, a consensus portal was activated which gave an overview of the current divergences from the group. From this point on, the respondent could access each thesis separately at any time until closure of the portal in order to check for updates and to revise own estimates. The group discussion came up with 840 written arguments equalling 9.3 comments per expert on average. The large number of comments underlines the quality of the data.

RESEARCH FINDINGS

Quantitative results

Within the scope of the Delphi survey and the expert communication process, an opinion convergence (CV) for all 16 projections could be achieved which is expressed in a percentage decrease in standard deviation (SD). On average, we observed a convergence rate of 12 percent (M=12.09, SD=4.56). Consequently, we could observe an agreement process over time during the ongoing discussion process and an approximation towards consensus. For 12 out of 16 projections, we achieved consensus which we defined by an interquartile range (IQR) of not larger than 1.20 (De Vet, Brug, De Nooijer, Dijkstra, & De Vries, 2005; Scheibe, Skutsch, & Schofer, 1975). Besides, we observed that experts increased their EP estimates for 10 projections and decreased estimates for the remaining 6 projections. Table 1 summarises the quantitative findings of our Delphi survey.

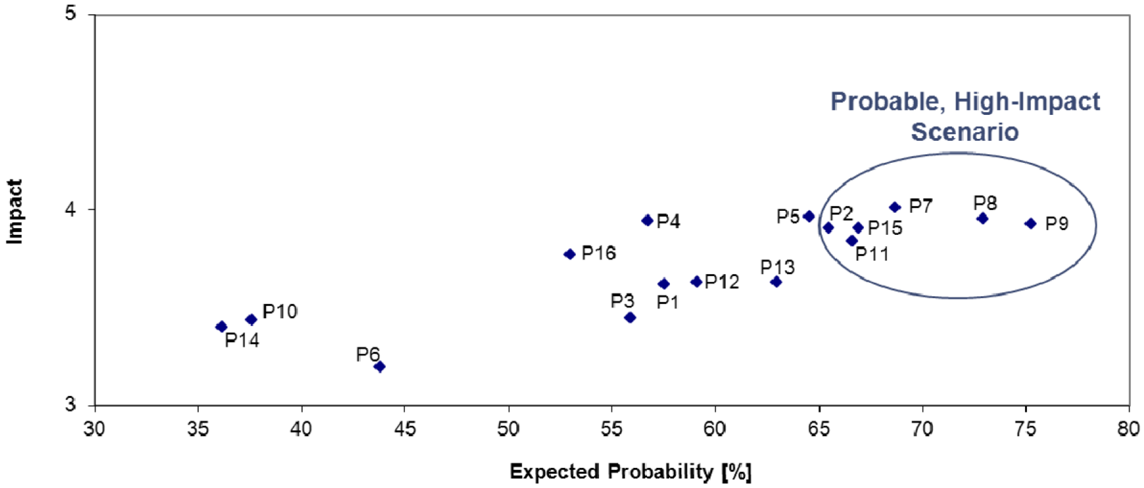
Table 1: Quantitative Delphi study results

No.	**Projections on Logistics in Emerging Countries**	**EP Final**	**EP First**	**I**	**D**	**IQR**	**CV**
1	Logistics companies in emerging markets continue to suffer from inadequately designed mechanisms for law enforcement (e.g. customs. capital collection etc.).	57.5	55.4	3.6	1.6	20	-12%
2	The establishment of free trade zones have fostered strong economic growth in emerging markets.	65.5	64.8	3.9	3.8	20	-8%
3	Social networks and personal contacts (e.g. Blat in Russia and Guanxi in China) have become key determinants of the supply chain structures in emerging markets.	55.9	55.7	3.4	2.5	20	-15%
4	Privatisation of state-owned transport organisations has reduced the role of government from major player to 'watchdog' in emerging markets.	56.7	56.0	3.9	3.8	20	-8%
5	The transport and logistics industry has become a focus area for (foreign direct) investment in the emerging markets.	64.5	64.2	4.0	4.0	12.5	-13%
6	Major infrastructure projects between emerging markets and least developed countries are primarily realised via barter trade (i.e. swaps of goods & services rather than cash).	43.8	46.7	3.2	2.8	30	-12%
7	Global trade flows have shifted such that new transportation corridors between emerging countries and least developed countries have been established.	68.7	67.3	4.0	3.9	20	-11%
8	Logistics service providers in emerging countries have strongly increased their depth of added value (i.e. they offer value-added services such as packaging, labelling, mounting).	72.9	71.4	4.0	4.0	10	-15%
9	Multinational logistics service providers have entered the domestic logistics markets in emerging countries.	75.3	74.0	3.9	3.7	10	-15%
10	Logistics service providers from emerging countries have gained significant market share in developed countries.	37.6	45.0	3.4	3.2	20	-21%
11	The logistics service industry in emerging countries has undergone a strong process of consolidation.	66.6	64.1	3.8	3.7	20	-14%
12	Promising career perspectives in emerging countries have attracted large numbers of skilled logistics professionals from developed countries.	59.1	61.0	3.6	3.4	20	-8%
13	The CEP market (Courier. Express. Parcel) in emerging countries has experienced the highest growth rate in the logistics industry.	62.9	63.0	3.6	3.3	25	-8%
14	Low-tech logistics solutions from emerging countries have flooded the markets in developed countries.	36.1	38.9	3.4	2.2	27.5	-21%
15	Domestic logistics service providers in emerging markets have significantly increased the level of automation in their logistics processes.	66.9	66.3	3.9	3.9	20	-8%
16	The centres of gravity in transport and logistics (e.g. innovations, technology, headquarters, and standards) have shifted to emerging markets.	53.0	53.5	3.8	3.2	25	-6%

For the development of a probable scenario, we studied which projections were assessed with the highest probability of occurrence. Thereby, we developed a strategic map which plots surveyed projections on a two-dimensional diagram (EP and I). While the axis of abscissa represents probabilities of occurrences, the axis of ordinates represents projections impact on the transport and logistics industry in emerging countries. Clustering around those two dimensions has been proven reasonable to derive appropriate actions and strategies (Akkermans, Bogerd, Yücesan, & van Wassenhove, 2003; Ogden, et al., 2005). As it can be seen in Figure 1, projections strongly vary in terms of their probability and impact. Since we want to draw a picture of a probable scenario, we consider only those projections with the highest probability of occurrence and define the cutting line for projections with a probability of occurrence of at least a 2/3 chance. Consequently, six projections of our Delphi survey have to be considered.

Figure 1: Strategic map for scenario development: Probability vs. Impact

Estimated probability of occurrence (0-100%) Impact (5pt.-Likert scale), 5=very high



Future of Logistics in Emerging Countries – a probable scenario

The findings show that six projections (P) are likely to describe a probable scenario (P2, P7, P8, P9, P11, P15). Tributary to the quantitative results for the probable projections, we conducted an in-depth qualitative analysis and studied the rationales provided by participating experts. As such, more than 850 qualitative arguments from the expert panel discussions additionally enriched the scenario writing and identification of influencing factors. Those rationales helped to comprehend experts' quantitative assessments and provide valuable input for the scenario writing process.

In order to proceed in a scientifically sound way to analyse the provided arguments, two academics conducted a coding exercise and coded the provided arguments. The results of these coding activities are reflected in the subsequent scenario descriptions.

> *2030: The establishment of free trade zones have fostered strong economic growth in emerging markets. (P2).*

Liberalised conditions for cross-border trade, as signalled by free trade agreements, have been an important factor in the development of international trade flows. Thereby, governments typically subsidise companies which relocate inside the zones, making them particularly attractive for manufacturing and exporting companies (Miyagiwa, 1986). The main objective of free trade zones is to attract foreign direct investments by facilitating market entry for foreign investors. In emerging countries, the number of free trade zones and similar arrangements is expanding rapidly. Currently 600 special economic zones are in the approval process in India. Free trade zones have also been established in Brazil, China, Mexico, Russia, South Africa, Turkey, and additional emerging countries. However, free trade zones alone are no guarantee for obtaining higher growth rates or attracting foreign direct investments. Though, certain factors significantly increase the likelihood of success, e.g. quality infrastructure, a supportive government, lighter regulation, strong export focus and large warehousing and handling capacities (United Nations, 2005). Several of these elements relate directly to the transportation and logistics (T&L) industry.

The Delphi experts argue that free trade zones will facilitate opening markets for international trading partners, providing benefits especially for those economies that are strong in export. In addition, free trade zones can support further globalisation if strategically located inventory buffers are established, allowing exporters to respond with quicker lead times to demand from the destinations which they serve. A closer look at the amount of foreign direct investment flowing into emerging countries suggests that the establishment of free trade zones may also have been a factor contributing to the recent upswing. For many emerging countries, free trade zones will help spur economic growth and logistics services providers will need to adjust their service offerings to serve these trade hot spots. The establishment of free trade zones and resulting increases in foreign direct investment will lead to above-average growth of the transportation and logistics industry in emerging countries.

> *2030: Global trade flows have shifted such that new transportation corridors between emerging countries and least developed countries have been established. (P7).*

A number of emerging countries have become centres of strong growth, increasing their shares of global capital significantly, which has made them major players in regional and global business. At the same time, some former competitive advantages, e.g. low labour costs, are decreasing. In order to stay competitive and keep production costs at a low level, as well as satisfy the domestic market, emerging countries have begun to source in neighbouring countries, other emerging countries or least developed countries. In order to satisfy growing demand, new trading relations are emerging and new transport corridors will establish. Increases in transport volumes will also require suitable transport infrastructure.

The development of new trade corridors is already underway to support Intra-Asian trade and increasing trade flows between Asia and other regions such as Africa and Latin America. Logistics companies are responding to new trading and investment patterns and adjusting their schedules accordingly. Many of the new trade flows will bypass developed countries. Panellists noted that this type of shift will affect talent development, planning and capacity cycles, as well as infrastructure development. The main trade corridors will relocate the growth regions for transportation and logistics operators from Asia to Africa, from South America to Asia and on the Asian continent. Asia and the emerging counties represent evolving economic powerhouses which will drive and shape the direction and future of global transport corridors. Many logistics companies are looking to respond to the development of new transport corridors, however the sheer geographic size of emerging countries and the multitude of cultures, attitudes and languages require a significant investment. Further, companies must be willing to adapt to the local markets where they wish to expand. Logistics service providers will need to take a targeted approach, which will require taking an active part in the design process of new transport corridors, developing adequate structures and pricing systems and initiating and building logistics clusters.

> *2030: Logistics service providers in emerging countries have strongly increased their depth of added value. (P8).*

As economic prosperity increases, customers will become more demanding in terms of quality and price. While logistics service providers in emerging countries frequently have limited their range of products to basic services like conventional transport in the past, suppliers of such a constricted service portfolio may find it increasingly difficult to satisfy future customer demands. Manufacturing companies in emerging countries will seek new opportunities to increase margins, become more efficient, and to focus on core competencies. As a result, the demand for value-added logistics and third party logistics services is expected to increase.

Such a shift is seen to have a strong impact on the industry, as the increase in the depth of added-value service offerings signifies an improvement of service level, quality and talent management. Further, it offers sustainable growth opportunities, higher profit margins and the opportunity to become internationally competitive. Notwithstanding, not every logistics service provider in emerging countries will be able to increase its range of value-added service offerings, due to financial restrictions or lack of capabilities.

> *2030: Multinational logistics service providers have entered the domestic logistics markets in emerging countries. (P9).*

Emerging countries have long been target markets of leading multinational logistics operators. Our research suggests that additional multinational logistics companies will have successfully entered the domestic logistics markets in emerging countries by 2030.

This means that multinationals will not only operate in emerging countries for advantages in international trade, they will also engage and operate in the domestic logistics markets. Experts point out that the rising number of market players, both international and domestic, will lead to increased competition and consolidation of the logistics industry in some emerging countries. The Delphi panellists further discuss appropriate modes of market entry and highlight the relevance of joint ventures and other collaborative forms. Such partnerships are often beneficial for both multinationals as well as domestic companies in emerging countries. In this win-win situation, multinationals profit from accessing valuable knowledge from their local partners, while domestic logistics service providers will benefit from technology transfer and expertise brought into their market.

> *2030: The logistics service industry in emerging countries has undergone a strong process of consolidation. (P11).*

Some phases of industry development already seen in developed countries are likely to be repeated in emerging countries. The number of logistics service providers in BRIC countries currently exceeds the tens of thousands mark (US Commercial Service, 2008). The spread ranges from one-man businesses to large companies with several thousand employees. Consequently, differences in competitiveness, financial resources and offered services can be observed. Small logistics companies with limited capital resources will aim to grow organically, while larger and financially-better equipped logistics companies will target growth by looking for suitable mergers and acquisitions (M&A) (AT Kearney, 2010). Consolidation of the logistics markets in emerging countries will be the consequence. The number of cooperation agreements or joint ventures is also likely to increase, some of which may eventually lead to further M&A. Analyses suggest that consolidation activities are already taking place in a number of emerging countries. The relative interest in Asia and Oceania targets (when deals are measured by target region) has grown significantly compared with deals targeting entities in other regions. Asia and Oceania targets accounted for 69% of deal volume announced in the second quarter of 2010, compared with 49% of volume announced in 2009 (PricewaterhouseCoopers, 2010).

Panelists argue that consolidation is a natural part of the maturation of an industry sector. Furthermore, the experts assert that consolidation is a necessary step towards achieving economies of scale in an industry which is as strongly fragmented as the logistics industry in emerging countries. Nevertheless, they also observe forces which could deter consolidation: socio-political instabilities in some emerging countries may complicate consolidation activities and state-owned companies have powerful positions in a number of emerging countries and may leverage their powerful position to decelerate consolidation waves.

> *2030: Domestic logistics service providers in emerging markets have significantly increased the level of automation in their logistics processes. (P15).*

Logistics processes in developed countries have been optimised and improved constantly in the past. Consequently, many transportation, handling and warehousing processes have become highly automated. In contrast, emerging countries are frequently characterised by very low labour costs and low levels of automation. Especially in the field of logistics, a large portion of logistics processes in emerging countries are conducted manually. The participants rate significant improvements in the use of automation in logistics processes as highly probable. Nevertheless, they argue that there are some factors which may put the brakes on the process of enhancing automation logistics processes in emerging countries. As long as labour costs are quite low, investments in technologies which allow increased automation do not pay off fast enough. One expert also notes that some shippers may not try to push automation too far in order to preserve employment levels. The logistics service industry in emerging countries will increase its level of professionalism, partly driven by strong commitment, technology and know-how transfer of multinationals in their markets.

CONCLUSION AND OUTLOOK

The world's supply networks are changing. New trade corridors are already becoming visible and those companies and countries able to capitalise on them will benefit most from the evolution of global trade. As emerging countries continue to grow, there will be a host of opportunities for logistics service providers of all sizes. Some of these will stem from the sharing of a whole range of good practices that are commonly used in developed countries, but not yet fully implemented in many emerging countries. These include strategies for managing people, such as diversity management, managerial accounting systems including the use of KPIs, sharing lessons learned during past liberalisation processes and developing robust corporate social responsibility practices and reporting. Others may involve emerging countries providers who are able to act as advisors to those entering their marketplace, to help scout out suitable acquisition targets, as just one example. Most importantly, though, logistics companies will need to develop or fine-tune their own specific strategies for operating in diverse emerging countries. They will need to understand how government regulation in each market affects them, be it changing customs procedures, the establishment of free trade zones, incentives for foreign direct investment or new sustainability requirements. This may mean adapting their service portfolio not once, but many times, as demand patterns change and emerging countries develop.

The value of our research is threefold: First, we bridge the research gap with respect to the importance of the transport and logistics industry in emerging countries. Second, we illustrate a real-time Delphi study to provide valid and reliable data for scenario planning. Thereby, our findings enable and support decision makers in updating, developing, or evaluating strategies regarding their future-robustness and adequacy. Finally, such a long term outlook offers thought-provoking impulses for strategic planners, governmental organisations, and further stakeholders to best prepare themselves for the future of transportation and logistics in emerging countries.

However, we had to focus on major aspects to keep the level of complexity manageable, realizing that numerous additional factors might exist that are relevant for the future development. Therefore, subsequent research could both address those projections which may have been left unanswered and focus on single regions to derive even more specific guidelines for involved stakeholder groups.

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Keywords

Emerging countries, transportation and logistics, Delphi, Foresight, Future

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SUPPLY CHAIN PROFESSIONAL COMPETENCIES:
INSIGHTS FROM INDUSTRY AND THE CLASSROOM

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ABSTRACT

Recent focus on various definitions of the 'supply chain professional' reflects the increasing role of supply chain management in business education. Much of this attention has been devoted to the 'functions' and related competencies of such professionals. Less attention has been given to the pedagogies required to support education in this field. Drawing on a parallel literature on post-experience/executive education pedagogies this paper explores their suitability in responding to educational needs in the supply chain management field. A series of round table discussions and in-depth interviews with senior supply chain managers/directors informed our understanding of supply chain professional competencies. Two popular pedagogies, case study-based and practice-based, were considered. Practice-based learning appears best suited to industry requirements and associated supply chain management competencies. However, limitations of this approach are also noted, in particular programme design should challenge learners and expand their mental models.

Keywords:
Supply chain professional, skills, competencies, pedagogy.

INTRODUCTION:

Given the growing role of supply chain management (SCM) the notion of a supply chain professional has attracted increasing attention. However, SCM skills and competencies raise quite a debate not only because of the wide variety of definitions of SCM but also due to the contested nature of skill and competency development. In this context educators have been challenged to respond to emerging needs (Aquino and O'Marah, 2009). This paper shares exploratory field work and pedagogical experiences in this field and thus aims to contribute to the discourse on supply chain professional competencies and associated educational programme design and delivery.

This paper reports on the first stage in a study that seeks to inform educators as to the pedagogies that respond best to a growing cohort of supply chain management professionals. This stage of the study focuses on supply chain management competencies as identified by senior management across a range of industries. The paper reports on the findings emerging from this exploratory work and also provides a synopsis of a review of pedagogical approaches adopted in post-experience/executive education programmes in Higher Education Institutes (HEIs). The next stage of this research will evaluate the impact of various pedagogies on competency development within the supply chain management field.

We commence by providing a brief review of both academic and practitioner literature on SCM competencies; following this we critique two popular pedagogical approaches adopted in post-experience/executive education; insights from the classroom are shared and frame subsequent discourse; this is followed by presentation and discussion of the key competencies that emerged from interaction with industry stakeholders; in this context the merit of a practice-based pedagogical approach is briefly considered; and finally conclusions.

SUPPLY CHAIN PROFESSIONAL COMPETENCIES

Gammelgaard and Larson (2001) provide a useful insight into supply chain competencies. Drawing on Bramming (1998) they classify skills as general rules that can be taught in a classroom and as such may be context-independent knowledge whereas competencies are context specific. Thus competencies are experience-based and context-dependent knowledge that is gained through organizational experience. Thus they concur with Dreyfus and Dreyfus' (1986) argument that "a competent practitioner makes decisions based upon rules and analysis, but with organizational experience can depart from rule-based analysis and make synchronic, intuitive, and holistic decisions" (p. 27).

Skills/competencies are usually classified as function specific or management-related, for example Tassabehji and Moorhouse (2008) group basic and advanced procurement skills and consider these as prerequisites to management skills, which they present as a progression from basic interpersonal skills through internal enterprise skills and external enterprise skills to strategic business skills. Mangan and Christopher (2005) also emphasise the importance of both functional depth and horizontal cross-functional understanding. Aquino and O'Marah (2009) argue that the 'old model' of recruiting on the basis of functional expertise needs to evolve with the evolution of the supply chain – i.e. a focus on business processes across functional areas. Thus they find that the SCOR model offers a useful classification of functional skills – i.e. Plan, Buy, Make, Deliver – that in turn are based on prerequisite business skills. Since they base their framework on demand, supply, and product design networks they also suggest three additional functions - Customer Service, Post-Sales Support and New Product Development Launch. These functions are supported by four 'enabling stations': Performance Measurement Analytics (ability to choose and define appropriate measures for supply processes), Technology Enablement (SC professionals should not 'own this' but should influence it), Governance (ability to understanding far-reaching consequences of decisions), and Strategy and Change Management (value engineers). Thus the role of the supply chain professional knowledge worker is increasingly evident, indeed in their survey of senior logistics managers' view of subordinates Myers *et al*. (2004) found decision-making and problem-solving as key predictors of employee performance. Thus a distinction between basic, function-specific and management competencies is increasingly recognised in the SCM field.

Aquino and O'Marah (2009)investigation of the management development in the SCM field supports this as all three stakeholders (educators, graduate students, executive education participants) in their study identified Interpersonal, Change Management, and Leadership as key competencies. It is interesting to note that both educators and graduate students identified 'Analytical' while executive education participants identified Project Management. In addition to engaging with these stakeholders they also conducted a case study of a global pharmaceutical company. The findings from this case study point to an employer interest in moving from a passive learner role to a more proactive learner role. Their investigation (confined to educators and graduate students) of preferred teaching modes identified a preference for proactive methods such as cases, simulations and site visits, in addition to lectures. Thus this study points to a learner centred pedagogy, with a preference for (or possibly exposure confined to) a classroom-based approach using simulations and games. The next section focuses on learner centred pedagogies in the post-experience/executive education sector.

PEDAGOGICAL APPROACHES – RESPONDING TO POST-EXPERIENCE EDUCATION

Post-experience education offers considerable growth opportunity in the Higher Education Institutions (HEIs), but also requires a rather different pedagogical model to that dominant in full-time educational programmes. Delivery to executive cohorts is influenced by both age (impacting on learning patterns) and the basis of engagement (post-experience and often part-time). In the HEI sector pedagogical models have been somewhat adapted to deliver full-time postgraduate management programmes that include older and more experienced participants, for example case-based work offers the opportunity to pursue student-led learning. However, the second dimension, basis of engagement, requires quite a fundamental pedagogical change. This typically requires an iterative learning process between both the classroom & the workplace and the between theory & practice. The role of such experiential learning is further influenced by participants' motivation to pursue executive education. A shift in recent decades from individual aims to corporate-based learning is evident. Hence the ability of the provider to engage not just with the student and with the student's broader environment but also with the corporate world is of paramount importance. This requires a rather different philosophy, structure and culture to that normally found within a traditional University. Of course over recent decades leading business schools have based much of their success on the development of these capabilities. The influence of not only full-time and but also executive MBA and other open & customised executive education programmes on business school rankings has reinforced the need to develop such pedagogical and delivery approaches.

While in many respects the 'classroom case-based pedagogy' is still dominant in full-time MBA programmes, there is a growing recognition of the role of a more practice-based approach, if not outright opposition to it from some quarters. Henry Mintzberg's *Managers Not MBAs* (2004) reflects a growing disillusionment with case-based MBA teaching, indeed this publication has become something of a rallying cry for change. This movement toward a more iterative approach to learning 'management practice' is increasingly evident in the wider portfolio of executive education. In particular the rising number of part-time students in employment creates the demand and environment for such an approach. Joesph Raelin of Northeastern University, US, a long-time advocate of 'practice-based learning' recently declared: "*Part-time students may also begin to resent, rather than tolerate, the spoon-feeding of information devoid of contextual appreciation of their workplace problems*" (2009:409).

