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(ISL 2008)**

Integrating the Global Supply Chain

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INTRODUCTION

We would like to welcome our friends and colleagues to the annual International Symposium on Logistics (13th ISL). It is 15 years since the first symposium on Logistics was held in Nottingham in 1993 and has now become a regular, well-established and premier international event in the field of Logistics and Supply Chain Management. As always many members of the ISL community look forward to meeting, sharing and exchanging their research ideas and results in both a formal and informal setting which the symposium provides. The ISL series continues to grow in strength and stature in terms of contributions made by the participants to the field of Logistics and Supply Chain Management. Similarly, the concept of alternating the symposium every year between Europe and the rest of the World is now well established. To date this event has successfully been held eight times in Europe (Nottingham, UK 1993 and 1995, Padua, Italy 1997, Florence, Italy 1999, Salzburg, Austria 2001, Seville, Spain 2003, Lisbon, Portugal 2005, Budapest 2007) and four times outside Europe (Iwate, Japan 2000, Melbourne, Australia 2002, Bangalore, India 2004 and Beijing, China 2006). This year's event in Bangkok, Thailand continues with the tradition following the very successful and productive event held in Budapest last year. As usual ISL 2008 brings together leading academics, researchers and practitioners to exchange ideas, views and the latest research in the field of Logistics and Supply Chain Management.

*The theme of this year's 13th International Symposium on Logistics is "**Integrating the Global Supply Chain**". To a certain extent this theme capitalises and builds upon the papers presented during the previous two ISL events. It also represents an emerging and highly challenging area of research and practice for both academics and practitioners alike. The current industrial context is characterised by increasing global competition, decreasing product life cycles, flexible structure of manufacturing, increased levels of global outsourcing, collaborative networked organisations, higher levels of uncertainties and, above all, customers, who are demanding higher levels of service. This means that the challenges to supply chain management have never been greater. In our view holding this event in Bangkok represents a timely opportunity for academics and researchers to explore pertinent issues surrounding logistics and supply chains with Thailand positioning itself as a logistics hub for Indochina as a key node in the global supply chain. This year's symposium attempts to address some of these issues.*

Potential authors were invited to submit an abstract to the Symposium Chairmen. All abstracts were reviewed by two experts from the International Advisory Committee and final papers were further reviewed by an International Panel of Reviewers. As a result papers are included in this volume with 220 contributing authors coming from 21 countries. This book of proceedings has been organised according to the following categories:

- *Supply Chain Management*
- *International Supply Chain Networks*
- *Supply Chain Performance Assessment*
- *Global Outsourcing*
- *Logistics Planning and Control Models*
- *Inventory Management*
- *Decision Support Systems and Communication Technologies*
- *Logistics in the Service Sector*
- *Environmental Logistics*
- *Distribution and Third / Fourth Party Logistics*
- *Reverse Logistics*
- *Organisational and Managerial issues in Logistics*

We would like to take this opportunity to express our sincere thanks to all the presenters, delegates, reviewers, Advisory Committee members, local organization 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, Professor Chandra S Lalwani and Professor Ruth Banomyong

July 2008

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SECTION 1

SUPPLY CHAIN MANAGEMENT

EXPLORING ADOPTION OF LOGISTICS AND SUPPLY CHAIN TECHNIQUES AND STRATEGIES IN THE THAI AUTOMOTIVE INDUSTRY

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ABSTRACT

The recognition of supply chain management (SCM) and logistics as key and vital tactics for Thai Automotive companies. The aim of this study is to explore the current status and pattern of adoption for SC logistics, techniques and strategies within Thai automotive companies, including evaluating factors affecting logistics and strategy formulation and implementation. This study also examines the degree of effectiveness after implementation. Current literature reveals that world class companies within the U.S. and European automotive industries have been widely using logistics and supply chain techniques, but there is little research on automotive companies in Thailand. This study should help encourage Thai firms to establish and implement a SC logistics and strategies.

For this paper, data was collected in *three* dimensions: **1. A Literature Review** was primarily conducted in issues related to using current SC logistics, techniques, and strategies, including formulation and implementation strategies; **2. Survey Method** was used to examine issues and relationships between study variables, and; **3. In-depth Interviews** were conducted to obtain deeper insights from Logistics Managers of Thai automotive companies. Deploying random stratified sampling, questionnaires were distributed to 110 companies within Amata Nakorn Industrial Estate in Chonburi province, Thailand. After a month, there were 89 questionnaires returned, for an 80.9 percent response rate. The sampling included Original Equipment Manufacturers (OEM) and Replacement Equipment Manufacturers (REM).

The survey revealed that 46.4 percent of companies are using logistics functions related to material management. 34.5 percent use physical distribution logistic functions. These companies have currently employed at least one SC logistic or strategy in specific functions, but not throughout the entire organisation. Japanese-owned companies rely heavily on logistics systems. On the other hand, Thai-owned companies have adopted logistics techniques and strategies by lesser degree. The main objectives for adoption were to better respond to customers' needs, improve customer service levels and reduce total costs, respectively. This study identified factors affecting logistics and SC strategy formulation and implementation. They consisted of four major factors: people, systems, process and culture. Finally, it provided conclusions and recommendations for improving business performance and organisational effectiveness of Thai automotive companies.

Keywords: Logistics, supply chain, strategy, Thai automotive, effectiveness

1. INTRODUCTION

The recognition of logistics and supply chain management (SCM) as key and vital tactics for enhancing competitiveness by reducing total costs and improving service levels. Even though logistics and supply chain have different meanings, they are used interchangeably. Both words are also used together to

explain how to effectively manage physical and information flows by providing excellent coordination and collaboration.

However, the research study (9) shows that companies fail to understand how to apply the logistics to their operations, and how to put logistics and supply chain strategies and techniques into action. Under marketplace pressures, companies need to hasten awareness and priority to logistics and SCM techniques, not just in specific functions, but throughout the entire organisation.

The aim of this paper is to identify the current gap between needs and implementation by exploring the status and pattern for adoption of logistics and SC techniques in Thai automotive companies. This includes evaluating factors affecting logistics and SC technique formulation and implementation. It also includes examining the degree of effectiveness and efficiency after implementation. The major benefit of this study should be to encourage Thai firms to adopt logistics techniques, thereby closing the gap

2. LITERATURE REVIEW

For this study, relevant literature was reviewed in relation to the role of logistics and SCM within the automotive industry. Two studies (1, 2) showed that an organisation can effectively create and develop a competitive position by adopting logistics and SCM, especially within rapidly changing industries. However, studies also revealed that the success of logistics adoption and implementation depends on other factors as well, for example leadership and organisational culture (2, 4).

This literature review also helped clarify the definitions of logistics & SC. It is important to have clear and concise concepts of logistics & SC, since each industry (or even companies within the same industry) may understand these terms differently. Also, different companies may use similar methods but call them by different names.

Relevant studies (1, 2), however, referred to SCM as process-oriented management, or, mainly focused on managing a relationship between processes (from sourcing to customer service). Logistics was defined as a service-oriented process related to movement of physical and information flow. Both terms are typically used together to explain how to effectively manage physical and information flows by providing excellent coordination and collaboration (1).

The literature revealed the different types of logistics and supply chain strategies used within various industries and countries, for example: just-in-time; quick response; lean and agile concept; and, economic order quantity. However, each technique can have unique approaches by different industries.

The literature also showed that companies have different and unique motivations for adopting logistics techniques, but the major motivations