A review of the development of executive education since the 1960s reveals changing learning needs, learning content, pedagogy, instructors, participant mixes, and organizational integrating mechanisms. From the 1960s to the 1980s MBA education mainly addressed strategic and functional learning needs. During the 1990s pedagogy began to evolve from theory-based to more applied approach largely in response to changing learning needs that often emerged from organisational change. In response to changing organisational structures and 'hyper competition', leadership and change management became increasingly prominent in programme content during this decade. The level of customisation has gathered momentum as participants changed from an individual orientation to a corporate orientation and leading business schools typically offer a range of open and customised executive education programme (Conger and Xin, 2000; Raelin, 2009).

Thus increasing attention has been devoted to 'communities of practice' and 'situated learning' over the last two decades (Schwen and Hara 2003; Taylor 2003; Wilson 1995). Indeed the subsequent success of executive education programmes will be increasingly assessed by measureable change achieved by graduates in the workplace compared to the simple post-session evaluations that we were accustomed to in previous decades[3]. Hence it is likely that the iterative learning process as identified above will become increasingly evident in programme pedagogy. Schwen and Hara (2003) highlight the

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[3] This trend is also evident in the training arena, for example the higher levels of the popular Kirkpatrick model and in particular the recent addition of a fifth level, return on investment by Jack Phillips (Kirkpatrick, 1994).

emergent nature of communities of practice and the need to be aware of their characteristics in order to nurture them.

INSIGHTS FROM THE CLASSROOM - POST-EXPERIENCE/EXECUTIVE EDUCATION

The authors have been involved in the development and delivery of a range (from undergraduate certificate to postgraduate masters levels) of part-time programmes in SCM over the past ten years. From the outset these programmes have adopted a practice-based approach. While module and annual programme feedback has been gathered and periodic programme reviews have been carried out, as is the norm, the authors wished to review and test their pedagogy in a more rigorous manner. This study aims to address this objective. As indicated above, this paper reports mainly on interaction with industry to identify SCM competencies, however a review of pedagogical approaches and application in the classroom has also framed the conceptual boundaries of this study. Thus the brief practical insight offered here while anecdotal is germane to interpretation of approaches to practice-based pedagogies and also provides the field laboratory to test emerging pedagogical approaches in the next stage of the study.

The design and delivery of this post-experience education in the SCM field has incorporated 'communities of practice' and 'situated learning'. In this context the role of action research, student-student and tutor-student interaction provides a platform for theory testing and critique and promotes an improvement-oriented dynamism within the learning community[4]. This has facilitated learning and application though specified assignment work including structured improvement projects such as the Lean SCM Green Belt and Lean SCM Black Belt projects in addition to various company-based assignments associated with modules. This is an interesting challenge, as a balance between education and training is fundamental to the academic standing of our SCM programmes. Thus students are not expected to merely complete company-based projects of commercial significance but to broaden their mental models by learning how to adapt to real changes in the business environment. This programme delivery model requires a partnership approach between the HEI and both client companies and practitioners. This has been facilitated through relationship building with companies in the region and further afield and working with various practitioners. A strong international and industry practitioner panel has been developed.

Given the shift from individual aims to corporate-based learning highlighted above and the related interest in situation-based learning, further exploration of employers' views of supply chain professional competencies would better inform pedagogical developments. Indeed Mangan and Christopher (2005) find their case study work insightful and call for further examination of link between the individual, organisational and supply chain learning. Hence an interaction project with employer stakeholders was launched to better understand their perspectives and requirements.

INTERACTION WITH INDUSTRY STAKEHOLDER:

Two sources of empirical data were used to explore industry's perspective, emerging definitions and scope of the SCM professional: A Supply Chain Round Table[5] group consisting of six senior supply chain managers across a wide range of industries; and three in-depth interviews with senior supply chain managers/directors, also across a range of industries (software, medical devices, and electronics). Two successive Round Table SCM surveys and workshops were held to (i) identify the competency set that is present in strong, highly capable SCM Professionals and (ii) identify 'technical competencies' and discuss how these competencies can best be developed.

In-depth interviews further explored key workshop findings. We focused on multinational subsidiaries that have established global supply chain centres of excellence. Interviews

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[4] In line with Gosling and Mintzberg (2006).

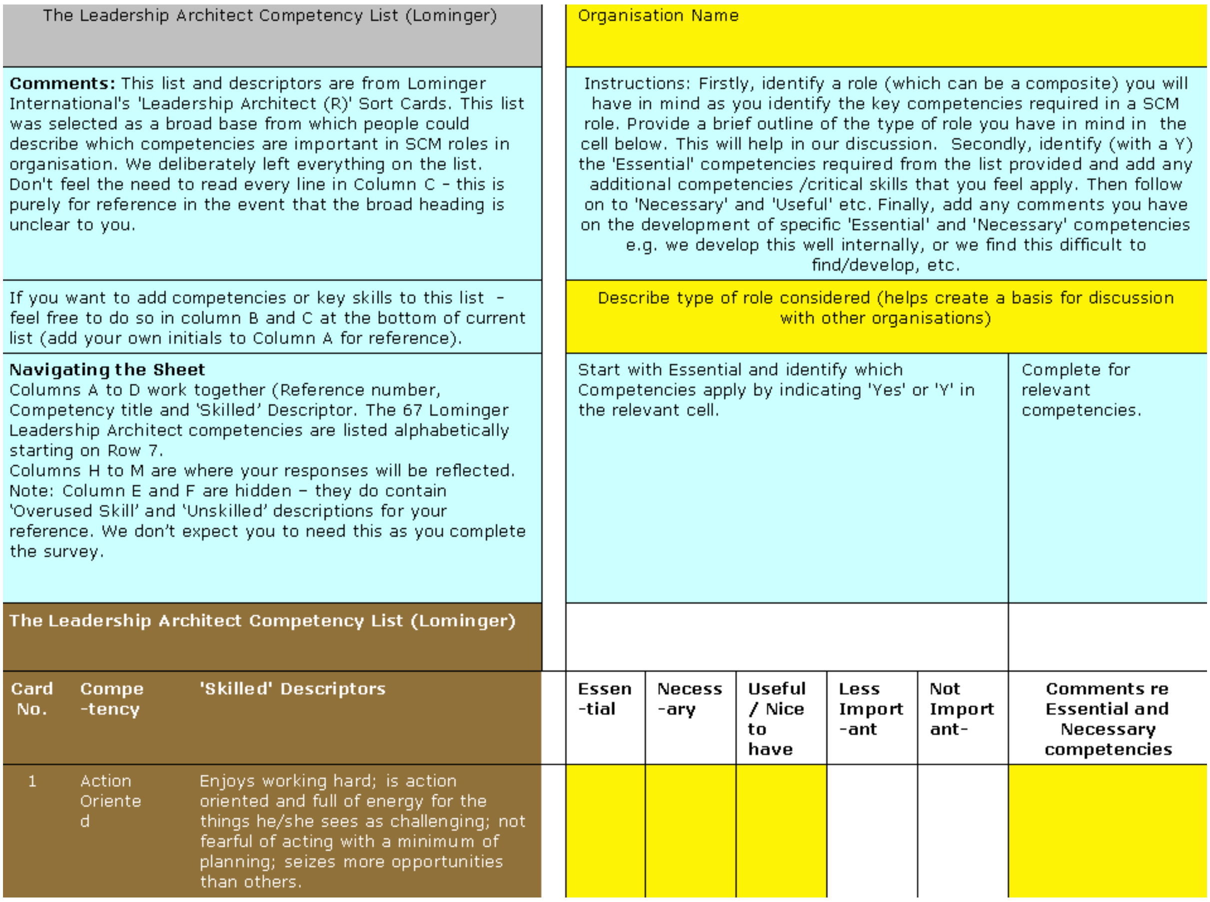
[5] The authors facilitate regular Supply Chain Management Round Table discussions. Membership is confined to senior supply chain managers and by invitation only.

were carried out with the Global Supply Chain Director in each case. In cases where the incumbent in this position had moved to another function, both successor and initial incumbent were interviewed.

The Round Table session prior to the first survey included a discussion of the definition of supply chain and supply chain management. Various perspectives were evident, including: a 'supply chain strategic orientation', internal & external flow of information, materials and finance, and business process management. This discussion also highlighted the impact of the supply chain position or role of the incumbent in question on the desired set of skills/competencies. Therefore, a 'mid-level' position was suggested as this would provide opportunity to consider the competencies that supported career advancement. In this context leadership/emergent leadership competencies were considered important.

In preparation for the next Round Table workshop participants were circulated a competency questionnaire based on Lominger's Leadership Architect list. The rationale for choosing a list was to provide respondents with a frame of reference. The Lominger list was used as this is a comprehensive generic list and as such did not prompt respondents through the use of SCM biased terminology. The survey was an Excel enabled self-completed questionnaire that provided respondents with the opportunity to comment on each 'competency' if they wished to do so and also add to the list. Figure 1 illustrates a snapshot of the questionnaire format and includes instructions given to respondents and one example, 'action-oriented competency'. As evident from figure 1 respondents were asked to rate each competency on the following scale: essential, necessary, useful, less important, and not important. Given the length of the list and the purpose of the survey they were encouraged to focus on the competencies that they considered essential first and work down through the entire list, and continue through each 'importance' level in this manner.

The responses to these preparatory questionnaires provided the agenda for the next Round Table discussion. This workshop found the Lominger 'competencies' provided a good profile of 'soft competencies'. The key competencies identified were grouped into two levels. Level one included: negotiation, customer focus, composure, 'decision quality', comfort around senior management and business acumen, while Level two included: conflict management, priority setting, 'drive for results', directing others, organising and timely decision-making. These reflect the importance of leveraging interpersonal skills and knowledge-worker activity and as such reflect the emphasis placed on progression from functionally-bound to 'management competencies' evident in the literature reviewed above.



The Leadership Architect Competency List (Lominger)

Organisation Name

Comments: This list and descriptors are from Lominger International's 'Leadership Architect (R)' Sort Cards. This list was selected as a broad base from which people could describe which competencies are important in SCM roles in organisation. We deliberately left everything on the list. Don't feel the need to read every line in Column C - this is purely for reference in the event that the broad heading is unclear to you.

Instructions: Firstly, identify a role (which can be a composite) you will have in mind as you identify the key competencies required in a SCM role. Provide a brief outline of the type of role you have in mind in the cell below. This will help in our discussion. Secondly, identify (with a Y) the 'Essential' competencies required from the list provided and add any additional competencies /critical skills that you feel apply. Then follow on to 'Necessary' and 'Useful' etc. Finally, add any comments you have on the development of specific 'Essential' and 'Necessary' competencies e.g. we develop this well internally, or we find this difficult to find/develop, etc.

If you want to add competencies or key skills to this list - feel free to do so in column B and C at the bottom of current list (add your own initials to Column A for reference).

Describe type of role considered (helps create a basis for discussion with other organisations)

Navigating the Sheet
Columns A to D work together (Reference number, Competency title and 'Skilled' Descriptor. The 67 Lominger Leadership Architect competencies are listed alphabetically starting on Row 7.
Columns H to M are where your responses will be reflected. Note: Column E and F are hidden - they do contain 'Overused Skill' and 'Unskilled' descriptions for your reference. We don't expect you to need this as you complete the survey.

Start with Essential and identify which Competencies apply by indicating 'Yes' or 'Y' in the relevant cell.

Complete for relevant competencies.

The Leadership Architect Competency List (Lominger)

Card No.	**Compe-tency**	**'Skilled' Descriptors**	**Essen-tial**	**Necess-ary**	**Useful / Nice to have**	**Less Import-ant**	**Not Import ant-**	**Comments re Essential and Necessary competencies**
1	Action Oriented	Enjoys working hard; is action oriented and full of energy for the things he/she sees as challenging; not fearful of acting with a minimum of planning; seizes more opportunities than others.						

Figure 1: SCM Leadership Competency Survey

The group also found that a 'Technical' skill/competency set also needed consideration. The SCOR model (148 skills referenced in SCOR 10.0) was selected as a framework for this. A similar methodology was followed in that a questionnaire based on SCOR skills was sent to participants for competition prior to the Round Table discussion. Given the high number of skills in SCOR 10.0 four broad functional areas were selected (purchasing, warehouse & logistics, customer service and planning & inventory) and participants were asked to rank each skill on a scale of 1-5 as follows: 5 = Essential; 4 = Necessary; 3 = Useful but not necessary; 2 = less useful; 1 = not relevant/useful. SCOR competencies for each of the broad functional were ranking based on addition of the rating scores. It should be noted that relatively low composite scores and poor differentiation of skills for Purchasing were reported. This may be a reflection of the background of the respondents as it emerged that none of six senior managers had a background in this area. Therefore, we considered it prudent to set these results aside.

Competence in planning and scheduling activities (e.g. production planning, inventory management, master scheduling) group together as the most important in the Planning & Inventory area and these are supported by a competency in related systems (e.g. ERP systems). Similarly scheduling is relatively important after an overall competency in logistics in management in that function (e.g. Delivery scheduling and delivery balancing). It is not surprising that participants identified communications and relationship management competencies as most important in the Customer Services function. While participants reported that the SCOR lists were helpful when considering 'technical skills & competencies' the Round Table discussion that ensued was much more informative. This discussion reflects Aquino and O'Marah's (2009) approach whereby SCOR type functions (plan, buy, make, deliver) are based on prerequisite skills and complemented by management and decision-making capability. Their phrase 'value engineers' does much to capture discussion which very quickly moved from basic skills (e.g. numeracy and literacy) and functional application to value-add contributions such as improvement to current processes, decision-making and cross-functional activity. Of particular interest was the relationship between this progression from functional to value-add and the 'leadership competencies' identified from the first survey – i.e. the competencies that support value-add activity as distinct from execution of transactions. This supports Myers et al (20040 finding that decision-making and problem-solving are good predictors of employee performance. The Round Table participants emphasised the importance of both soft and hard skills and ability to recognise the interaction and trade-offs across functions. This reflects Mangan and Christopher's (2004:187) finding that the "ability to think in terms of process and flow" is a key competency.

Three in-depth interviews were conducted to delve deeper into the themes emerging from the Round Table discussion. The progressive development of supply chain management competencies at organisational level was of particular interest. Three multinational subsidiaries (electronics, medical device and software) that had established global supply chain centres of excellence were purposively selected for this in-depth interview phase. Subsidiary activities evolved in all cases beyond the initial mandate due to execution excellence. The supply chain functions associated with on-site activity included: procurement, planning, order fulfilment, logistics, and customer services. This supply chain mandate was linked to execution excellence. In all cases we find instances of international supply chain experience (at both individual and subsidiary levels) leveraged from opportunities/challenges presented by an extended mandate. Thus subsidiary management were interested in supply chain professionals with execution skills, but once proven these were leveraged to achieve value-add. This second level requires competence in project and systems management, both underpinned by strong inter-personal skills, to deliver company-wide services. Problem-solving and decision-making competencies were of particular importance to progression through level two, this reflects Myers et al (2004). Evidence of a third level also emerged from these interviews that reflect global organisational competencies as much as supply chain specific competencies. These competencies are centred on a global mindset and corporate citizenship. These findings support those of Mangan and Christopher (2005) with respect to executive education participants' rating of project management among their top four competencies.

PEDAGOGICAL APPROACHES THAT RESPOND TO COMPETENCY DEVELOPMENT

The objective of this research was to explore supply chain management competencies as identified by senior management across a range of industries and consider pedagogical approaches that respond to the educational demands that arise. The earlier review of pedagogical approaches finds an increasing interest in 'practice-based' approaches. Given the competencies identified in this study such approaches appear appropriate, as they support a learning environment within the workplace. This follows the conceptualisation of 'competencies' as experience-based and context-dependent knowledge. However a word of caution, as practice-based/situated learning may not offer the learner the opportunity to see beyond their current activity and role. Therefore, programme design (content, learning tools, and, especially, assessment) must expand the mental model of the learner, otherwise learners are bounded by their own experiences. Thus peer-to-peer learning (e.g. communities of practice), research-informed teaching and wider reading are all necessary elements of programme design. This exploratory study has pointed to rather well established competency development and application pathways in the context of achieving execution excellence, progressive achievement of intra and inter-organisational management. As one travels on this journey the territory becomes increasingly 'foreign'. This is particularly evident in the context of global organisations and global supply chains. As such these executives demand more advanced programme design that may go beyond current thinking with regard to practice-based pedagogies.

CONCLUSIONS:

This is a discursive paper that is informed by industry workshops and depth interviews. As such it contributes to the debate on SCM competencies and we hope is of interest to practitioners and scholars alike. In addition the impact of these findings on the role of pedagogic approaches adopted in management practice education should be of interest to educators and human resource managers. While practice-based approaches have enhanced the learning environment through extension of the classroom to the workplace, further consideration should be given to pedagogical approaches that support an environment that leverages execution excellence and broadens the learners experience.

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CHANGING REQUIREMENTS FOR MANAGERIAL SKILLS AND COMPETENCIES IN CONTEMPORARY SUPPLY CHAINS

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ABSTRACT

Contemporary supply chains are shaped according to new mega-trends such as globalization, security and risk problems, environmental and resource protection technological innovations , social responsibility, regulation and compliance with changing statutory requirement an demographic development. As human factor is one of the most important issues of supply chain and logistics , it is subject to essential transformation concerning a profile of skills and competencies. The major change of qualifications of supply chain managers consists of greater focus on “soft” managerial abilities and intercultural skills in global supply networks.

INTRODUCTION

World business is facing new challenges in the present millennium. Actual economic reality becomes constantly more difficult for companies due to a synergy of larger complexity and growing dynamics of business processes. It results in discontinuity of development of businesses, particularly in the environment troubled by economic recessions and cycles of shrinking business opportunities. Given high unemployment, financial regulations and escalating healthcare costs, the uncertain economy remains the number one driver behind Human Resource Management efforts forcing the organization to operate more efficiently, in order to secure company’s organic growth and achieve organizational growth goals.

Business problems resulting from the troubled economic environment are even more serious due to the fact that despite long-term efforts many companies have still not implemented concepts of mature holistic responsibility for customer-to-customer process in a supply chain. Typical supply chain systems business systems require customer-differentiated reliability, flexibility and cost efficiency.

The most important trends in supply chain management, such as globalisation, security requirements, the need to protect environment and spare resources, social responsibility, and also modification of business systems, require new competencies from logistics managers. This paper presents the profile of actual supply chains and indicates what challenges it creates for managerial skills and competencies.

MEGA-TRENDS IN CONTEMPORARY SUPPLY CHAINS

Important macroeconomic and social trends have a constant effect on the development of logistics and supply chains. Those trends constitute major challenges for logistics managers, who have to catch up with evolution of dynamic trends in corporate development. At the beginning of the 21st century the main directions in logistics development were identified as follows (Skjoett-Larsen, 2000):

- supply chain management cooperation normally including such characteristics as joint planning and mutual exchange of information, co-operation based on end users' requirements, cross co-ordination on several levels in the participating companies long-term co-operation and trust between the actors, fair sharing of risks and benefits and common visions and company cultures;
- globalization of the supply chain concerning supplier and customer markets where domestic and local suppliers and customers play a less important role compared to global suppliers and customers; within Europe, it resulted in removal of trade and transport barriers between EU countries, opening of new markets in Eastern Europe, acceptance of a single European currency, development of information technology and fast communication systems, and emergence of pan-European logistics service providers offering fast, reliable and cost-efficient distribution in Europe;

- strategic partnerships focusing mainly on strategic supplier co-operation, distinguishing between four generic supplier strategies ; strategic partnerships/system suppliers, outsourcing of non-critical purchase, leverage purchasing and bottleneck purchasing;
- virtual enterprises, held together by trust, synergies of the partners, contract and information technology (Hedberg et al., 1994); they result in creation of virtual supply chains operating without long-term relationships, can be enabled or dissolved easily on a real-time basis; they are characterized by a networks of internal and external relations that constantly change;
- e-business with Internet applied as a fast and efficient means of communication; electronic commerce with completely new distribution concepts and needs for agreement on a common standard;
- greening the supply chain, i.e. carrying out life cycle analyses of products and processes in order to reduce adverse environmental impact on the total supply chain; requirements for environmental certification from suppliers; packaging area faced with stricter requirements for repossession and recycling; the transport area facing with changes and city logistics becoming an area of growing interest; use of environmentally friendly trucks and high capacity utilisation of the transport materials; reverse logistics being a concept that is applied in processes connected with recycling, reusing and reducing the amount of materials used; demands for a reduction in CO_2;
- relations management in connection with external co-operators such as suppliers, third-party operators or customers; important issues concern negotiation of partnership agreements, maintaining and developing co-operative relations with external partners and developing inter-organisational information systems.

The prediction was that first of all globalization, strategic partnerships and e-commerce would dominate theory and practice within the logistics area at the beginning of the 21st century. At present we witness increased domination of such concepts as virtual enterprises, "green supply chains'' and process-oriented management

It might be interesting to confront the above mentioned set of forecasted trends in supply chains with later research that identified the main trends in logistics and supply chains on the basis of interviews with managers of total 897 trade companies, manufacturers and logistics service providers from Germany, USA and China (Straube F, Pfohl H Ch, 2008). Table 1 summarizes the opinions concerning the importance of the main mega-trends in logistics and supply chains as perceived by the respondents.

Table 1 indicates several major mega-trends that have the greatest influence on logistics at present and their significance in 2015, i.e. (Straube F, Pfohl H Ch, 2008):

- globalization based on internationalization of procurement, production and distribution posing – according to respondents - the biggest logistics challenge; some of the respondents expect a related geographic extention of logistics chains;
- security and risk problems, resulting from increasing globalization, dynamics of the market, outsourcing concepts and single-sourcing strategies; all these trends result in an increasing number of potential "failure points" and organizational vulnerability of supply chains;
- environmental and resource protection as an issue of the increasingly more important concept of sustainable development, with sustainable logistics strategies facing global supply chains, and yet at the same time reducing e.g. emissions of climate gases;
- technological innovations like information and communication, RFID technology particularly in the trading sector, etc.
- social responsibility for the effects of logistics and supply chain activities on society;

% of companies affected by the listed trend to a „large” and „extremely large” degree

MEGA-TRENDS IN LOGISTICS	TRADE				INDUSTRY								SERVICES			
	Retail		Wholesale		Plant engineering		Automotive		Electrical engineering		Chemical		3PL		Freight forwarding	
	2008	2015	2008	2015	2008	2015	2008	2015	2008	2015	2008	2015	2008	2015	2008	2015
Globalisation	40	52	40	68	48	74	57	76	73	84	78	86	62	83	71	85
Security	14	43	39	52	39	57	24	43	51	64	74	95	46	60	52	65
Regulation, compliance	35	50	48	48	52	59	19	33	45	60	52	73	31	38	58	67
Social responsibility	40	60	16	24	26	52	19	48	30	47	43	59	26	47	40	52
Environmental and resource protection	14	64	24	68	21	55	19	76	27	76	48	91	27	76	31	82
Technological innovation	29	67	24	80	42	55	20	48	36	65	22	68	32	70	53	78
Demographic development	14	48	32	42	-	44	5	48	9	42	4	18	12	50	12	53

Table 1: Influence of mega-trends on logistics and supply chain management
Source: Straube F, Pfohl H Ch, (2008)

- regulation and compliance with changing statutory requirements which may be a bigger challenge due to uncertainty of political framework conditions and increasing state regulation;
- demographic development, and mainly an aging society and resulting from that shortage of skilled personnel; it also should be connected with the increasing age of the end customers of companies.

Some trends will show their full impact in the coming years, while others probably will take longer to develop their full picture. Above mentioned predictions unanimously indicate that globalization / internationalization, sustainable development and "greening" the chain are the main robust trends in contemporary supply chains. Those trends have been manifesting themselves for a long time. Also technological innovations are not an unexpected tendency influencing logistics and supply chains. However, there are new developments in logistics and supply chain management that recently exposed new mega-trends which were not widely discussed neither in earlier literature nor in hitherto practice. Those trends are connected to security issues, regulation and compliance, and corporate social responsibility problems.

According to the demographic development trend, companies must understand how the definition of success is changing in the light of new business trends , how to measures success in those new circumstances, and be able to track the impact of those new mega-trends on human resource management efforts. In order to empower logistics and supply chain managers to make better decisions, probably differentiated hiring, retention and development plans should be created for critical talent and risk management to support organizational growth.

This paper aims at answering the main research question: *how managerial talents impact the supply chain business by understanding which managerial competencies are critical to business growth and performance*. Talent management activities should become a part of everyday supply chain business; and provide the right data to all stakeholders to understand, measure, and monitor the effect of talent decisions on the business

HUMAN RESOURCES IN LOGISTICS AND SUPPLY CHAINS

In 2003 a note in *Harvard Business Review* indicated that `…despite years of process breakthroughs and elegant technology solutions, an agile, adaptive supply chain remains an elusive goal. Maybe it's the people who are getting in the way.` (Beth et al., 2003). It is commonly believed that instead of considering the supply chain to be a 50/50 mix of infrastructure and information systems technology, rather any supply chain is more like 45/45/10 mix of human behaviour, systems technology and asset infrastructure (Gattorna, 2006).

Andraski and Novack (1996) indicated that people are "… the most important element of the logistics marketing concept." Daugherty et al. (2000) noted: "To take supply chain performance to the next level, companies will have to tap into this human element more intensively. Many companies have pushed hard on technological and infrastructure improvements and investments. The next wave of improvements and investment should center on the people who manage and operate the supply chain."

One of the research reports created a model of impact of the way of managing human resources. "Generally, the HR policies create a positive organisational social climate, creating higher levels of trust, cooperation and people engagement. Secondly, the HR policies increase human capital flexibility - the skills and behaviours needed for the organisation to change. The changes in human capital flexibility and organisational social climate have an impact on nonfinancial performance. Companies that have better non-financial performance also reported in the survey better financial performance and delivered higher returns on their assets as shown in their published annual reports" (Bourne et al., 2008).

More often companies are organised in relation to cross-business processes rather than according to traditional functional areas. Cross-company efficient co-ordination and management of the processes has been ensured by setting up teams of employees within purchasing, production, product development, logistics and sales/marketing. Due to progressing integration of companies in supply chains (especially at the top management level e.g. in retail trade) the nature of work also changes: inter-organisational teams with employees from key suppliers sometimes are formed in order to ensure a smooth flow of goods and "frictionless'' decision-making between the links in the total supply chain. In contemporary supply chains the role of the "logistics co-ordinator" changed from solving daily logistics problems to a kind of project manager for cross-functional and cross-company teams of internal and external employees (Skjoett-Larsen, 2000).

Current challenges also include managing changes associated with an aging work force that is yielding to a new generation of youth performing frontline logistics activities.

Importance of human resource management and change of management priorities is presented in Figure 1. It clearly shows that actual privileged investments in IT systems in future will probably be replaced by investments in the field of employees support and training (Straube F, Pfohl H Ch, 2008). The criticality and complexity of logistics personnel was also discussed on the basis of literature review in some professional journals (Ozmet & Keller, 2009).

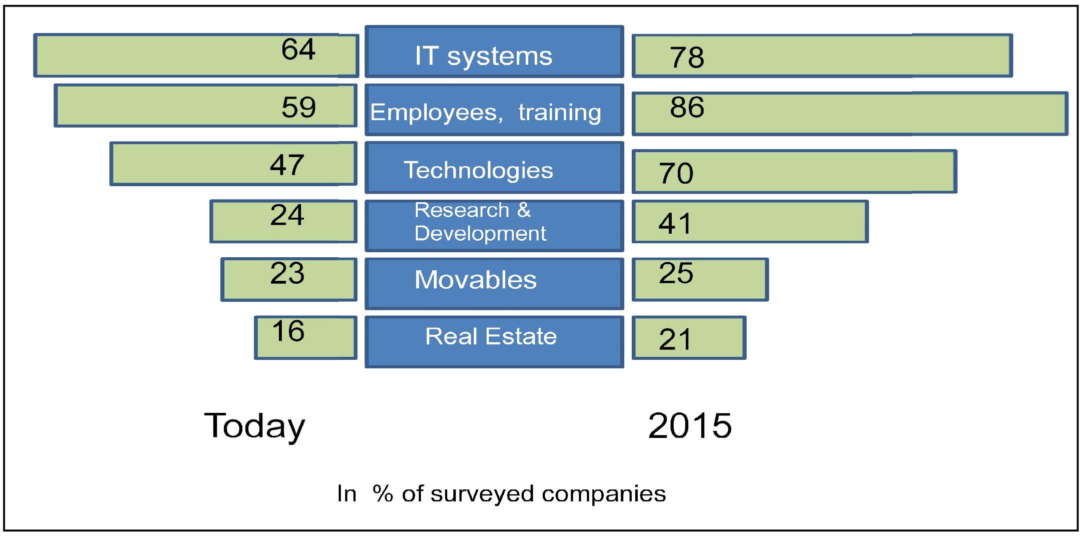

Figure 1: Direction of investments in contemporary and future supply chains
Source: Straube F, Pfohl H Ch, (2008)

EVOLUTION OF REQUIREMENTS FOR LOGISTICS MANAGERIAL QAULIFICATIONS

Even long time ago the opinion was that entry-level logistics managers needed basic knowledge in economics, marketing, industrial management, and statistics that was believed to be of immediate use for employers (Henderson 1963). The most important logistics skills were customer service, transportation management, warehousing management, and inventory management. Then the evolution of logistics concept increased focus on greater skills in information management, and in supply chain and production management (Ozmet & Keller, 2009). Further research results showed that those managers realize greater productivity from logistics supervisors who are well-equipped with social skills (interpersonal and leadership), decision-making, problem-solving, and time-management skills (Myers, 2004; Mangan and Christopher, 2005). Senior managers rated logistics operations managers very high with respect to the skills in social, problem-solving, time-management, and integrity-type skills, but decision making was an advanced skill rewarded by increased financial compensation (Daugherty et al., 2000).

Senior-level logistics managers must possess a broad-based skill-set that includes first, general managerial attributes, specific attributes of logistics management, and then general business skills (Murphy and Poist, 2007). Logistics skills were seen as important, but to a lesser degree than general management skills.

Similar results were obtained in research conducted in emerging market economy of Poland when logistics started to be more widely adapted by companies and supply chains became a major business concepts (Kisperska-Moron, 2009).

Contemporary supply chains and their modified profiles, as described earlier in this paper, resulted in a specific logistics knowledge being almost a prerequisite for 88% of surveyed European companies (Straube F, Pfohl H Ch, 2008). Figure 2 shows that among basic skills of logistics managers fundamental value belongs to relationships management such as the ability to manage projects efficiently, ability to cooperate one on one, with colleagues and with customers and partners and also use modern information and communication technologies competently (extremely good skills in fully automated information systems. Implementation skills would be also another requirement valued quite high. However, it is easy to notice that besides those qualifications there are, so called, "soft skills" which seems to be of utmost importance: social skills, methodological skills and intercultural skills, extremely needed the global environment of contemporary supply chain operations.

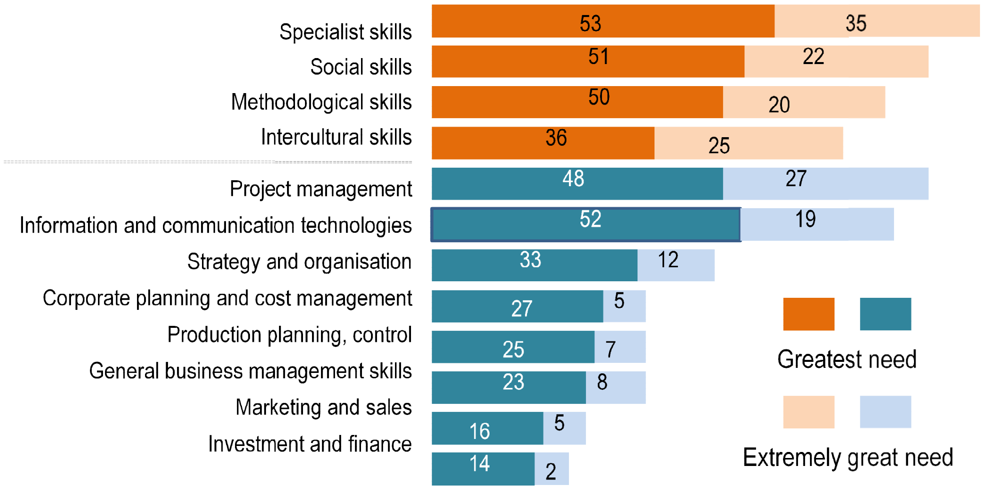

Figure 2: Requirement profile for logistics managers in Europe
Source: Straube F, Pfohl H Ch, (2008)

Due to frequent discontinuity of business and temporal arrangements in many product flows, contemporary supply chains demand even more specific skills of their managers:

- Increased requirements for highly educated personnel even at the operational level, since contemporary supply chain offers extremely high level of customer service and it has to operate in the best possible way from the start. There is no time for long-term training and education of personnel, employers like to recruit from "the best" ones available on the market.
- Good communication skills required for efficient coordination of day-to-day activities of collaborating firms, and in particular
  - Convincing to reach compromise between the partners in a temporary business,
  - Team work of partners who do not have large previous experiences of joint task completion,

- Critical analysis of problems and their not conventional solution often required in business situations not to be experienced by companies operating in companies with long-term relationships and opportunities to improve them,
- Extreme adaptability to constantly changing requirements of a temporary business
- Open mind and innovative talents.

In order to sum up the new profile of qualifications of managers in contemporary supply chains a matrix in Figure 3 classifies competencies according to their shallow or profound character and their narrow or broad scope. Only profound competencies would be suitable for management of contemporary supply chains.

COMPETENCIES

Profound	**Competencies of a branch expert**	**Competencies of a polymath (omnibus knowledge)**
Shallow	Competencies of an ignorant	Encyclopedia knowledge
	Narrow	Broad

Figure 3: Competencies of managers in a contemporary supply chain
Source: Kisperska-Moron 2010

Long-term experience of the author of this paper with the process of certification of professional achievements of logisticians (within the framework of European Junior and Senior Logistician Certificate of the European Logistics Association) allows to notice that those new requirements for qualifications of logistics managers result in modified personal professional careers of logistics managers:

- Chance for personal influence emerges on professional career, professional development and education.
- Professional career is not a vertical one since flat organizational structures do not provide adequate number of hierachical levels.
- Professional career depends on individual intelectual assets of each potential employee.
- The value of employee does not depend on the job decsription but is the result of his or her acquired skills and other competencies.
- Professional career does not result directly from being employed but rather from being well prepared for potential employment and being an asset for potential employers.

CONCLUSIONS

Today logistics managers have to operate in the environment that could be described by co-existence and co-operation of different generations, diversification and individualization of career types, temporary co-operation and long-term collaboration. Even in such a complex business situation in the end, it is the employees and not the systems and processes that ensure solutions to the logistics tasks and provide the company with the necessary competitiveness. In contemporary supply chains a single person might be a serious force

Yet, in Europe, many companies are already searching in vain for suitable employees, also in the field of logistics. 66% of European companies are already unable to find suitable recruits for vacant logistics positions and only one in five companies say there is no personnel bottleneck. More than one in three European companies is greatly in need of logistics managers (in all sectors of industry, trade and services). Moreover, two in three European companies are convinced that they will in future need a high number of employees with logistics skills (Straube F, Pfohl H Ch, 2008). Therefore, it is crucial not to underestimate the human and cultural aspects in the implementation of logistics and supply chain operations, becoming more often robust projects of change.

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EMPIRICAL LOGISTICS AND SUPPLY CHAIN RESEARCH IN AFRICA

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INTRODUCTION

Africa is increasingly seen as one of the next major areas for expansion in global trade (Chironga et al., 2011). One of the major challenges with this growth will be ensure that supply chains and logistics networks are able to meet the requirements for international trade. The World Bank's Logistics Performance Index (LPI) highlights clearly how countries within Africa are perceived to perform badly when compared to other nations (Arvis et al, 2010). In fact, 7 of the 10 lowest scoring countries are in Africa.

For businesses entering this market, it is important that there is a full understanding of the nature of logistics costs – for example, transport costs are often higher than in the developed world (Teravaninthorn and Raballand, 2008) – while marketing efforts need to be appropriately tailored (Neuschel and Russell, 1998). From an academic perspective, there is a need to understand whether business practices can transfer to different operating and cultural environments (Dadzie, 1990). Education programmes also need to take this into account, especially as African nations are represented in many student cohorts (Pyne et al., 2007).

Given this situation, it is timely to consider the current state of the art in relation to published literature on logistics and supply chain management in Africa. As will be discussed shortly, there is a perception that a dearth of literature exists, making it challenging to understand how business practices in the continent relate to established theory. As Dadzie (1990) notes, it is often the case that techniques developed for supply chains in developed countries need adaptation to work in Africa. Therefore, the aims of this paper are (i) to explore the nature and extent of empirical logistics research in Africa; (ii) identify key themes that emerge from the research; (iii) identify future research opportunities.

THE GEOGRAPHY OF LOGISTICS RESEARCH

The geographical distribution of research is often considered as part of the bibliometric analysis undertaken within literature review papers, and therefore does not often form part of the main 'topic' for publication. Two exceptions to this are Luo et al. (2001) and Svensson et al. (2008). In the former publication, 30 articles covering the period 1990 to 2000 are examined, focusing on supply and logistics in "non-Western developing countries". Within this sample, there are four references to articles featuring African research, which is comparable to South America but less than Eastern Europe and Asia Pacific. The authors particularly highlight that logistics management is related to the culture, economic system and infrastructure of individual countries.

Svensson et al. (2003) reflect upon what they term the "geocentricity" of logistics research. They examine empirical research published in the Journal of Business Logistics, International Journal of Physical Distribution and Logistics Management and International Journal of Logistics Management over the period 2000 to 2007. They find no empirical research relating to Africa in their sample of 443 articles. However, they have omitted Beamon and Kotleba (2006) which does contain empirical data pertaining to Kenya to South Sudan aid flows. Nonetheless, Africa appears to be under-represented in the sample, with South America appearing four times.

Geographical analyses also appear in a number of other papers. Babbar and Prasad (1998) analyse 141 articles on purchasing, inventory and logistics published between 1986 and 1995. They found 50 articles that were country specific, but only two that related to African counties. Cunningham (2001) examine agrifood supply chain research between 1987 and mid-2001, with just 2 articles from a sample of 123 using data from Africa. He attributes this lack of publications to the less extensive research infrastructure in these countries. Selviarides and Spring (2007) review the literature on third party logistics between 1990 and 2005 and, of the country specific studies that they list, none are from Africa. However, it may be that this list is not comprehensive in its coverage. Finally, Schoenherr (2009) reviews the literature on global and international supply chain management. The sample covers the period 2000 to 2008, with 726 articles. South Africa was the most mentioned country, with 6 instances, although Botswana, Ghana, Nigeria, Sudan and Uganda were also mentioned in the article. By contrast, China was the most mentioned (77 times, while Brazil was mentioned 10 times. These papers reinforce the view that there is limited research on Africa published.

Studies of author affiliations also highlight a lack of African presence. Luo et al. (2001) observe that much research on developing countries adopts a polycentric view, with the researchers being from overseas and observing business practices as an outsider. Reviews by Sachan and Datta (2005), Svensson et al. (2008) and Maloni et al. (2012) all demonstrate a lack of publications by authors based at African institutions. Sachan and Datta (2005) also draw parallels between the affiliations and research focus, suggesting that there is a need to engage with locally based academics in order to increase publications from developing countries generally.

Despite this, there is evidence of research that does examine African business practices. The regular reviews of PhD dissertations published in the Journal of Business Logistics (Stock 1987, 1988, 2001; Stock and Luhrsen, 1993; Stock and Broadus, 2006) contain studies that have focused on Egypt, Eritrea, Guinea, Kenya, Nigeria (five examples), South Africa (twice), Zambia and Zimbabwe. A similar review of Scandinavian doctoral dissertations includes Tanzania (Zachariassen and Arlbjørn, 2010). Further, Farris et al. (2010) report on a Fulbright Scholar visit to Swaziland, highlighting international links with local institutions that may, in the longer term, encourage the development of research papers.

METHOD

In order to evaluate the extent of logistics and supply chain research in Africa, a structured literature review has been carried out (Tranfield et al., 2003). In the literature, two approaches to article sampling are suggested – the use of databases with search terms or a systematic review of specific journals (Suri and Clarke, 2009). Generally, the former gives greater breadth but, because of the potential number of articles produced, tends to be used where there are a range of search terms that helps to narrow the sample. By contrast, the systematic approach tends to be used when an overview of the field is presented. Given that this study is aiming to provide an overview of the field of logistics research in Africa, the latter approach was adopted.

Eight journals were selected for inclusion within the review – International Journal of Logistics Management (IJLM), International Journal of Logistics: Research and Applications (IJLRA), International Journal of Physical Distribution and Logistics Management (IJPDLM), Journal of Business Logistics (JBL), Journal of Supply Chain Management (JSCM), Supply Chain Management: An International Journal (SCMIJ), Transportation Journal (TJ) and Transportation Research Part E: Logistics and Transport Review (TRE). These eight were selected following consultation with a range of other review articles relating to logistics/supply chain management. Referring to these articles also indicated that a time span of 1990-2011 (inclusive) would give a good level of detail. It should be noted that the first editions of SCMIJ and IJLRA were in 1996 and 1999 respectively.

The initial search focused on the electronic versions of each journal, with the keywords firstly being "Africa" and then the name of every country within the continent. The search was conducted over the full text of the articles. Where electronic versions were not available, reference was made to hard copy originals. The search results were filtered to a final sample using the following four questions:

1. *Is this a research paper?* The purpose here was to remove book reviews and editorials.
2. *Does the article focus on logistics/supply chain/freight transport management issues?* Not all the journals published articles solely on logistics and supply chain management. For example, Transportation Journal also included public transport.
3. *Does the article feature empirical research?* This reflected the aim of the study to examine business practices rather than theoretical insights. Empirical research was defined as "research that makes use of data that is derived from naturally occurring field-based observations, taken from industry" (Scudder and Hill, 1998)
4. *Does the full text of the article include reference to Africa or a specific African country?* This removed articles where, for example, only the author biography or cited references contained one of the keywords. With references, the text was cross checked to ensure the information cited was not Africa specific.

This approach resulted in a sample of 152 articles for further coding. Three categories of article were identified, and appropriate coding approaches adopted, as outlined in Table 1. A final sample of 98 articles resulted from this process, as Category C articles were excluded from the study. The analysis firstly focused upon providing a bibliometric overview of the sample, particularly based around the 27 Category A articles.

Category	**Description**	**Coding Criteria**	**No. of articles**
A	Articles where the empirical research contains data that relates specifically to Africa and where this link can be clearly identified.	Author; Affiliation; Year; Journal; Research design; Data source(s); Level of analysis; Industry sector; Key points and issues; Keywords mentioned	27
B	Articles that contain passing reference to logistics/SC practices in Africa, but the substantive research is not Africa related.	Year; Journal; Keywords mentioned; Key points relating to Africa	71
C	Articles where no insights into logistics/SC practices are given, which cite articles included in the search only or are reprints of older articles.	Year; Journal; Keywords mentioned; Reason for exclusion	54

Table 1: Categorisation and coding criteria for articles

A review of recurrent research themes was also conducted, to provide detailed insights into logistics and supply chain management practices throughout Africa. Using the coding for Category A and B articles on 'key points and issues', clusters were identified. The articles were then re-examined to fully understand the context in which these points were made and to ensure consistency within the clusters. From this, common issues within each cluster were identified, providing insights into the nature of logistics and supply chain issues within Africa and providing an opportunity to identify future research directions.

BIBLIOMETRIC ANALYSIS

Table 2 shows the spread of articles over the period studied. Overall, there is a slight upward trend throughout the period, and particularly from 2004 onwards. This suggests that there is an increasing awareness of business practices within Africa, possibly due to growing trade links with the continent. Interestingly, this growth does not appear to be linked to the recent emergence of humanitarian logistics as a research area. Many of the insights emerge from Category B articles, as there is not a significant increase in the number of detailed academic articles published. This lack of detailed articles confirms the trends identified earlier in the literature review.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
Category A	2	1	1	1	2	1	0	1	1	0	1	1	0	1	3	1	3	0	2	2	3	0	27
Category B	1	1	3	2	0	1	0	4	2	5	3	2	2	3	4	4	4	5	3	10	7	5	71
Total	*3*	*2*	*4*	*3*	*2*	*2*	*0*	*5*	*3*	*5*	*4*	*3*	*2*	*4*	*7*	*5*	*7*	*5*	*5*	*12*	*10*	*5*	*98*

Table 2: Distribution of articles over time

In terms of where the articles are published, Table 3 provides a breakdown by journal. Of the top three journals listed, two of these started publication during the period studied. However, while IJLRA has a number of Category A articles, the articles in SCMIJ are predominantly from Category B, with only passing mention of logistics in Africa. For IJPDLM, the early to mid-1990s featured six articles, no doubt encouraged by the editorial perspective at that time which encouraged articles on practice from developing countries (Stock, 1991). The remaining three articles were published between 2008 and 2010, two of which featured humanitarian logistics (Kovacs and Spens, 2009; Jahre and Jensen, 2010). It appears that there has until recently been a shift away from publishing in IJPDLM, which may also explain some of the trends observed in Svensson et al. (2008).

Journal	**Category A**	**Category B**	**Total**
IJLM	1	6	7
IJLRA	8	11	19
IJPDLM	9	19	28
JBL	2	2	4
JSCM	2	2	4
SCMIJ	3	21	24
TJ	0	5	5
TRE	2	5	7

Table 3: Distribution of articles by journal

The geographical spread of the articles is depicted in Figure 1. A further 35 articles only refer to Africa, without being specific as to which particular area/country. As can be seen, a wide range of countries have been mentioned in the literature. In particular, there is a focus on the eastern side of the continent, with fewer articles mentioning central and West Africa. East Africa is particularly studied in detail, with twenty different references to the area within Category A papers. The country mentioned the most frequently is South Africa. However, 20 references are in Category B papers with only 3 from Category A (van Zyl, 1992; Cilliers and Nagel, 1994; Sohail et al., 2004). This suggests that, while there is awareness of business practices within the country, there is the need for more recent, detailed publications to ensure the latest practices are fully understood.

In terms of the geographic spread of affiliations, it was found that the majority of authors are not based within Africa, reflecting Luo et al (2001). Of those authors from Africa, most are based in either Egypt or South Africa, reflecting the top two nations depicted in Figure 1. However, while the former are distributed throughout the time period examined, authors from the latter country feature only in the early 1990s with Cilliers and Nagel (1994) being the latest article within the sample.

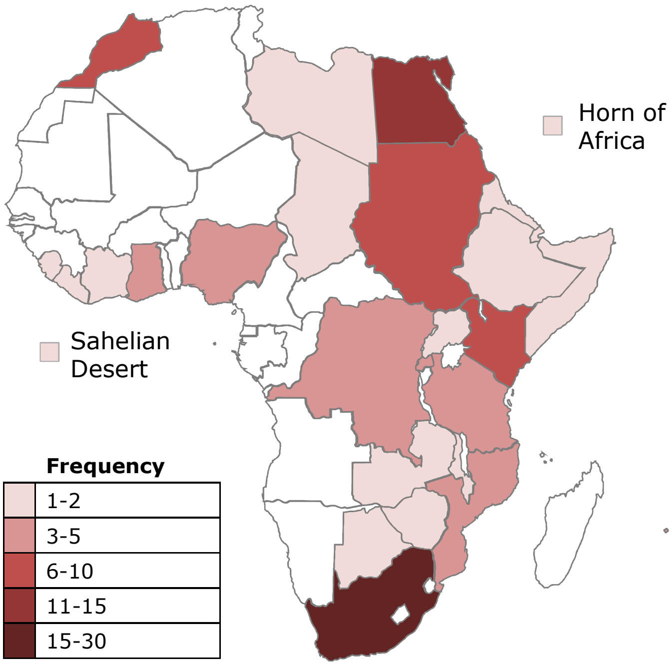

Figure 1: Geographical distribution of research

For the Category A papers, the research approaches adopted to conduct the research are summarised in Table 4. Generally, there seems to be a tendency towards qualitative approaches, with interviews particularly popular. The challenges of publishing qualitative research in logistics have been well documented (e.g. Näslund, 2002; da Mota Pedrosa et al., 2012) and, therefore, the choice of this method may be influential in the low publication levels. It also suggests that the 'personal touch' is perhaps more effective from a cultural perspective. Several articles reflect upon the personal experiences of both academics and industrialists and are more reporting in style as well as being published during the early 1990s. Most research designs and data sources are spread across the journals and countries outlined above. The exception to this was TRE, where both Category A papers (Alizadeh and Nomikos, 2004; Wu and Goh, 2010) use databases of panel data to carry out econometric analyses. Of the questionnaires, four are carried out within Africa while two (Lowson, 2001; Carter et al., 2008) draw on external samples from North America and Europe, to provide a view on offshore production in Africa.

Research design	Frequency	Data source	Frequency
Case study	10	Interviews	13
Database	3	Questionnaire	6
Experience	3	Archival	5
Panel study	7	Observation	3
Survey	6	Panel data	3
		Workshop	1
		Opinion	1
		Not stated	2

Table 4: Research approaches adopted

Finally, consideration is given as to the industrial sectors represented in the literature. The level of analysis varies from case to sector level and with no clear trends, while the specific sectors can be found in Table 5. The key sectors researched are humanitarian and textiles/clothing. In the context of humanitarian aid, much of this research is focused around East Africa, including Sudan, Rwanda, Ethiopia, Somalia and Mozambique. Kenya also appears frequently, as a staging post for aid stocks before distribution in this region

(Long and Wood, 1995; Beamon and Kotleba, 2006). Research related to textiles and clothing particularly focuses upon Morocco and Egypt (for example, Browne et al., 2006; Abdelsalam and Fahmy, 2009), although Hines et al. (1998) provide a case study from Kenya.

Industrial Sector	**Frequency**
Humanitarian	6
Textile and clothing	6
Agriculture	4
Food and drink	3
Manufacturing	3
Petrochemicals	2
Logistics	2
Other	5
Unspecified	5

Table 5: Industrial sectors featured in the research (Category A only)

Agriculture and food are also important export sectors in Africa, with many different products (especially if Category B papers are also included), such as cocoa (Dadzie, 1990), flowers (van der Vorst et al., 2002), potatoes (Binet and Wilson, 1997; Loader, 1997), rock lobster (Batt and Morooka, 2003), vegetable oils (Jonsson et al., 2007), wheat (Abbas and El Deen Aly, 2004) and wine (van Hoek, 1997). However, there is also evidence of similar products also being imported to Africa, including beef from Brazil (Zucchi et al., 2011) and whisky from Scotland (Grant et al., 2006).

The sectors represented in Table 5 are reflective of those also featured in the Category B articles. The only additional sector identified from this wider sample of papers was the automotive industry. The research particularly highlights the movement of European manufacturers to Africa (Lemoine and Skjoett-Larsen 2004; Göl and Çatay, 2007), using both locally supplied (Pfohl and Gareis, 2005) and imported (Doran, 2004; Hausmann et al., 2010) parts.

COMMON THEMES

To complement the bibliometric analysis, common themes that emerged from the sample of papers were identified, considering both Category A and B papers. A summary of the main points can be found in Table 6. Offshoring is the most covered issue in the literature. For organisations based outside of Africa, the continent is recognised as a low cost sourcing area, although Lowson (2001) found that the cost saving is comparable to Eastern Europe and less than that obtained from Asia and South America. Consequently, the popularity of outsourcing to Africa is less, although this may also be due to a lack of knowledge on the operating environment there (Carter et al., 2008, 2010). While offshoring by African based organisations does occur (van Zyl, 1992), it is not always desired to have these organisations as customers (Nollet et al., 1994). Several authors report that local sourcing is significantly cheaper for these organistions, although there may be quality issues (Hines et al., 1998; Pazirandeh, 2011).

In terms of mechanisms for market entry, there are many different examples contained within the literature including subsidiaries (Sohail et al., 2004), partnerships (Sohail et al., 2004; Ellram, 1992), alliances (Taps, 2000; Evangelista and Morvillo, 1999), mergers (Brooks and Ritchie, 2006), liner shipping conferences (Clarke, 1997) and licencing (Ciliberti et al., 2009).

Theme (No. of papers)	**Main points**	**Sample references**
Offshoring (20)	• Africa a low cost option although not popular • Limited offshoring by African organisations • Variety of methods of entry into the market	Carter et al. (2008) Nollet et al. (2004) Taps (2000)
Inventory (14)	• 1990-1993 had a business focus, with high inventory levels • JIT seen as an option to reduce inventory • 2006-2010 focused on humanitarian aid, and particularly pre-positioning	Mady (1991) Msimangira (1993) Beamon & Kotleba (2006)
Training (14)	• Specialist training seen as essential to improve processes and efficiency • Cultural issues mean that often it is only top managers that receive training	Nollet et al. (1994) Msimangira (2003) Kovacs & Spens (2009)
Safety and security (12)	• The loss of product due to theft and bribery is a problem, especially humanitarian aid • Terrorism also an issue, disrupting supply and adding administration	Thomchick et al. (2004) Pettit & Beresford (2005)
Government (11)	• Government often controls elements of logistics, to provide benefits to the economy • However, may not understand logistics and therefore cause problems • Deregulation is becoming more common	Dadzie (1990) Van Zyl (1992) Abbas & El Deen Aly (2004)
Infrastructure (11)	• Infrastructure quality is variable • Creates challenges with reliability, leading to the use of alternative modes • Also difficult to implement Western practices • No change over the sample time frame	Dadzie (1990) Sohail et al. (2004) Kovacs & Spens (2009)
Reliability (9)	• Maintenance and availability of spare parts the main issue • Mainly older articles in sample	Long & Wood (1995) Hines et al. (1998)
Transport (9)	• Costs are high but rates are often set by government at a low level • Infrastructure quality creates issues with road vehicle use	Cheesman (1990) Abbas & El Deen Aly (2004)
Coordination (7)	• Some evidence of vertical integration in business supply chains • Horizontal collaboration in humanitarian supply chains	Loader (1997) Jahre & Jensen (2010)
Finance (7)	• Financing issues affect investment in equipment and raw materials • Solutions include counter-trade and funding from customers in developed world	Msimangira (1993) Hofmann & Kotzab (2010)
ICT (6)	• Variable levels of technology usage • Evidence of use of Internet in supply chains	Loader (2007) Van der Vorst et al. (2002)
Perception (6)	• Logistics and supply chain management perceived as easy and not important • Creates challenges in respect of training	Cilliers & Nagel (1994) Msimangira (2003)
Bribery and corruption (5)	• Challenge to business practices • Accepted as 'normal' for this environment	Nollet et al. (1994) Carter et al. (2008)
Quality (4)	• Problems with the quality of raw materials	Nollet et al. (1994) Abdelsalam & Fahmy (2009)

Table 6: Summary of main issues from literature sample

DISCUSSION

Synthesising the above, there are a number of opportunities for future research that emerge. There needs to be greater engagement with the academic community in Africa, to encourage publication in what are regarded as the 'top' journals in logistics and supply chain management. This will overcome the polycentric perspective highlighted in Luo et al. (2001). Much of this research will be exploratory in nature, and therefore issues of research quality need to be adequately addressed. Where quantitative modelling is used, it needs to be recognised that data availability may be less than in other places. A mechanism by which this could be achieved is through a journal special issue, although a previous suggestion of this route (Stock, 1991) appears to have not been adopted.

In terms of research topics, it is clear that some areas have had little coverage since the 1990s. Countries such as Egypt, Kenya, Morocco, Nigeria and South Africa appear to offer opportunities for further detailed research, while there are many countries where very little is published within the sampled journals. Equally, there appears to be an opportunity to develop research in the automotive sector. This sector has been well studied in Western countries but is only mentioned in passing within Africa, despite many of the production sites being run by multinational organisations. Of the common themes, there is a need for more recent research relating to inventory in commercial supply chains, the role of government and reliability. Issues such as terrorism have also been highlighted as issues, and a more detailed examination would be worthwhile.

The literature recognises the need for personnel to be trained in order to improve logistics operations. This is an area where academics can contribute effectively, either through attracting students to courses (as reported in Pyne et al., 2007), or by offering training within Africa. However, it is important that such training is appropriate to the African context, a point made by Dadzie (1990) and reflected in a number of the other papers examined in this study.

CONCLUSION

The first aim of this paper was to consider the nature and extent of empirical research relating to Africa. Through a structured literature review of 8 journals over the period 1990 to 2011, a sample of 99 articles was identified. It was established that there is only limited research conducted within Africa. Much of the research is published in three journals, and particularly focuses on countries to the east of continent. Sectors examined include humanitarian, textiles/clothing and agrifood.

Fourteen themes have been identified from this sample of papers. Key issues include inventory, training, safety/security, government and infrastructure. While many issues represent challenges for logistics and supply chain operations, there are also suggestions on how to overcome these. Finally, a number of opportunities for future research and other activities have been identified.

In terms of limitations, it should be acknowledged that this paper is based around a sample of only eight journals. Adopting a database orientated search (the alternative approach outlined in Suri and Clarke, 2009) would yield a significant number of articles from a much broader range of journals. Therefore, it may be that key issues have been overlooked. The main themes developed from the literature assume that importance is proportional to the number of journal papers in which the issue appears. It may be that this may under and over represent the importance of specific issues, although the breadth of the sample should help overcome this.

REFERENCES:

Due to space limitations, references are available upon request from the author (e-mail: PotterAT@cardiff.ac.uk)

PROFILES OF POSTGRADUATE SUPPLY CHAIN AND LOGISTICS PROGRAMS

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INTRODUCTION

Companies worldwide have been turning to logistics and supply chain management to give them a distinctive edge. The success stories of Wal-Mart, Toyota, 7-Eleven, and Dell are but a few of the many celebrated exemplars of the contributions logistics and supply chain management makes in helping organizations to achieve superior performance. As a cradle for honing logistics and supply chain management talents, universities play a significant role in moulding future logistics and supply chain management professionals to face the evolving challenges and drive changes in industry.

As logistics and supply chain programs continue to evolve in response to industry demand, two of the pertinent questions in this regard are: how do universities around the world organize their degree offerings to meet the growing demand for logistics and supply chain professionals? What do universities see as the requisite blend of domain knowledge essential for supply chain and logistics graduates to meet industry expectations? This paper examines the postgraduate logistics and supply chain degree programs offered by universities around the world.

BACKGROUND LITERATURE

As a profession, logistics and supply chain management has progressed through a number of evolutionary phases over the last 50 years (Ballou 2007). The evolutionary changes that have taken place over this period, as summarised in Ballou (2007), van Hoek (2001) and others (see for example Christopher et al., 1998) may be characterised as a search for an appropriate identity. This relatively windy road of identity development has also impacted on the way logistics and supply chain management programs have been organised and developed in institutions of higher learning, whose preoccupation has been directed to increasing the market relevance of their course offerings (Gravier and Farris 2008).

In tune with the evolutionary changes taking place in practice, the study of curriculum development in logistics and supply chain management has also been given substantial attention by academics over this period. In a review of 81 scholarly papers on logistics education published in academic journals since the early 1960s, Gravier and Farris (2008) noted that studies on logistics curriculum is the most dominant of the three themes identified (i.e., curriculum, content and skills, and teaching methods). In their analysis, Gravier and Farris (2008) unearthed three distinctive foci among the 49 articles that examined curriculum: practical applicability, marketability of logistics graduates, and composition of logistics programs (or what constitute a logistics program?). Gravier and Farris (2008) further found that though papers studying logistics curriculum form the majority of the articles reviewed, the publication trend of this topic has been declining since the 1960s. The apparent hiatus in the study of logistics and supply chain curriculum after 1990 may be an indication that the field has already evolved to a stage of "stability", with clear distinctions having been established between marketing and physical distribution management (Christopher et al., 1998) and logistics management and supply chain management (Ballou 2007), among a host of other similarly overlapping fields of practice.

From the perspective of designing an industry relevant logistics and supply chain curriculum, perhaps, the question "what should constitute a logistics and supply chain management curriculum?" has already been answered. The corollary of this deduction is thus the associated questions: how do universities around the world organize their degree offerings to meet the growing demand for logistics and supply chain professionals? What do universities see as the requisite blend of domain knowledge essential for supply chain and logistics graduates to meet industry expectations?

To some extent, Wu (2007), through an analysis of the logistics curriculum offered by 77 universities in Europe, North America, and Asia, had attempted to respond to the above questions. While Wu's (2007) study had covered many aspects, including an inter-regional comparison as well as the range of core and elective courses at both the undergraduate and postgraduate levels, a number of gaps remain. Two of these are: How similar (or different) are the course offerings at different universities world-wide regardless of regions? What is the relative share of core and elective courses? Further, Wu's (2007) sample was confined to programs offered by departments which had either "logistics" or "supply chain" included as part of their departmental title.

This paper extends Wu's (2007) analysis by examining how similar (or different) logistics and supply chain programs around the world are in terms of their course offerings. The investigation is exclusively on postgraduate degrees and focuses on two types of programs: dedicated logistics and supply chain management programs (referred to as dedicated programs hereafter) or postgraduate programs (such as Master of Business Administration) with logistics and supply chain management (or related fields) as one of the majors (referred to as non-dedicated programs hereafter). For the purpose of this study, related fields included operations management, maritime logistics, shipping, and freight transportation.

METHODOLOGY

Data Collection

Data for this study were compiled from program information on websites of universities known to offer either dedicated or non-dedicated postgraduate logistics and supply chain management programs or both. The selection of universities was confined to those using English as the medium of instruction. A total 44 of universities in North America (14), Europe (15), Asia (6), and Australia and New Zealand (9) were identified and their wed-sites accessed between 8 and 28 August 2011. The search resulted in 42 dedicated programs and 38 non-dedicated programs.

Other than basic program information, such as degree title, admission requirements, duration of study, and school (or department) offering the program, data on program structure, and list of core and elective courses that make out the program curricula were collected. After a review of the syllabi of the courses offered in each of the degree programs, which constituted the unit of analysis, all the courses (i.e., both core and elective) were grouped into one of 16 categories: procurement, inventory management, transport and distribution, supply chain and logistics management, technology related, accounting and finance, statistics and data interpretation, operations research, operations management, environmental sustainability, global trade operations, project management, research project and dissertation, general business and management, shipping and maritime, and others.

Date Analysis

This study is exploratory in nature. No hypothesis was formulated. Our aims are to understand how universities structure their dedicated and non-dedicated logistics and supply chain management related programs and to build characteristic profiles of different program types for both dedicated and non-dedicated programs. Because our intention was to examine how similar (or different) these programs are in terms of their course offerings, the 42 dedicated and 38 non-dedicated programs were separately cluster analyzed based on the number of core and elective courses in the 16 categories. Further, we adopted the hierarchical clustering technique, rather than the *K-means* clustering algorithm, to capture the clustering process in order to determine the appropriate number of clusters formed. The differences between the resulting clusters with respect to their course offerings in each group of courses were then tested using analysis of variance.

RESULTS AND DISCUSSION

Result of Hierarchical Cluster Analysis

The results of the hierarchical cluster analysis for the dedicated and non-dedicated programs are shown, respectively, in Figures 1 and 2. The dendogram in Figure 1 suggests that the 42 dedicated logistics and supply chain management related programs essentially fall into 10 clusters. The first cluster is the biggest of the 10, containing 17 programs: four in UK, five each in USA and Australia, and one each from the Netherlands, Hong Kong and Singapore. Cluster 2 encompasses four programs, one from each of the following countries: Canada, New Zealand, Singapore, and UK. Cluster 3 has 14 programs, again distributed across a number of countries: six in Australia, five in UK, two in Singapore, and one in Denmark. The remaining seven clusters are single-university clusters (i.e., only one university is in the cluster), located in UK (Cluster 4), USA (Clusters 5 and 8), Netherlands (Cluster 6), Australia (Cluster 7), and India (Clusters 9 and 10).

Six clusters were identified among the 38 non-dedicated programs (Figure 2), with 20 in Cluster 1, 11 in Cluster 2, 3 in Cluster 3, one each in Clusters 4 and 5, and 2 in Cluster 6 (Figure 2). Of the 20 programs in Cluster 1, 11 were from UK, two from Belgium, two from UAE, two from the USA, and one each from Canada, Hong Kong, and Netherlands. In Cluster 2, eight of the 11 programs were from the UK and one each from Germany, Ireland, and Netherlands. The three programs in Cluster 3 were all from North America - two USA and one Canada. The single-university Clusters 4 and 5 are programs from New Zealand (Cluster 4) and USA (Cluster 5). The two programs in Cluster 6 are from UK.

The distribution of dedicated programs by cluster and country shown in Figure 3 indicates regional convergence in program offerings among the majority of the universities examined (i.e., those in Clusters 1, 2 and 3). However, a few boutique programs remain (i.e., those in Clusters 4 to 10). While there are signs of regional convergence in program offerings among the non-dedicated programs (i.e., Cluster 1 in Figure 4), regional distinctiveness is evident, as the concentration of European universities in Cluster 2 and North American universities in Cluster 3 demonstrate. Convergence in course offerings among the dedicated programs suggest that, despite cultural differences and local business practices, the design of postgraduate logistics and supply chain management programs has been largely influenced by some industrial imperatives that span globally. Globalization, however, does not appear to have an impact of a similar magnitude in the non-dedicated programs.

Cores versus Electives

Not all the dedicated and non-dedicated programs have a typical core-elective split (see Figures 5 and 6). Four of the dedicated programs and two of the non-dedicated programs, all of which are single-university clusters, do not give students a choice of electives. At the other extreme, one of the single-university clusters among the dedicated programs has less than 20% of its courses listed as core. In sum, it appears that there is no consensus on the proportion of core versus electives among both the dedicated and non-dedicated programs. However, on an aggregated basis, a 3 to 1 split between core and elective courses appears to be the norm.

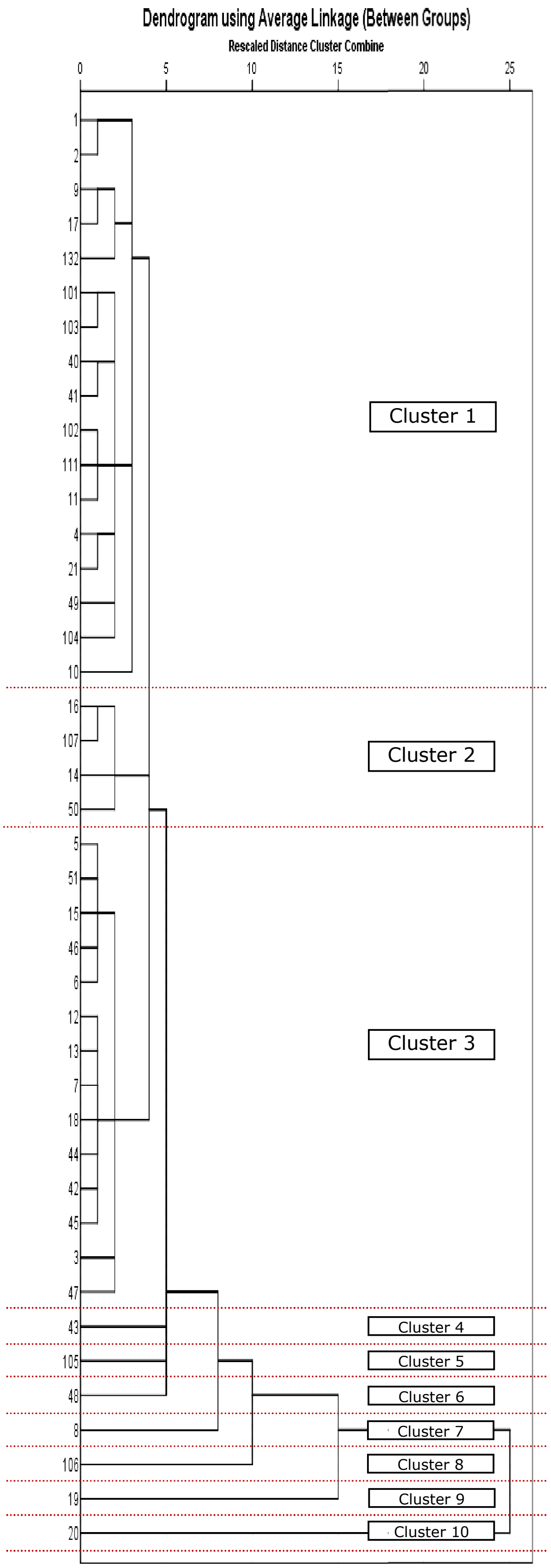

Figure 1: Results of Hierarchical Cluster Analysis for Dedicated Postgraduate Logistics Management-related Programs

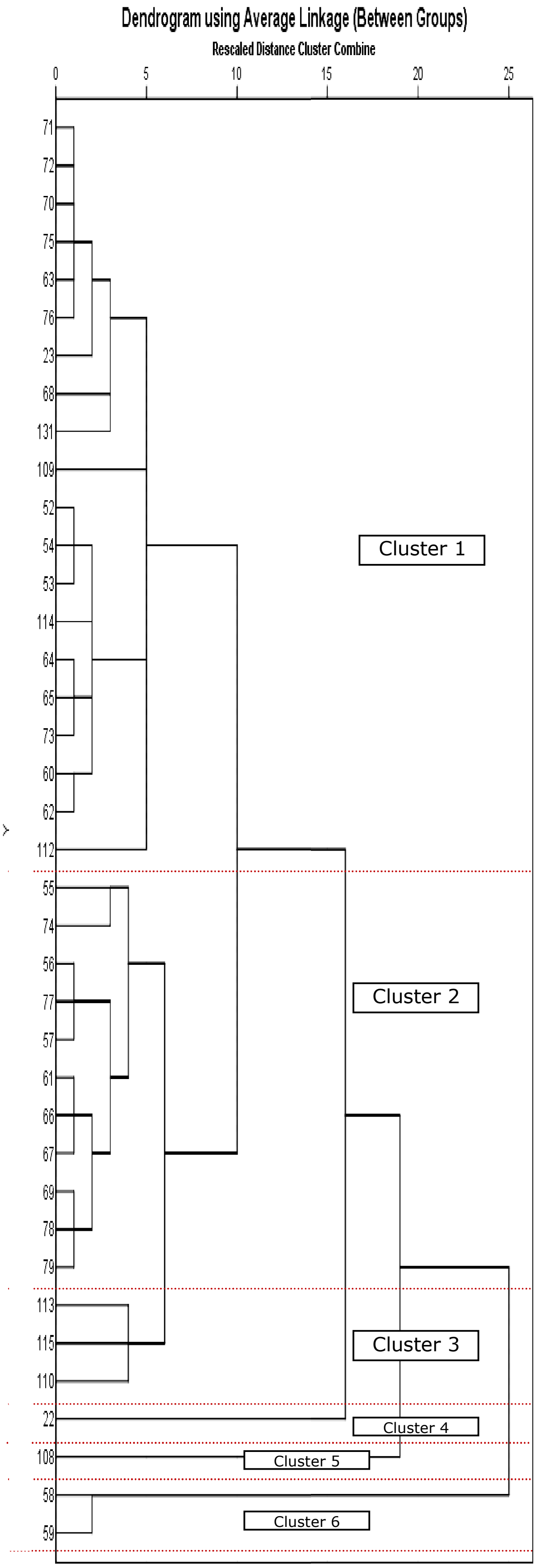

Figure 2: Results of Hierarchical Cluster Analysis for Non-Dedicated Programs

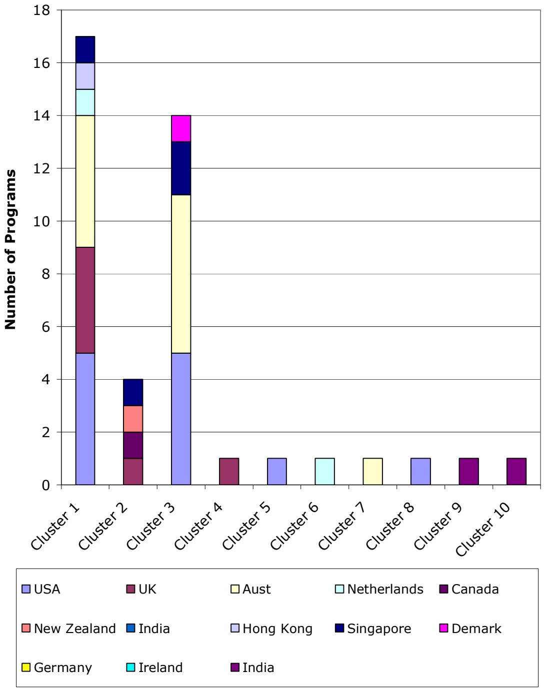

Figure 3: Dedicated Programs by Country and Cluster

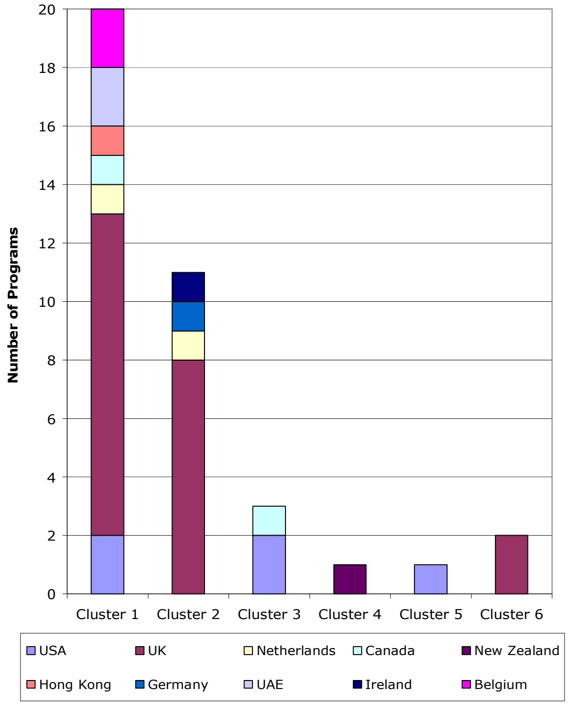

Figure 4: Non-Dedicated Programs by Country and Cluster

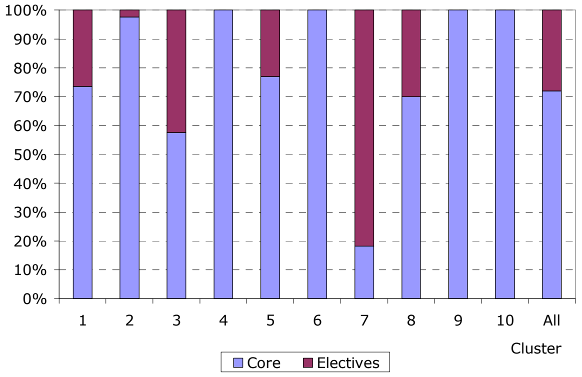

Figure 5: Core vs Electives in Dedicated Programs

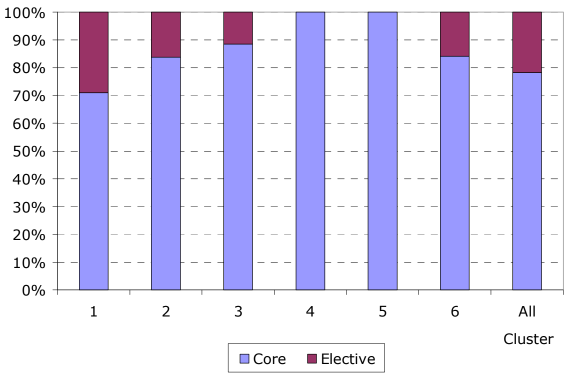

Figure 6: Core vs Electives in Non-Dedicated Programs

Composition of Core Courses

Notwithstanding the composition of the core courses in the seven single-university clusters, the three dominant dedicated program clusters (i.e., Clusters 1,2 and 3) are differentiated by the number of courses in seven of the 16 categories: inventory management, supply chain and logistics management, operations research methods, global trade operations, project management, general business and management, and shipping and maritime (Table 1). On the whole, supply chain and logistics management courses (e.g., supply chain design and logistics decision making) are the dominant core courses, making up about a quarter (24.2%) of all the core courses offered. General business and management courses (e.g., marketing and human resource management) form 11% of the core courses, while operations management related courses constitute 8%, followed by courses on transport and distribution management with a 6.2% share. Despite the importance of information and communication technology on supply chain and logistics operations, courses related to technology applications (e.g., e-supply chain and roles of technologies in logistics and supply chain operations) only obtain a 5.2% share of the core courses. Further, despite the publicity on climate change and global warning, courses linked to environmental sustainability (e.g., green supply chain management and reverse logistics) make up less than 1% of the course offerings. Equally, courses linked to global trade operations only have a 2.5% share of the core offerings, with project management courses having a marginally larger share (3.2%). Lastly, except for three single-university clusters, programs in the other seven clusters all have a research project component or a minor thesis.

Compared to Wu's (2007) findings, which reveal that business and management courses (i.e., financial management and business negotiation in Table VI of Wu (2007, p. 516)) were only included as electives in logistics and supply chain programs some five years ago, the above results highlights the importance of general business and management courses universities have now attached to supply chain and logistics management programs. The aggregated composition of the core courses among the 42 dedicated programs further indicate that project management has become recognised as an important knowledge domain of supply chain and logistics management operations. The incorporation of a research project or thesis as one of the core courses also suggests that universities (and, by inference, the industry) now see the importance of research skills as a component of postgraduate training in supply chain and logistics management.

As expected, business and management courses dominate the core of the non-dedicated programs, forming over two-thirds of the core courses offered (Table 2). Operations management and supply chain and logistics management courses form the two main groups of courses in the supply chain and logistics management major, with a share of 10% and 5% of the core offerings. Other typical supply chain and logistics management courses, such as procurement, inventory management and transportation, are either absent or only given minuscule emphasis. These findings indicate that graduates in non-dedicated programs with a supply chain and logistics management major do not share the same pool of domain knowledge as their counter-parts from dedicated programs. They underscore the importance of offering dedicated supply chain and logistics management programs to ensure the advancement of the discipline to provide the business world with a differentiated edge to meet evolving challenges.

CONCLUSION

From a narrowly defined discipline rooted in marketing, transport, material handling and physical distribution, supply chain and logistics management has evolved into a multidisciplinary field of study. By developing a typology of characteristic profiles of contemporary postgraduate supply chain and logistics programs, this study has not only shed light on how the discipline has evolved in the last few years but also provided a framework to the development of globalised supply chain and logistics management curriculum. To the extent that universities structure their program offerings to meet the future needs of industry, this study has provided a glimpse of the knowledge domains upcoming supply chain and logistics management professionals would be equipped with to help businesses meet the next wave of challenge.

LIMITATIONS AND RECOMMENDATIONS FOR FURTHER STUDIES

This study assumes that courses offered by universities are reflective of the universities' responses to the skills and domain knowledge required by industry, which is a major limitation. A logical extension of this study is thus to examine the match and mismatch between supply chain and logistics program offerings and industrial needs in different parts of the world. A second major limitation of this study is the lack of indepth analysis on the contents of the courses. Probing into the contents of the courses offered by universities will be a logical extension of the current study.

	Cluster 1 *(N=17)*	Cluster 2 *(N=4)*	Cluster 3 *(N=14)*	Cluster 4 *(N=1)*	Cluster 5 *(N=1)*	Cluster 6 *(N=1)*	Cluster 7 *(N=1)*	Cluster 8 *(N=1)*	Cluster 9 *(N=1)*	Cluster 10 *(N=1)*	Total *(N=42)*
Procurement	5.0%	4.6%	3.1%	0.0%	10.0%	0.0%	0.0%	0.0%	3.7%	0.0%	3.9%
Inventory management**	4.3%	5.9%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.1%
Transport and Distribution	5.7%	5.9%	8.8%	0.0%	0.0%	8.3%	0.0%	0.0%	3.7%	7.1%	6.2%
Supply Chain and Logistics Management**	19.6%	28.2%	32.9%	9.1%	50.0%	8.3%	100.0%	0.0%	29.6%	0.0%	24.2%
Technology related	4.8%	6.2%	6.3%	0.0%	10.0%	8.3%	0.0%	0.0%	3.7%	0.0%	5.2%
Accounting and Finance	3.9%	4.6%	1.7%	0.0%	0.0%	0.0%	0.0%	28.6%	0.0%	0.0%	3.3%
Statistical methods	4.3%	1.3%	2.4%	0.0%	0.0%	8.3%	0.0%	14.3%	11.1%	10.7%	3.8%
Operations research methods*	3.5%	0.0%	6.1%	18.2%	0.0%	0.0%	0.0%	7.1%	0.0%	0.0%	3.8%
Operations management	8.3%	6.3%	7.5%	36.4%	10.0%	0.0%	0.0%	7.1%	3.7%	3.6%	8.1%
Environmental sustainability	1.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
Global trade operations*	3.7%	3.3%	0.0%	0.0%	10.0%	8.3%	0.0%	0.0%	0.0%	0.0%	2.5%
Project Management*	4.4%	0.0%	3.5%	0.0%	10.0%	0.0%	0.0%	0.0%	7.4%	0.0%	3.2%
Research project and Dissertation	17.8%	11.6%	18.4%	9.1%	0.0%	8.3%	0.0%	0.0%	7.4%	10.7%	15.0%
General business and management***	5.6%	20.9%	7.5%	27.3%	0.0%	8.3%	0.0%	42.9%	29.6%	25.0%	11.1%
Shipping and Maritime*	6.2%	0.0%	0.0%	0.0%	0.0%	41.7%	0.0%	0.0%	0.0%	42.9%	5.1%
Others	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Total Core	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 1: Distribution of Core Courses in Dedicated Postgraduate Logistic and Supply Chain Management Related Programs

Note: ***, ** and * denote, respectively, the largest of the three percentages among Clusters 1, 2 and 3 is statistically significant from the smallest of the three percentages at p <0.01, p <0.05, and p < 0.1.

	Cluster 1 *(N=20)*	Cluster 2 *(N=11)*	Cluster 3 *(N=3)*	Cluster 4 *(N=1)*	Cluster 5 *(N=1)*	Cluster 6 *(N=2)*	All Clusters (n=38)
Procurement	0.9%	0.0%	0.0%	0.0%	10.5%	0.0%	0.8%
Inventory management	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Transport and Distribution	0.6%	0.0%	0.0%	0.0%	5.3%	0.0%	0.5%
Supply Chain and Logistics Management*	5.2%	2.3%	3.4%	0.0%	42.1%	0.0%	4.9%
Technology related	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%
Accounting and Finance***	2.5%	0.0%	17.2%	0.0%	0.0%	0.0%	2.7%
Statistical methods**	1.1%	0.0%	6.4%	0.0%	5.3%	0.0%	1.3%
Operations research methods	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Operations management	8.5%	9.0%	11.7%	50.0%	10.5%	5.6%	10.2%
Environmental sustainability**	0.0%	0.0%	2.4%	0.0%	5.3%	0.0%	0.4%
Global trade operations**	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	0.2%
Project Management	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Research project and Dissertation**	13.3%	4.8%	0.0%	12.5%	5.3%	0.0%	8.4%
General business and management***	64.0%	83.9%	54.8%	0.0%	15.8%	94.4%	67.3%
Shipping and Maritime	0.0%	0.0%	0.0%	37.5%	0.0%	0.0%	1.3%
Others**	0.0%	0.0%	2.4%	0.0%	0.0%	0.0%	0.2%
Total Core	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 2: Distribution of Core Courses in Dedicated Postgraduate Logistic and Supply Chain Management Related Programs

Note: ***, ** and * denote, respectively, the largest of the three percentages among Clusters 1, 2 and 3 is statistically significant from the smallest of the three percentages at p <0.01, p <0.05, and p < 0.1.

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ENHANCING THE STUDENT'S LEARNING ON SUPPLY CHAIN MANAGEMENT THROUGH THE APPLICATION OF A BUSINESS GAME

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ABSTRACT

Globalisation, shorter product life-cycles, and time to market force companies to cooperate in order to stay competitive. This trend has been seen for decades, and much research has focused on trying to understand the needs and requirements of efficient and effective supply chains. Supply chain management has also been an educational topic throughout several business schools. However, such courses focus mostly on research findings than on actual practice, which leads to an educational gap. Students gain theoretical knowledge, but hardly apply it. An approach that seeks to reduce this gap is the use of business games in education. Games offer students the opportunity to experiment in a safe environment in order to gain knowledge that can be transferred later to the real world. This article reports on the results of a workshop that employed a simulation game for decision making in supply chain management offered to post-graduate students enrolled in a supply chain management course.

1. INTRODUCTION

Product complexity, decreasing product life cycle times, and higher customisation, among other factors, drive companies to produce products in cooperation with other enterprises. Although globalisation of manufacturing has offered significant gains on both the company and the Supply Chain (SC) level, it has made competition stiffer for each involved member and for the chain as a whole, as competition takes place in an increasingly dynamic market and sourcing environment. A main result of this development is the emergence of complex and widespread, more vulnerable supply and manufacturing networks (Jüttner, 2005). As a result, SC managers need to make decisions on multiple levels, while facing uncertainties. These decisions will not only affect their own organisation, but also suppliers, partners etc.

Within business schools, the criticism between transferring knowledge based upon research rather than practice, with an emphasis on conflicting benefits for relevant stakeholders effectively linking research results and actual (or future) practice has been documented (Starkey and Tempest, 2005). For students, the SC and its management are still mostly addressed primarily at a theoretical level. When they graduate from a SC-related discipline of a business school, most students will need to make decisions in variable environments, lacking the previous experience of anticipating their strategic impact on the other SC stakeholders in practical terms. The next section discusses the learning process and the contribution of simulation-based games in it. This is followed by a section that introduces the simulation gaming environment we used in the workshop, followed by the analysis and findings, providing final conclusions at the end.

2. THE LEARNING PROCESS AND THE SIMULATION-BASED GAMES

In education, theory and practice are often separated creating a gap between knowledge and action. However, this gap has to be closed in order to prepare the students on their future tasks. The theory of experiential learning is based upon the paradigm of constructivism. Kolb (1984, p. 38) postulated that "learning is the process whereby knowledge is created through the transformation of experience".

Kolb's (1984) four-stage learning cycle suggests how experience is translated through reflection into concepts, which in turn are used as guides for active experimentation and the choice of new experiences. The first stage, *concrete experience*, is where the learner actively experiences an activity, such as a lab session. The second stage, *reflective observation*, is when the learner consciously reflects back on that experience. The third stage, *abstract conceptualization*, is where the learner attempts to conceptualize a theory or model of what is observed. The fourth stage, *active experimentation*, is where the learner is trying to plan how to test a model or theory or plan for a forthcoming experience.

In approaching reflection, Schön (1987) distinguished between reflection-in-action (taking place during the activity) and reflection-on-action (taking place retrospectively). Business games used in a blended learning context can achieve both. Most are based upon the approach of learning by experiencing, and experiencing by gaming has been introduced in education. Mediating knowledge by gaming has proved to be particularly effective whenever soft skills are essential and traditional learning methods fail (Windhoff, 2001). Warren and Langley (1999) underscored that decision makers should have access to gaming simulation tools in order for them to cope with the business systems in which they evolve, and to reap strategic management skills. Further, Scholz-Reiter et al. (2002) strongly emphasized the need for the insertion of management games to practitioners and engineering students in organizations and universities, respectively, in order for them to learn specific tasks and aptitudes like communication and co-operation in complex distributed production systems such as production networks.

Simulation games are learning processes or environments that help activate double-loop learning (Bakken et al., 1992) and the feedback structures existing within the system can be deducted risk-free (Senge 1990, p. 312-338). The best out of these learning environments, therefore, is that they make cause and effect relationships more visible to the user. Simulation games enable accelerated learning, what Probst and Büchel (1994) called *learning by doing*, and Senge (1990) *learning through doing*. Simulation games are generally case-based computer models, which are used with the objective to answer effectively the issue raised by the case such as the optimization of profits, costs or lead times. Therefore people can choose among a wide range of policies, try them out, and get the interactive feedback. During this process of trial and error, users are supposed to acquire knowledge through experiential learning. For instance, the beer game (Sterman, 1989) under its web-based version is a multi-player interactive simulation game tackling the issue of the bullwhip effect (demand variability) in a simplified production and distribution system.

Previous studies have indicated that learning using games is degraded in dynamic systems because of the misperceptions of feedback (Sterman, 1989; Diehl and Sterman, 1995; Moxnes, 2004), since human beings hardly can handle more than 7 ± 2 variables. However, recent research evidence has demonstrated that simulation-based learning environments with debriefing sessions can reduce the misperceptions (Qudrat-Ullah, 2007). Business Games used in a blended learning context, i.e. with reflection will decrease the misperceptions of feedback, and hence, these games will increase learning (Senge & Sterman, 1992).

Consequently, playing business games, i.e. trying out different strategic scenarios in a virtual environment, can help increase students' understanding not only in how to apply the different SC theories and methods, but also in making them aware of, and in some cases in anticipating, the impact of their decisions on the whole SC. We aimed to research the SC strategic awareness and practical applicability gained by postgraduate students with the use of a specific business game, allowing students to cope with uncertainties and realise the impact of their decisions on the SC configuration and coordination. Moreover, we aimed to assess the contribution of such a game to the students' learning experience and teaching effectiveness.

3. THE GAMING ENVIORNMENT OF 'SECONDS'

In the workshop we used a gaming environment that is developed for training SC related decision making. The game *Seconds*, developed at the University of Bremen, is used to train students in SC-related decision making. It is a multi-player online game implemented in a workshop setting. The gaming environment aims at increasing the awareness of how a participant's own decision making impacts on the SC. The game creates a safe learning environment in which the students can apply different approaches for improving the flexibility and efficiency of manufacturing and analyse the impact on the SC. Two players are assigned to a role and based on the role description each role will produce products, assemble products etc. The students also have to negotiate with their potential partners in a dynamic competitive environment, where apart from price, they also have to consider issues of availability, quality, logistics costs, as well as long term relationships.

The major objects of the model are the entities 'process' and 'resource', which are linked to each other: the process manipulates and transforms resources, which in turn are used for other processes. Unlike models that are based on a Bill of Material, this model supports multiple outputs. That means a process can produce more than one product. Further, resources in this model are user-configurable. The most important data of a resource is its contribution to a process. The simulation distinguishes between three types of resources which are treated differently: consumable material, non-consumable material, and non-material. Furthermore, resources have two properties: one value specifies the total amount of a resource, while another specifies the currently available amount. This makes it always possible to keep track of the resources that are currently in use.

The first step a player has to undertake is to establish a site, which is a location where the player can have an office or any kind of building allowing him to do business. Once the player has established a site, he is able to buy buildings. The purpose of a building is to store materials. Since certain materials can only be stored in certain buildings in the real world, this is also implemented in the model. The price of a building depends on the location it is built, and buildings can also be sold if deemed necessary. In the simulation model a process is used to transform input materials into output materials. The duration of a process is given by a predetermined value which is multiplied by a site factor. The site factor, however, depends on the process category and a corresponding site attribute. For transport processes the game designer can also define a route. By doing this, it is possible to constrain the execution of certain processes to certain sites, while the output site of the process is defined during runtime by the player. Input materials show a different behaviour depending on their type like consumables and durables as well as tangible or intangible. These can be, for instance, knowledge or permissions, which are necessary to execute a process, but are neither occupied nor do they vanish after completion (Hüther, 1996).

4. THE WORKSHOP SETTING AND THE GAMING SCENARIO

Our research included running a workshop with postgraduate students at Nottingham University Business School, enrolled in an SC Management (SCM) module aiming to give an in-depth coverage of SCM and Logistics. The main task was to develop and manufacture and also sell a car (the actual end-product of the SC) built in collaboration on a global SC. Each team should compete on income and costs, yet consider the long term strategic implications of their membership in a SC. The product consisted of several components (e.g. chemicals, steel, rubber) produced by different stakeholders to create a competitive environment among the players. Using the game *Seconds* the scenario included car retailers, as well as companies that produced car bodies, tires, glass, plastic, steel, textiles etc., covering the whole range of parts and components that would be required to manufacture the final product, namely cars. Nevertheless, admittedly the SC created in the scenario was one with reduced complexity compared to reality.

Two sessions were offered (of three hours and two hours and a half in duration respectively), with the first session also including a brief introduction to the gaming environment. 24 students participated in the gaming scenario, which was set up for 15 roles (i.e. the different stakeholders' positions in the SC) and three played by the facilitators, in order to cover the end-to-end SC. That ensured that every component was offered by at least two competitors. After the first session the experiences of the participants were discussed in order to reduce the possibility for misperceptions. This is very important for complex systems, since the number of variables influencing the game is higher than the students can normally handle. In the second session the players were allowed to change their strategies and additionally, in order to foster the collaboration, they were not allowed to buy from the market (an option which is computer-triggered and allowed players to source the required parts at high prices if an agreement among the players was not achieved). At the end of the second session the results were analysed, the best-performing role (in terms of profit) was identified, and a discussion on approaches and reasons for success followed. During the game it was observed that the students got very involved. This is one of the advantages of using games. In order to analyse the learning outcome and the experience students gained during the game, the students were asked to complete a questionnaire after the second session. The questionnaire included initially questions to capture the information in relation to the participants, as well as their experiences in using computers and playing computer games. The subsequent sets of questions aimed to capture teamwork and time to prepare, as well as issues relating to the application of theory and strategic thinking in their decision making and the game concept. The final part of the questionnaire allowed for individual comments and suggestions for improvements of the simulation game. The next section provides the analysis of the questionnaire, including the oral and written input by the participants, which are coupled with our observations as facilitators, and discusses the findings.

5. ANALYSIS

We received 20 completed questionnaires, and the participants ranged from early twenties to early thirties. About half of the students were female, all knew each other before and most of them did have some working experience in the past, as well as experience with playing computer games.

No particular directives were given to the students, allowing them the freedom to select how they should manage their roles. In the preparation phase (i.e. the time allowed to them to discuss the approach they would follow in managing a specific role), the vast majority replied they needed more time, suggesting that time was important in preparing for the work. This is interesting, considering that in the preparation (pre-game) phase it was the time they had to decide upon the strategy to pursue for each pair, depending on the type of the role they had assumed. With the students having been exposed throughout their studies to the theories and issues to effectively manage a SC, this perhaps suggests a problem when one has to apply 'in practice' (even in a virtual environment) the relevant theories and approaches.

During the game play, the vast majority suggested they felt motivated in playing the game, and also an average level of stress. The latter point is also, we believe, an indication of the level of engagement by the side of the players. Stress could be attributed to the 'limited', as indicated by the participant, time in the pre-game preparation phase, or to the nature of the game, i.e. the players bargaining prices, nature of relationships (e.g. exclusivity or not), or trying to manage costs. The students did not find the structure of the game difficult (the results indicate an average level of difficulty), and the vast majority indicated the gaming scenario was realistic in their view. In addition, the vast majority (almost all of them) indicated that the gaming environment did help them considerably to understand the theories they had been studying, and similarly assisted them in increasing their awareness of the impact of their own decisions in SC cooperation and in developing strategies, helping them to apply what they had learned theoretically.

Most of the students indicated that they had to engage in making many decisions, and that they had to apply some form of strategic thinking in making the appropriate decisions. Most interestingly, the vast majority indicated that they had the feeling that their decisions were important in the game play (i.e. they had an impact on other players as well), and that they did receive an impression on the cooperation between different stakeholders. An interesting observation during the two-day game play is the nature of strategic thinking they employed. During the first day the players devoted most of their time on bargaining prices rather than long-term relationships. Most of these prices were very close (only marginally lower) than the prices of components in the open market (a feature that ensured steady supply if the required component was not sourced by another player). Very few attempted to establish a collaborative SC, and arms-length relationships were the norm. This situation altered significantly during the second day, when access to the open market was not an option anymore. The prices for components fell significantly compared to the open market, and buyers, not having any more access to a steady source of components, were seeking sourcing exclusivity in order to ensure steady supply. Although the students indicated that they made strategic decisions, the facilitators observed that many of the decision were made ad-hoc and not always based on a long-term strategy, this could be the result of the dynamic competitive environment and some sort of flux in the SC relationships.

The vast majority also indicated that the gaming experience did help them recognise their own strengths and weaknesses (e.g. on issues like price bargaining), and that it did help them to enhance their learning on SC cooperation, as they did feel part of a cooperation. In fact, several relationships emerged and also broke during the second day of the game play. The students indicated that the gaming situation did change their understanding of cooperation in SC, and that it will impact their future work, as it supported their learning process.

Overall, the students found the game useful for enhancing their decision making process. The vast majority also suggested that the gaming situation would have increased the learning outcome further if it had been played over a longer timeframe (i.e. regularly over the duration of their SC-related course), but this is a limitation we had to incorporate in the two-day workshop, due to time-constraints. Finally, in relation to the software itself, the students suggested that it does not really require too much time to learn how to use, and it does not require that they have to remember too many details.

6. FINDINGS AND CONCLUSIONS

Probably the most interesting outcome of the workshop is that the students did perceive the gaming experience as a means of enhancing their strategic awareness and impact of their decisions. Moving from theory to practice signifies an important step in one's mind-set, and this was indicated in our results. As mentioned above, the players needed time to prepare for this step, and consideration for decisions (of a strategic level) needed effort. The strong indication that the game helped the players in changing the understanding of decisions in SC and even more positively in their understanding of cooperation which is essential in SCM is very important. Taking into account that the game was played by postgraduate students (as mentioned above) who had been looking in detail into the theory of SCM during the last year, this is a very interesting observation. It shows that the use of games does offer students a new way of applying their knowledge and of experiencing the impact, so that the awareness is increased. Expected is, however, that they should be able to apply this knowledge and gain some new insights. This objective seems to be fulfilled, since most of them report that they recognised strength and weaknesses and learned about SC cooperation issues. This was an experience the players valued by playing the simulation game, as several of them had either no relevant SC-related experience, or not in the particular automotive scenario. The students perceived the experience as valuable for their future career, as they coupled it with the theory. As a result, our workshop further supports the enhancement of teaching effectiveness when it is coupled with practical application in the form of a gaming experience where they apply their knowledge.

Our paper provides avenues for enhanced teaching in SCM. It is based on the premise that knowledge may drive action but also that action generates knowledge (Crookall and Thorngate, 2009). The experience so far has shown that a well-designed game will not only help the learners to transfer their theoretical knowledge to practical skills, but also to transform gained experience into knowledge so that they can assess previously acquired knowledge and generate new understanding. Although limited in terms of the participants, this is confirmed by our workshop in the discipline of SCM, indicating a form of a gap between theory and actual practice (even in a virtual environment). It is also interesting to notice, that some students did find it so engaging that they asked to play the game for a second time. This shows how important *virtual practice* is as part of a theoretical course. The observation fits well into Kolb's (1984) learning model and also to Senge's (1990) *learning through doing.*

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TOWARDS A FULL DETERMINATION OF FREIGHT TRANSPORT EXTERNALITY COSTS – THE CASE FOR SOUTH AFRICA

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INTRODUCTION

Trade results in physical exchanges causing both costs and benefits being involuntarily imposed on and received by others. These external costs leads to overproduction in a competitive environment if understated and underproduction if overstated.Both cases are inefficient and distorts the market (Pretty, et. al, 2000). To avoid the distortion these external costs need to be quantified and allocated. Appropriate externality cost allocation will, for instance, inflate the real cost of carbon-intensive transport (McKinnon, 1999). More sustainable logistics decisions will follow, such as modal shifts, local sourcing and even relaxation of JIT scheduling. If appropriate internalisation costs are passed on to the end-consumer, it could direct purchasing behaviour to more environmentally friendly options. (Piecyk and McKinnon, 2007).

In 2010 the logistics costs (excluding externality costs) for South Africa amounted to 12.7% of the GDP (Simpson and Havenga, 2011). This is higher than first-world figures (efficient economies) of around 9.5% (Roberts, 2003). According to standard economic theory it is highly likely that this 12.7% is being spent inefficiently, because the external costs are not accounted for.(Tinch, 1999).

The purpose of this study is to quantify the external costs associated with logistics in South Africa. The results presented here are the initial outputs of the first ever study where a localised model for each externality cost component has been developed. Externality costs are defined as costs related to accidents, emissions, roadway land availability, policing, noise and congestion. The next section contains, in turn, literature reviews for each of the externality cost drivers, a discussion of the methodology employed to calculate the external cost and the outcome of the quantification. The impact on logistics costs when externalities are included will subsequently be depicted.

ACCIDENTS

Literature Overview

Maibach et al. (2008) propose that accident related externalities can be quantified according to the bottom-up or top-down approaches: The bottom-up method, Figure 1, uses the correlation between traffic levels and accidents, and risk assumptions. The bottom-up method is based on willingness-to-pay (WTP) valuations: the rate at which individuals are willing to substitute wealth for risk of death.

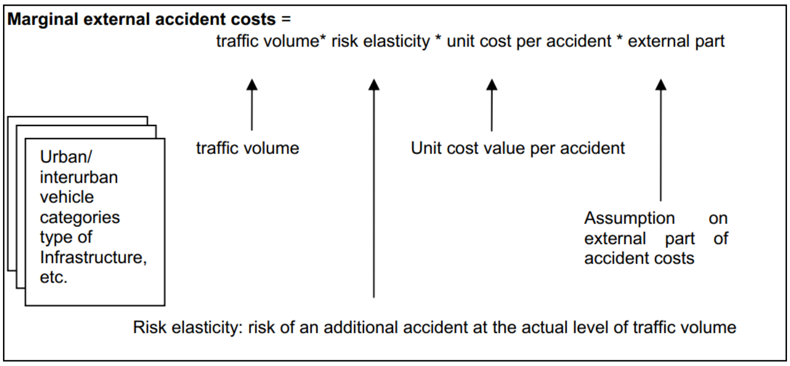

Figure 1: The bottom-up approach for estimating marginal external accident costs (Maibach et al., 2008)

The top-down approach is based on national accident statistics and insurance systems with a focus on material damages, administrative costs, medical costs, production losses and societal valuation of risks. It is a combination of the gross output approach of finding the net present value of the future earnings lost, with an added portion for grief, pain and suffering as well as direct accident cost. Therefore the external portions of these costs are considered to be losses in production and value of human life. According to Maibach et al. (2008) the bottom-up approach only considers parts of total accident costs and therefore leads to lower values than the top-down approach.

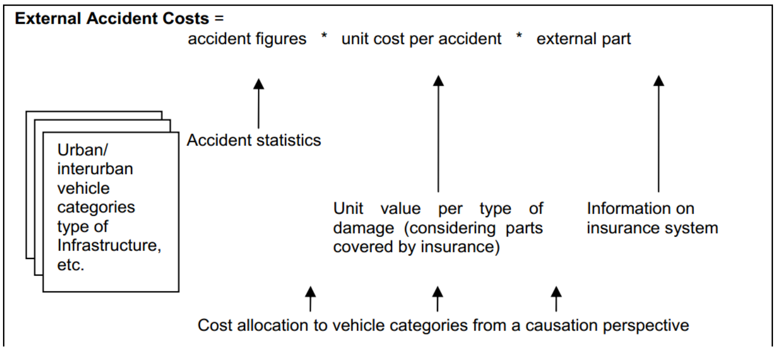

Figure 2: The top-down approach for estimating marginal external accident costs (Maibach et al. 2008)

Regardless of the approach, a crucial part of quantifying the external costs associated with accidents is the assumptions made on individual and collective risk behaviour as well as the allocation of insurance premiums. The potential differences between willingness to pay to reduce own risk and risk of others affect the portion of external cost. If rational behaviour is assumed, individuals should be able to anticipate their own risk and little externality is incurred in self accidents as only the willingness to pay for others are considered. If there is no difference in willingness to pay for others and willingness to pay for self, the external costs are similar for self-accidents and accidents involving other actors (Maibach et al., 2008).

Currently, estimates of South African accident externality costs differ widely. Jorgensen (2009) notes that in the March 2000 report, "A Quantitative Analysis of the Full Costs Associated with Motor Vehicle Use in South Africa," a conservative estimate of the external accident cost for all vehicles in South Africa was valued at R5.04 billion in 1998. Due to a lack of South African crash statistics, Jorgensen estimated the external accident costs via extrapolation methods from the European Union, Canada and Australia at 6c / tonne-km. February (2011) estimated the external accident cost attributed by road freight at R11.02 billion, based on an average costs per accident and 2006 data from the South African Department of Transport.

Methodology

Due to the risk of underestimating external freight transportation costs when using the bottom-up approach, the top-down approach, also used by February (2011), is recommended. For the purposes of quantifying road freight externality cost the methodology below, used in a 2003 DoT study conducted by CSIR Transportek (DoT, 2004) to calculate total road accident externality cost, was adjusted to reflect freight vehicle accidents only. The following data inputs are required:

- Fatal accident statistics.
- Vehicle counts of different vehicles involved in fatal accidents.
- Costs of accidents classified by severities (casualty outcomes for the accidents) and urban/rural (additional costs)
- Costs for towing, car hire, insurance administration, assessors, legal, accident administration and time delay per accident for each vehicle type
- Total tonne-kilometres for road freight

The calculations were done with 2010 total road accident fatalities. The unit casualty cost tables and the vehicle cost tables from the DoT study (DoT, 2004) were adjusted according to CPI inflation. A cost calculation table for a single road fatality was generated from the actual data of 2002. After a total estimate has been calculated, the final sum less the total amount outstanding and paid out by the Road Accident Fund (RAF), which is funded from the fuel levy and is not an externality, is portioned according to how many light delivery vehicles and trucks were involved in fatal accidents. Additional costs per vehicle and per accident are then added for accidents involving light delivery vehicles and trucks. To obtain a rate per tonne-km the total cost is divided by total road tonne-kilometres.

Calculations

Due to a lack of detail of recent road accident statistics (only fatal accidents) the number of severe and slightly injured road users were estimated through the most recent figures, 2004, in relation with the road fatalities. The application of the calculation resulted in the estimated external cost of the loss of a life for the different age categories for urban and rural accidents.

The sum of the cost values added up to R59.9 billion. From this, the sum of R21,3 billion (R11.4 million RAF payments added to the R9.9 million outstanding claims, which is accounted for in the fuel levy) was subtracted. From the remainder only 10.7% and 19.5% was attributed to truck and LDV related accidents, respectively, resulting in a total of R9.53 billion of road freight external accident costs attributed to loss of output

To estimate the costs additional to that of the loss of output, the values as per Table 1, were used to cost each accident and vehicle involved in an accident. These costs added up to R1.71 billion.

Vehicle type	Per vehicle						Per accident		
	Towing	Car hire	Insurance admin	Assessors	Legal	Total	Accident admin	Time delay	Total
LDV	2460	4101	2296	492	377	9727	9513	8201	17714
Truck	3280	4101	2296	820	377	10875	9513	8201	17714
Articulated truck	11482	4101	2296	492	377	18748	21323	8201	29524

Table 1: Additional External costs incurred per vehicle and per accident, 2004 values adjusted to 2010 for CPI inflation (Rand per vehicle)

In 2010 accident externality costs related to road freight transport therefore cost the South African economy an estimate of R11.24 billion at a rate of 4.92367c / tonne-km.

EMISSIONS

Emissions form a large portion of external transport costs. Particle matter (PM) such as NO_X, SO_2, O_3 and VOC (volatile organic compounds) are the main components. Air pollution from transport emissions adds to health costs, building and material damages, crop losses and impacts biodiversity and ecosystems. (Van Essen, 2008)

Literature Overview

An advanced and detailed quantification process, the Impact Pathway Approach, is discussed in a European Commission (2005) paper and is proposed as a best practice methodology. Ricci and Friedrich (1999), Navrud et al. (2006) and Maibach et al. (2008) propose an Impact Pathway Approach and state that it is widely accepted and acknowledged. Ricci and Friedrich (1999) define it as a detailed bottom-up approach to solve the problem of technological diversity in transport equipment. The complete chain of causal relationships, through emission, diffusion, chemical conversion in the environment and impact on the various receptors (humans, crops etc.) and, finally, the monetary valuation of such impact is followed.

Although a bottom-up approach is regarded as the ideal way, it is highly data-intensive. Alternatives to the bottom up approach are a top-down approach or a marginal abatement approach. The top-down approach as proposed by Salvatore and Romano

(2002) approximates emission levels through means of proxy variables (road length and population) and multivariate regression. Based on these values emissions are estimated at urban, highway and provincial levels. Marginal abatement cost curves (MAC) are important tools to give countries a set of options to follow in order to reduce their emissions footprint. It is an important tool for understanding emissions trading and shaping policy discussions. Based on a MAC, the cost of a tonne of an emission factor can be established, given the target level emissions a country wants to achieve (Morris, Paltsev and Reilly, 2008).

Methodology

Due to the lack of available data inputs required for the bottom-up method as well as the lack of emissions simulation models and receptor sites for South Africa, the Impact Pathway Approach could not be implemented for this study and the top-down approach used. The method used in this study is based on offset cost of emissions from the European Union, (Van Essen, et. al. 2008) converted through PPP-adjusted GDP per capita and empirical data sourced from the Freight Demand Model (FDM) for South Africa as applied in the Logistics Cost Model (Havenga, 2010) used in tandem with vehicle data from the Road Freight Association (2011). The following data inputs are required:

- Diesel emission breakdown
- Offset cost for different emission types
- Estimated breakdown of vehicle fleet
- Average vehicle payload per trip
- Tonne-km per different mixes of vehicles used
- Load-factors for each type of commodity hauled
- Emissions per kWh generated by Eskom (South Africa's electricity public utility)
- Total tonne-kilometres for road and rail freight.
-

For road transport, for each different types of vehicles, the average transport distance was calculated from the 2010 FDM through means of dividing the tonne-kilometres by the tonnage and the load factor. By then dividing the total tonnes hauled by the average payload for the given vehicle composition, a total kilometres per annum (KMPA) was calculated. From the KPMA the litres of diesel consumed by road freight were obtained by multiplying each KMPA with the respective vehicle composition mileage (litres per kilometre.) The total litres were then cost based on the emissions breakdown per litre of diesel multiplied by the total litres and the cost per tonne of emissions.

Because only an estimated 8.5% of freight is transported via diesel in South Africa, the calculation for rail emissions are initially split into two parts, electrical and diesel. The diesel is then calculated on the total amount of litres consumed as with road. The electrical part is calculated on the total amount of kWh consumed by the electrical rail infrastructure and multiplied by a CO_2 equivalent emissions factor (Letete, Mondli and Marquard, 2012) per kWh generated and then costs are calculated.

Calculations

In 2010 road freight transport consumed an estimated 3.768 billion litres of diesel. The total offset cost for all road emissions amounted to R10.61 billion (Table 2) which is equivalent to 4.64538c/tonne-km. Diesel rail emissions cost for 2010 was an estimated R337 million resulting in a figure of 3.528c/tonne-km. The bulk of rail tonnes, moved via electrified railways, had an emission offset cost of R568 million, or 0.5225c/tonne-km, which drove down the total rail cost of emissions to 0.7779c/tonne-km (Table 3).

	NO_x	**PM metro**	**PM rural**	**HC**	**CO**	**CO_2**	**SO_2**
g/l	26.5	1.194	1.194	0.7	4	2688.9	12.559
2010 Rand cost per tonne	18692	413278	121726	5470	5470	225	36472
Total emissions road (‘000 tonnes)	161.73	0.198	7.091	4.272	24.41	16411.01	76.65
Rail diesel emissions (‘000 tonnes)	5.17	0.001	0.231	0.13	0.78	524.6	2.45
Total rail diesel cost (millions)	85.20	0.542	28.207	0.66	3.76	92.5	78.79
Total road cost (millions)	3023.193	82.088	863.216	23.373	113.56	3692.4	2795.733

Table 2: Emissions per litre of diesel and PPP-adjusted GDP/capita transferred abatement cost of emissions per tonne.

Eskom emissions per CO2 equivalent (Kg/kWh)	1.015
Tonnes CO2	2 393 541.54
Cost of electric CO2 (Rand millions)	538
Diesel and electric combined cost (Rand millions)	876
Rail tonne-km (millions)	112 649
Cost per tonne-km (c/tonne-km)	0.7779

Table 3: Rail emissions calculation

ROADWAY LAND

Road users do not pay rent or property tax when using roadway land, it is therefore considered to be a sunk cost. (Victoria Transport Policy Institute, 2012). To avoid under-pricing of space intensive modes, roadway land should be priced and taxed at the same rate as competing uses. If economical neutrality is not reached, transport will be under-priced relative to other goods.

Literature Review

The Victorian Transport Policy Institute (2012) defines roadway land value as the rent that road users would pay for roadway land, or at a minimum, the equivalent of property taxes. It reflects the cost of land used for road rights-of-way and other public facilities dedicated for automobile use. Newman and Kenworthy (1989) observed a positive relationship between annual car kilometres per capita and meters of roadway per capita – as per-capita travel increases so must the amount of land devoted to roads. Not all the costs should have to be recovered by road users. It is acknowledged that 25% of roadway land costs are to be attributed to basic public access.

The valuation of road- and railway land can be based on the total land surface area being used by the infrastructure, cost at property prices, and discounted annually.

Methodology

South Africa has a vast road network spanning many different urban and rural areas. In addition, transportation is not limited to a single province or area. It is therefore proposed that roadway land cost be calculated as a national average. The following data inputs are required:

- Total kilometres of road and rail
- Width requirement for each type of and rail track
- Property prices
- Discount rate
- National total vehicle mileage

Once the average width requirements of a certain type of road are added, multiplying it by the length of road, gives the surface area. Costing the surface area at an average price for land gives the total sunk cost of the road network. This total sunk cost can be transferred to road users through discounting it annually.

Transnet (South Africa’s national rail, port and pipeline operator and infrastructure owner) owns the land their railways are built on, and rents the land in metropolitan areas, no external costs are accrued.

Calculations

Based on a sample of a hundred vacant land prices from all over South Africa, the average cost per hectare was estimated at R24 563. The surface area used for the road network was calculated as per Table 4. The total value of roadway land was estimated at R78.6 billon. Given a 10% discount rate, based on the 2010 interest rate, the annual cost of roadway land was R7.86 billion. The total estimated vehicle kilometres travelled for 2010 was extrapolated from South Africa's vehicle database as maintained by the Department of Transport time series data to R127 billion which resulted in a cost of 4.629c per vehicle kilometre. Using total road tonne-kms, this translates into a roadway cost for trucks and light duty vehicles of R2.29 billion rand, or 1.00315c/tonne-km.

Classification	Paved (km)	Gravel	Average Lanes	Lane width(m)	Reserve (m)	Total width (m)	Total surface Area (km^2)
National	16170		4	4	20	56	905.52
Provincial	48176	136640	3	3	20	49	9 055.98
Metros	89373	316619	2	3	20	46	18 675.63
Unproclaimed		140000	2	2	10	24	3 360.00
Total							31997.13

Table 4: Break-down of road network and space requirements

POLICING

In contrast to road-related transport, rail freight transportation has no external portion of policing cost.

Literature review

The Victoria Transport Policy Institute (2012) carried out a comprehensive literature review on how to quantify the costs associated with traffic services. They propose that for each public service, be it fire and rescue, traffic police, courts or jailing, the budgets for each of these services proportionally allocated to traffic related incidence.

Methodology

Based on the assumption that more people require relatively more policing, approximations of the per capita cost of policing could be calculated based on population and budget density. Based on the relationship between metro police budget allocated per person as a function of population density the national average cost of policing can be estimated and transferred to road freight through the total proportion of registered vehicles attributable to trucks and light delivery vehicles. The following data inputs are required:

- Municipal Metro Police budgets
- Municipal populations
- Municipal surface size
- National population
- National surface size
- Proportion of registered vehicles attributable to trucks and light delivery vehicles

Calculations

Based on the data from Table 5 the relationship between money density per square kilometre and population density per square kilometre was used to calculate the money density per square kilometre for the country as a whole. The total cost of policing was estimated at R2.2 billion, this cost was then transferred to road freight through the total proportion registered vehicles attributable to trucks and light delivery vehicles which totalled at R589 million. The effective cost was 0.25814c/tonne-km.

2010/2011	Metro-policing budget	Surface Area	Population	Money density per square km	Population density per square km
JMPD	1500000000	1644.96	4031432	372.07	2450
Ekurhuleni	603776503	1975	2824597	213.75	1430
City of Cape Town	297907000	2455	2998802	99.34	1221

Table 5: Data used for calculating policing cost per population density

NOISE

Due to the logarithmic nature of sound, if the traffic volume has doubled, the noise will increase with 3dB. This relationship causes the marginal costs to rely and be very sensitive to current traffic flows.(World Bank, 1997)

Literature review

Maibach et al. (2008) discuss both a bottom-up and a top-down approach. The bottom-up approach commences with the traffic flow at a particular route. Once this reference scenario has been set up with the appropriate speed and density distributions of cars along the route, a marginal scenario is created which is the same as the reference, but with one additional vehicle. The top-down approach, as depicted in Figure 3, uses willingness to pay or accept compensation for additional health or more silence, scaled to a national level. The bottom up approach attempts to quantify the marginal noise costs of smaller or heavily used (noisy) roads. The top-down approach uses the total national impact aggregated by total distance driven to give average cost implications.

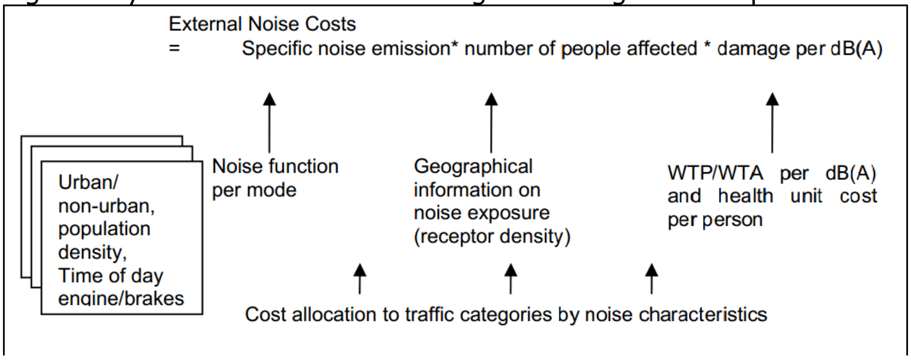

Figure 3: The summarised approach for estimating external noise costs (Maibach et al., 2008)

The following factors are highlighted by Maibach et al. (2008):

- There are different opinions regarding the threshold for annoying sound (50dB(A), 55dB(A) or even 60dB(A)). The threshold impact has a substantial effect on the marginal noise cost as research has shown that changing the threshold from 50 dB(A) to 55 dB(A) reduces the impact of noise pollution of cars by nearly 50%.
- Rail noise is experienced as less annoying and is therefore usually given a 5 dB(A) "discount".

Methodology

Due to the total lack of receptor sites (locations for particle matter readings) in South Africa, the literature-proposed methodology could not be employed and an extrapolation-method had to be used. Caution needs to be taken before extrapolating noise costs from one country to another because the negative impact of noise will vary from country to another based on the vehicle fleet composition and population densities of different receptor areas. The method used within this study was to identify possible country relationships at a national level based on density-based statistics and to extrapolate the costs through them. The following data inputs are required:

- Noise cost as a percentage of GDP
- GDP/capita for the countries under scrutiny
- National vehicle fleet counts

- National population counts
- National surface sizes

Once noise cost has been estimated as a percentage of GDP, the noise cost of rail and road freight can be allocated.

Calculations

Country	Noise cost % of GDP	People per square mile	Square miles	PPP-adjusted GDP/capita	GDP per capita per square mile
FRA	0.24	289	210668	34385	0.16
GER	0.2	609	135236	36225	0.27
NOR	0.23	39	118865	56498	0.48
GBR	0.5	650	93278	37000	0.40
USA	0.06-0.21	84	3539225	45613	0.01
JPN	0.2	836	152411	35011	0.23

Table 6: Data used for estimating noise cost as percentage of GDP

Based on the assumption that the more densely populated an area is, the more cost will be incurred due to noise, exponential relationships based on data from Table 6 were compared between people per square mile, GDP per capita per square mile and vehicles per 100 people, and percentage noise cost of GDP. The relationship between vehicles per 100 people only held for countries that have more than 400 vehicles per 100 people. The relationships between people per square mile and percentage of GDP estimated the noise cost of South Africa as 0.14% while the GDP per capita per square mile-based relationship estimated the cost at 0.15% of GDP. For the purpose of this study it was then assumed that noise cost in South Africa will be an estimate 0.145% of GDP i.e. R4.322 billion.

The total cost was split between road and rail in the same relationship as the total vehicle kilometres travelled per mode. Rail noise was found to be insignificant, i.e. 0,49% of total noise cost. The relative noise weights, (Tables 7 and 8) obtained from Maibach et al. (2008), multiplied by the estimated vehicle kilometres travelled resulted in road freight accounting for 77% of the road noise cost at 1.88278c/tonne-km. Rail is therefore accountable for R21.211 million at 0.01883c/tonne-km (91.5% of rail traffic is electrified, therefore a 33% noise discount is applied).

Mode	Relative noise weight
Car	0.04506400
Motorcycle	0.09030335
Bus	0.22532001
LDV	0.22532001
Truck	0.41399264

Table 7: Relative noise weights for different modes

Mode	Relative Noise weight (Metro)	Relative Noise weight (Rural)
LDV	0.056478	0.001815
Truck	0.103838	0.003266
Freight Train	0.743876	0.090728

Table 8: Relative noise weights for LDVs, trucks and freight trains

CONGESTION

Literature review

According to Jorgensen (2009) congestion has become a growing concern in South African urban areas. Maibach et al. (2008) propose a bottom-up approach which is capable of "(estimating) very detailed values." Congestion should be calculated based on reiterative remodelling of marginal trip costs based on the demand elasticity of travel on a certain route. When quantifying congestion costs, the general approach that can be followed is seen in Figure 5.

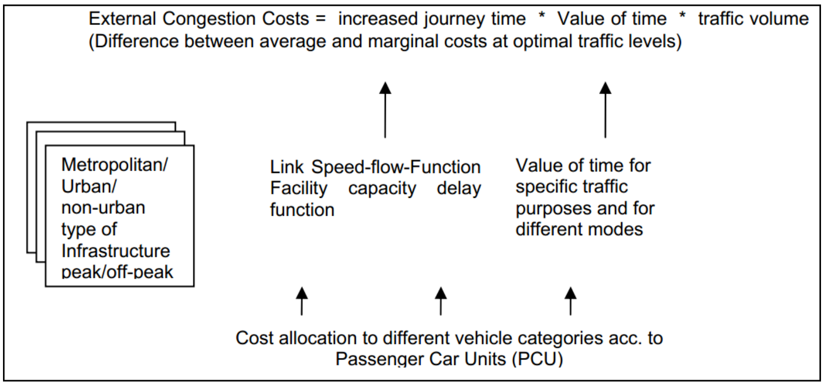

Figure 5: The summarised approach for estimating marginal congestion costs (Maibach et al., 2008)

The following steps are recommended when quantifying congestion costs which produced similar results to a study based in New Zealand.

1. Data inputs:
    (a) Classification of the traffic network into metro/urban/interurban and single/multiple lanes.
    (b) Speed-flow curves for the different types of traffic network segments in (a).
    (c) Valuation of travel time savings. Usually 50%, 100%, 150% of free flow time valuation.
    (d) Local elasticities of demand and traffic reaction patterns.
2. Computation of marginal external cost (MEC) functions based on valuation travel time savings.

$$\mathrm{MEC}_{Cong}(Q) = \frac{VOT.Q}{v(Q)^2} . \frac{\partial v(Q)}{\partial Q}$$

with:

- VOT: Value of Time (R / vehicle hour)
- Q: Current traffic level (vehicles / hour)
- $v(Q)$: Speed-flow function (km/hour)

Methodology

Calculating the national congestion costs which are attributable to road freight according to the generally accepted methods would be difficult due to the lack of data. A proposed, conservative approach is based on SANRAL vehicle statistics for the purposes of this study. The following data inputs are required:

- SANRAL vehicle counts
- Average speed and speed limit per section monitored
- Distance per section monitored
- Maximum vehicles per lane per hour monitored
- Estimated value of time
- Average daily trips and truck trips per section

The proposed methodology is based on the assumption that most people (taking into account speeding drivers and drivers who drive below the speed limit in the absence of congestion), on average will drive at the speed limit. The difference in average speed observed and the speed limit are therefore attributable, under the assumptions, to congestion.

Research by Nel and Pienaar (2009) found that the appropriate free flow volume of traffic on South African roads is 1600 vehicles per lane per hour. Based on this, only sections where there were more than 1600 vehicles per lane per hour at any given time were used in the calculations. The total time lost due to trucks is then allocated by calculating which portion of the average passenger car equivalent daily trips was caused by trucks.

Calculations

Based on the methodology a total of 5.36 billion minutes of extra travel time was caused by road freight, which valued at R1 a minute (Nel and Pienaar, 2009) resulted in a cost of R5.36 billion or 1.9225c/tonne-km.

IMPACT ON TOTAL FREIGHT LOGISTICS COSTS

South Africa's surface freight transport costs amounted to R181 billion in 2010 (Simpson and Havenga, 2011). The externality costs calculated in this paper are significant and amounts to R34.9 billion (1.2% of GDP) (as depicted in Figure 6), i.e. almost 20% of freight transport costs are not "invoiced".

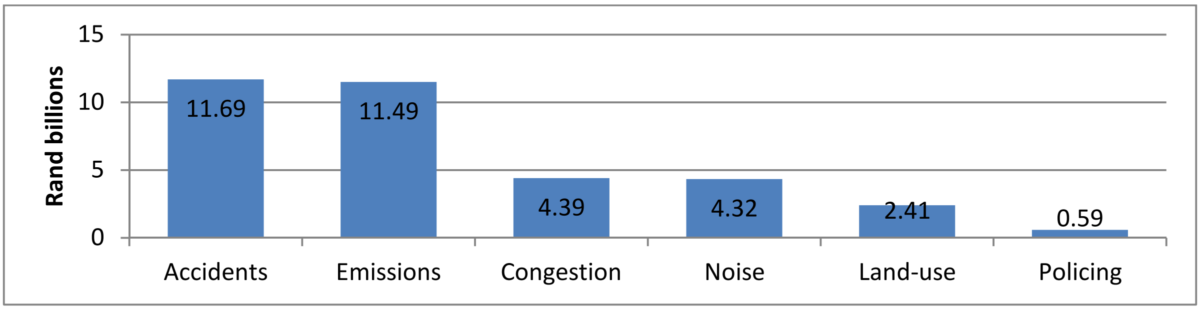

Figure 6: South Africa's surface freight transport externality costs based (2010)

CONCLUDING REMARKS

The research presented in this paper is the output of the first ever localised model for surface freight transport externalities in South Africa. Many of the models applied internationally have onerous data requirements, and adaptations were made as required to obtain an executable approach for South Africa. The initial results highlight that freight externality costs are a significant cost that has not yet been accounted for but are borne by the public at large.

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NATIONAL LEVEL LOGISTICS COSTS MEAUSUREMENT FOR SOUTH AFRICA – IDENTIFICATION OF RISK FACTORS

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INTRODUCTION

South Africa's freight logistics cost survey was developed as a macroeconomic measurement tool to facilitate the development of national freight logistics strategic objectives and policies. The latest survey indicates that South Africa's freight logistics bill for 2010 was R339 billion. While this is a 4.9% increase from the R323 billion recorded in 2009, logistics cost as a percentage of GDP has improved from 13.5% to 12.7% as depicted in Figure 1. In absolute terms, national logistics cost for 2010 is on par with the logistics costs for 2008, with the negative impact of the global economic recession evident in the lower logistics costs for 2009 (Havenga *et al.*, 2010).

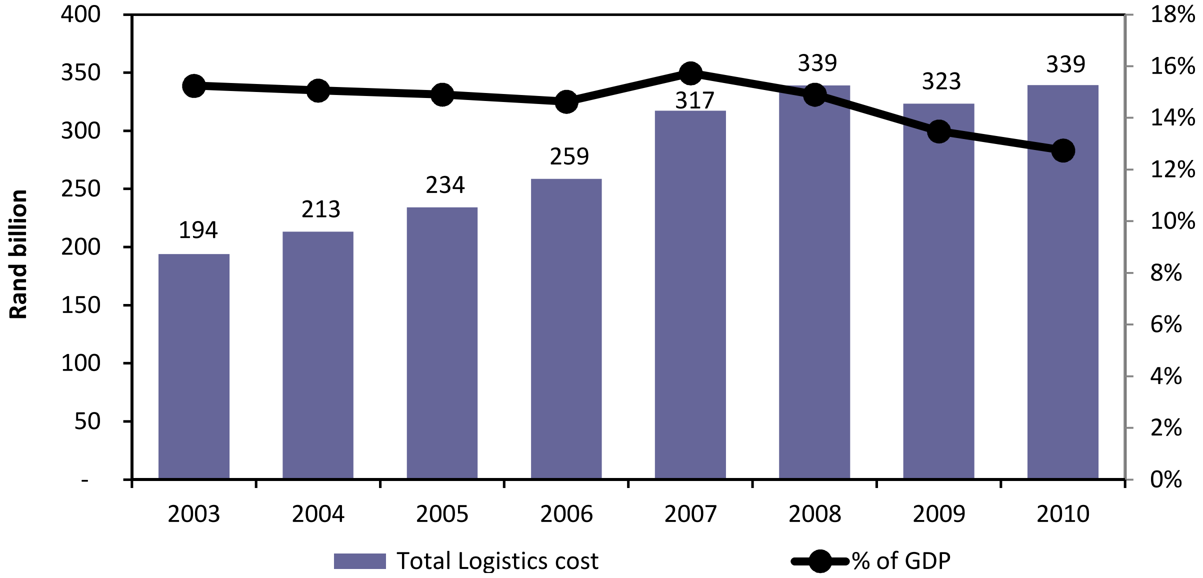

Figure 1: South Africa's logistics cost as percentage of GDP

The continuing downward trend in South Africa's logistics cost as a percentage of GDP to its lowest point since measurement is in contrast to recent movements in the USA (Wilson, 2010), where this percentage increased from its lowest ratio of 7.7% to 8.3% in 2010 (Figure 2).

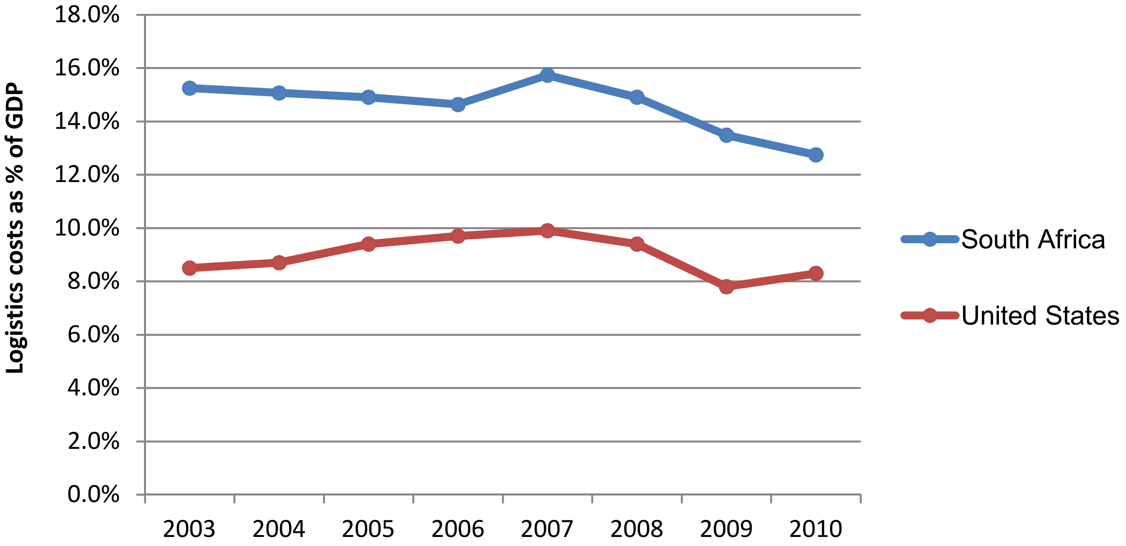

Figure 2: A comparison between the logistics cost as percentage of GDP for South Africa and the USA

There are at least two apparent reasons for this dissimilarity. The first has to do with the development status of the underlying economies and will be discussed briefly. The second pertains directly to the prevailing paradigm in the logistics field and will be analysed in more detail.

The first reason is that the composition and dynamics of the two economies differ, one being the biggest developed economy in the world and the other being a fast developing economy. Economic growth in developing economies is usually skewed towards tertiary sector growth that is not as logistically intensive as the other two sectors. This trend is clearly evident in the South African economy in Figure 3 where the growth in the primary and secondary ('transportable') sectors is compared to that of the tertiary ('services') sector over the last 65 years.

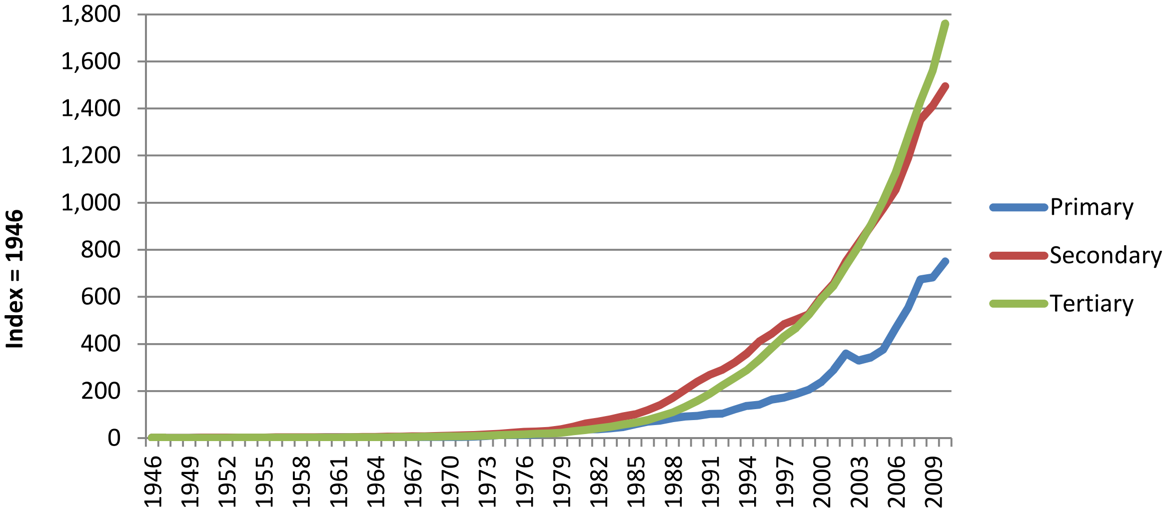

Figure 3: Sectoral GDP growth rates: 1946 – 2010 (Lehohla, 2004) (StatsSa, 2011)

The second reason is that the cost management trade-off between inventory and transportation in the USA's mature economy are causing the upward creep. In this paper the trade-off in the USA is discussed in more detail, followed by an analysis of South Africa's logistics cost components to determine whether the USA trend should serve as warning signals on South Africa's growth path. Scenarios are then developed to highlight the potential risk if the warning signals are not heeded.

THE COST MANAGEMENT TRADE-OFF BETWEEN INVENTORY AND TRANSPORTATION

In mature economies, such as the USA, logisticians have made great efforts to decrease logistics costs facilitated inter alia by deregulation and technology (Murphy *et al.*, 2011) . Deregulation of transport provided logisticians with more modal choices and the ability to lower total cost of ownership. Deregulation of other industries (such as for various agricultural commodities) removed the natural accumulation of commodities and challenged logisticians to become more lean and agile. Technology enabled the concepts of richness and reach, meaning that the advantages of decentralisation (being responsive and closer to your customer) and centralisation (efficiency) are both enabled. At the same time, however, increasing specialisation increases transport costs --- driven by the pull-phenomenon of consumer power as well as globalisation.

The majority of supply chains in mature economies are already highly efficient, making it difficult for companies to compete on a cost level. Inventory control is often seen as one of the last areas of competitive advantage (Grant *et al,* 2006) as it is often the largest single investment in assets for most manufacturers, wholesalers and retailers (Stock & Lambert*,* 2001). Inventory carrying cost is also not that apparent as a system cost in the enterprise's profit and loss statement (Bowersox & Closs*,* 1996), creating an opportunity for logisticians to demonstrate value. Furthermore, inventory control is influenced and improved on a firm level, reaping direct rewards for those companies that accelerate their inventory turnover. These developments resulted in an emerging culture of optimising inventory control to drive down logistics costs. The trade-off of tighter inventory control, however, is increased demands placed on the transport function --- causing an increase in transport costs. Figure 4 shows the indisputable trend in transportation and carrying costs in the USA over the last three decades. This implies that the core tenets of logistics thinking are still geared towards driving down inventory levels, rather than optimising transport on a national level.

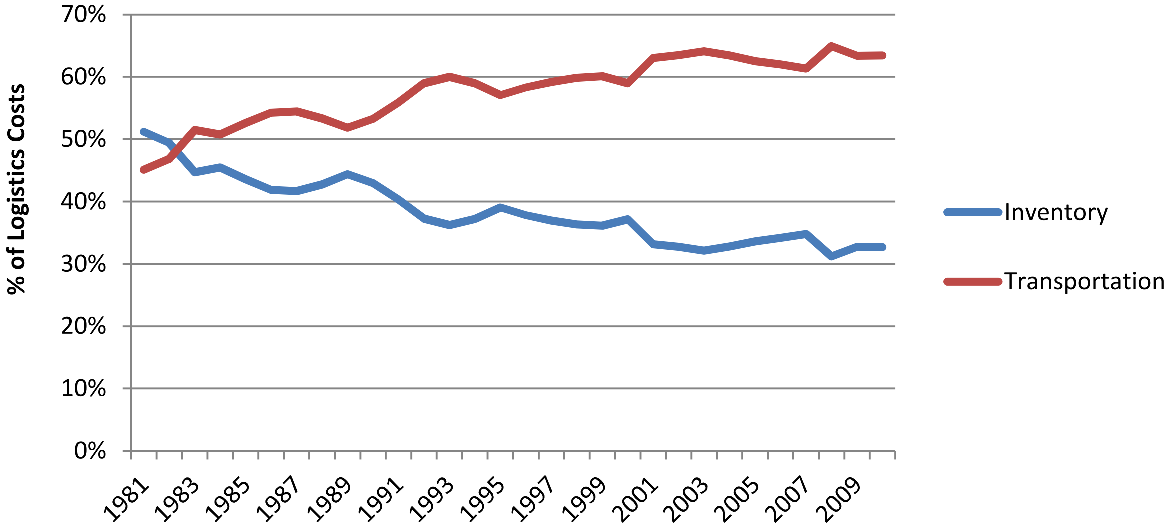

Figure 4: Long-term inventory carrying and transportation cost trends in the USA (Wilson & Delaney, 2003), (Wilson, 2010)

It is hypothesised that the logistics costs challenges facing the USA (Figure 4) are driven by a trade-off between transport and inventory carrying costs that is based on the underlying belief that the current price relationship between their respective primary cost drivers, i.e. fuel for transport costs and interest rates for inventory costs, will not change. Transport costs might however expected to rise much more sharply than anticipated, driven on the one hand by the increasingly negative outlook of the fuel price given peak oil concerns, and on the other hand by the imminent inclusion of externality costs in transport costs in the near future.

The expected change in transport costs is so momentous that long-standing global economic trends are being revised to cope with the impact. For example, relatively low transport costs allowed nations to import raw materials and export products to such a scale that global trade grew exponentially over the last two centuries (from 1% of global GDP in 1820 to 10% in the early seventies, a third by the turn of the century and soon to approach a half of global GDP) (Havenga, 2011). This allowed countries to specialise in the production of final consumption products for certain industries while importing the final consumption products for other industries --- a trend called mass specialisation. It is expected that this trend will be reversed to cut down on the costs of transport externalities.

COMPONENTS OF SOUTH AFRICAN LOGISTICS COST

Figure 5 shows a detailed trend analysis of the four major logistics cost components since 2003. It is notable that although, in absolute terms, the total logistics costs for 2010 are on par with that of 2008, there has been a remarkable decrease in inventory carrying costs and an equally significant increase in transport costs. These drastic changes are understandable, given the sharp short term changes in the diesel price and interest rate (Figure 6), the respective underlying cost drivers of transportation and inventory carrying cost. In contrast to South Africa, the proportional contribution of transportation and inventory carrying cost to overall logistics cost in the USA remained the same. Given that the diesel price is derived from the global oil price, which therefore also would have impacted on the USA's transportation cost component, the relative impact of these short term shocks on South Africa's national logistics costs implies vulnerability within the national logistics system. The key question is what the long term expectations of the value of these two cost drivers are, given the impact on logistics costs of severe shifts, as illustrated during 2010.

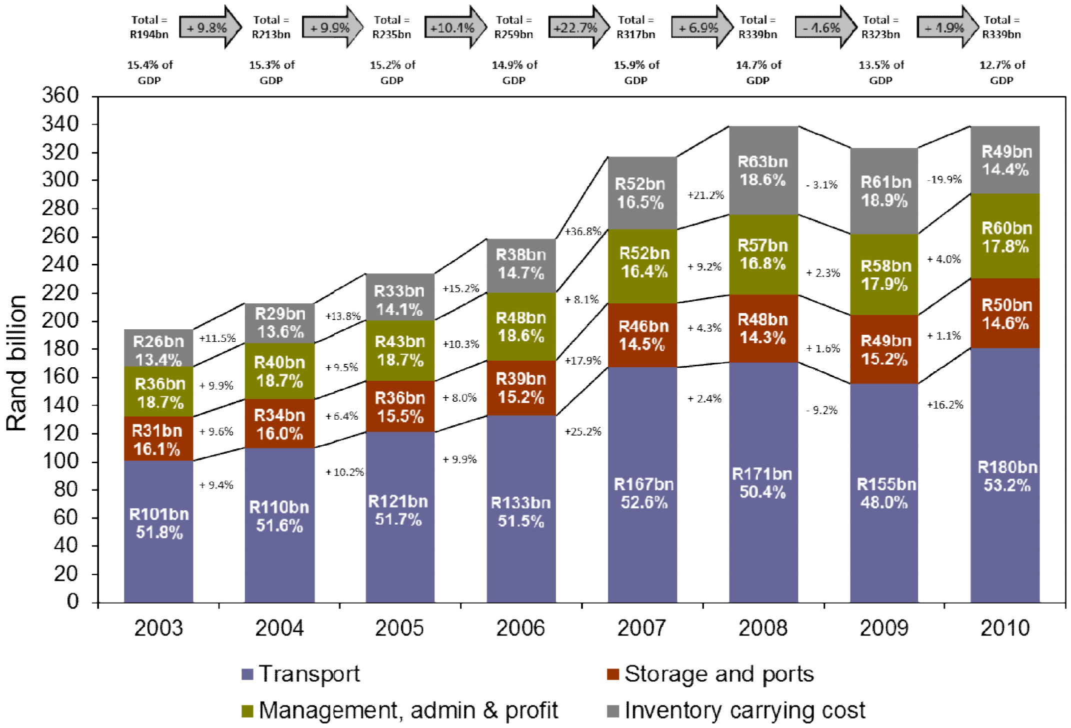

Figure 5: Components of South Africa's logistics costs

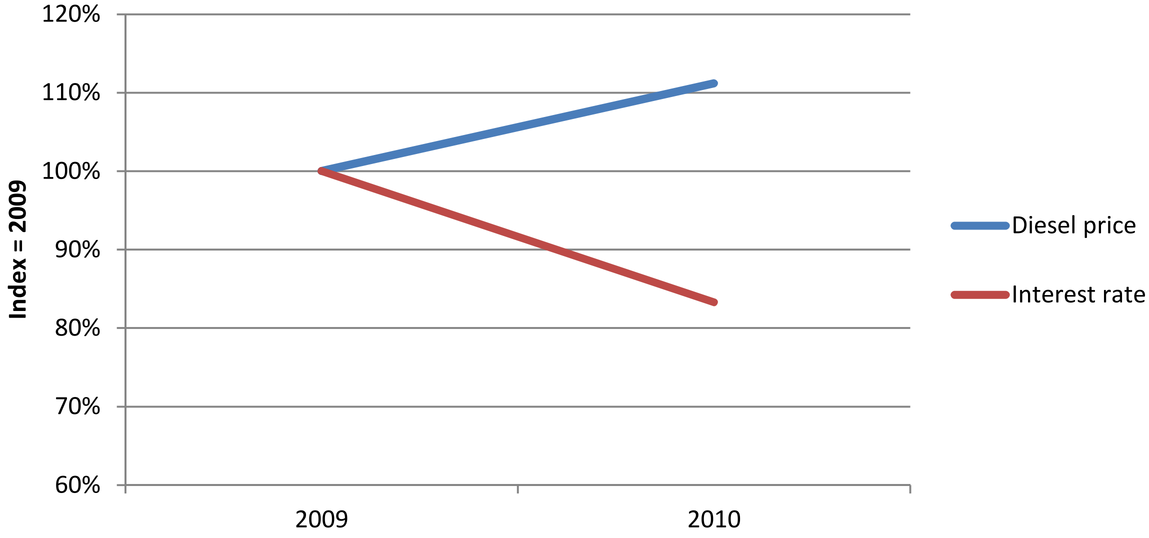

Figure 6: Short-term changes in the key cost drivers of transport and inventory carrying cost for South Africa

Inventory carrying cost

The decrease in inventory carrying costs from 2009 to 2010 (Figure 5) is partly due to lower overall inventory volumes, but mostly due to the lower interest rate in 2010 (Figure 6). At the beginning of 2010, South Africa's prime lending rate was 10.5%. Three decreases during the year saw it ending the year at 9%. This had a significant impact on the cost of carrying inventory. Had the interest rate for 2010 been that of 2009 (which saw a high of 15% at the start of 2009), inventory carrying costs would have been R9.8 billion more, which would have put the total logistics cost as a percentage of GDP at 13.1% instead of 12.7%.

Transport cost

The marked impact of South Africa's 11% fuel price increase between 2009 and 2010 on transport costs is no surprise considering that the fuel price is the primary transport cost driver. A breakdown of the road transport costs are given in Figure 7, clearly showing the impact of fuel costs, being 36% of road transport costs (more than double the cost of wages).

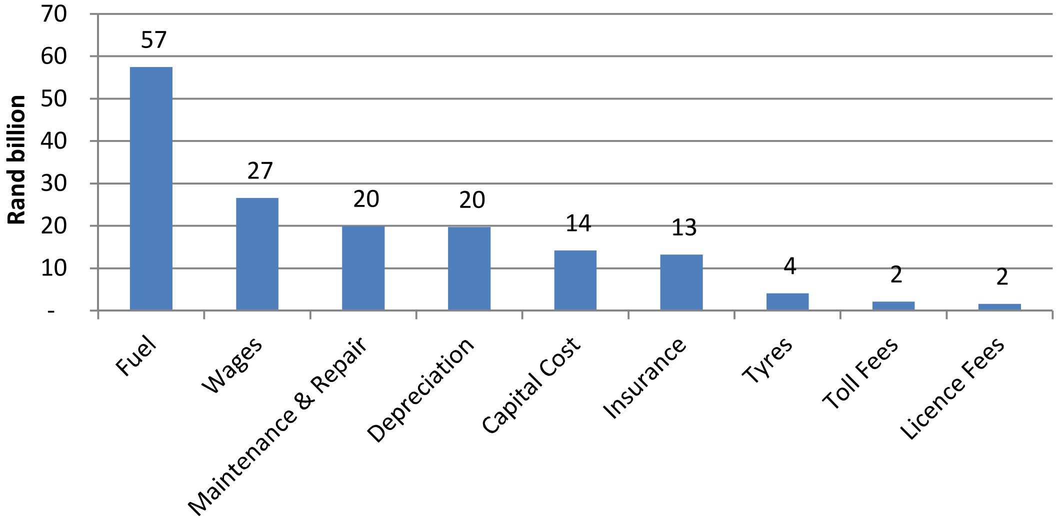

Figure 7: Road transport cost components

Had the fuel price remained that of 2009, total transport costs in 2010 would have been R5.8 billion less, consequently putting logistics cost as a percentage of GDP at an even more favourable 12.5%. Transport cost as a percentage of total logistics cost would then have been 52%, instead of 53%. Globally, transport cost as a percentage of logistics costs is less than 40%, which makes South Africa's percentage relatively high. It is the prospect of an upward trend, however, that is more alarming. (It is noted that, as depicted in Figure 4, transport cost as a percentage of logistics costs is much higher for the USA than for South Africa, but this is believed to be due to a difference in methodology - some management and administration costs that are depicted separately in South Africa's survey seem to be included under transport costs in the USA.)

When expressing ton-kilometre requirements in terms of GDP (i.e. how much is contributed to the GDP by moving a ton of freight one kilometre), as depicted in Figure 8, South Africa emerges as a highly transport 'hungry' country compared to the rest of the world, especially Western Europe. The transport 'hungry' nature of the country, combined with the fact that the key driver of transport cost is a commodity with a volatile pricing structure attests that transport is, in fact, a *strategic* resource requiring national attention.

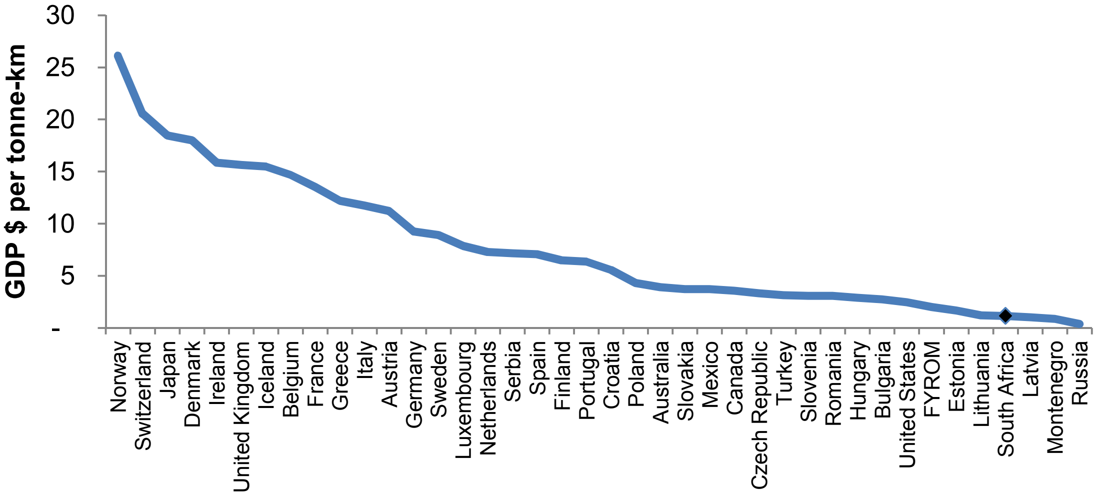

Figure 8: GDP dollars per ton-kilometre – global comparison (OECD, 2010), (Bambulyak & Frantzen, 2007), (United States Department of Transport, 2007)

Externality costs

Externality costs are the costs induced by transportation that are not reflected in the financial statements of the users of the logistics system. The five types of externality costs considered in the 2010 study (i.e. accidents, CO_2 emissions, congestion, noise and policing) are depicted in Figure 9. To calculate CO2 emissions, a cost of R225 per ton of CO2 is assumed, in line with the proposals of South Africa's National Treasury[6]. The other externality cost elements were calculated using the same assumptions as in the previous survey (OECD, 2010). Total externality costs for 2010 are estimated at R27.8 billion. This is significant as it is a yet unaccounted for cost in the South African logistics system. From a macroeconomic point of view these costs should be included in an analysis of logistics costs and should inform trade-off decisions. From a strategic supply chain point of view, the cost of CO_2 emissions will be internalised through taxation or other similar mechanisms in the near future and, therefore, deserves further analysis.

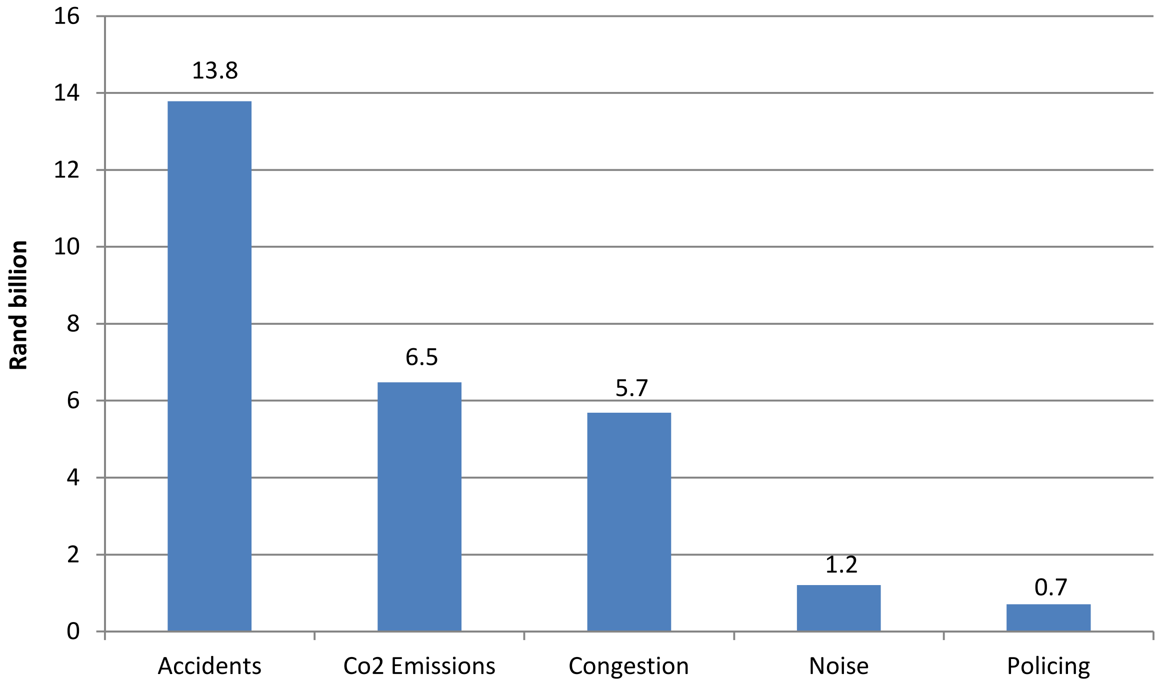

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Figure 9: Externality costs by category in South Africa for 2010

SCENARIOS

In this section the effect of three variables, oil price volatility, exchange rate volatility and emission tax uncertainty, on the total cost of logistics is investigated. As highlighted in the prior analyses, transport is the biggest logistics cost component in South Africa with the biggest cost driver the price of diesel. The local diesel price, in turn, is determined by the international crude oil price and exchange rate --- both volatile exogenous variables. Accounting for some externalities of transport, notably emissions, is also imminent as the increasing global pressure to internalise emission costs makes taxation in the near future highly likely, despite the uncertainty about the actual levels of these taxes. Table 3 outlines three paradigmatic scenarios based on the three variables mentioned.

Table 3: Three paradigmatic scenarios based on oil price volatility, exchange rate volatility and uncertain emissions cost levels

	Good	**Bad**	**Worst**
ZAR to USD exchange rate	R7.50	R10.00	R15.00
USD per barrel crude oil	\$150	\$250	\$500
CO_2 emission cost per ton	R225	R300	R500

Should the worst case scenario have existed in 2010, South Africa's logistics costs would have increased by R354 billion as depicted in Figure 10 (more than the country's current total logistics costs). The probability of such a scenario materialising should be high on the country's research agenda.

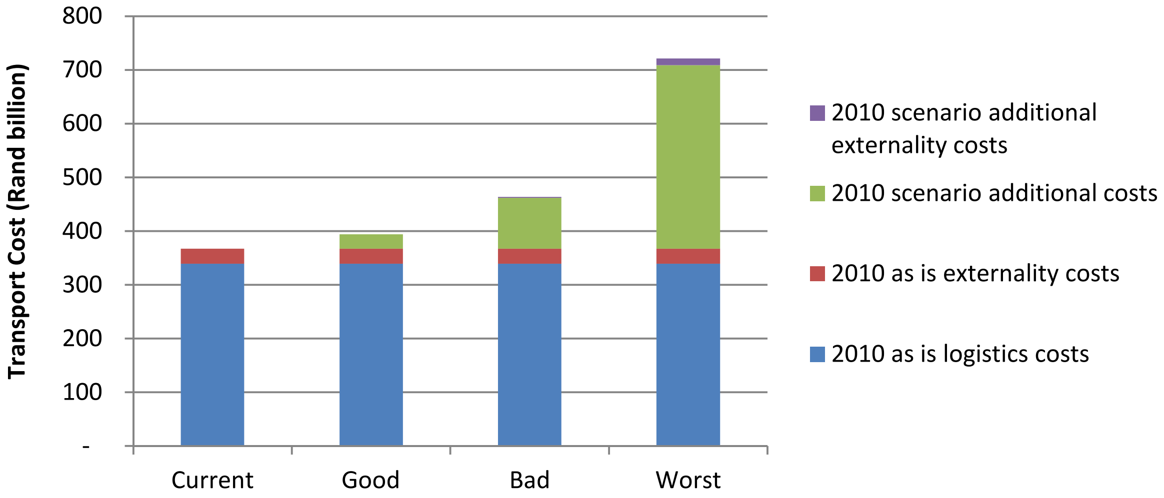

Figure 10: Scenarios: Impact of externality costs on logistics costs

CONCLUSION

At a glance South Africa's logistics cost as percentage of GDP is improving. This should however not be blindly interpreted as an actual improvement in the country's logistics capacity and capability. The dynamism of the transport-inventory trade-off should not be underestimated. Currently the behaviour of logisticians still favours lower inventory carrying costs at the expense of lower transport costs, but a major structural change in underlying cost drivers might be looming as a possible consistent rise in fuel prices could overshadow the rise in the interest rate. Should this happen, the current 'total cost' oriented inventory-transport balance would become invalid, leaving the country locked into dismal cost inefficiencies through long-term infrastructure decisions (such as warehouse locations) that did not cater for such a game-changing development. This implies that the transport cost challenges should be strategically addressed through collaborative, industry-wide and even nation-wide initiatives. Transport improvements have much more potential to lower national logistics costs than company- or supply chain level inventory management strategies. However, decisions regarding transport investments have a long-term impact on the country and careful (yet urgent) consideration is required.

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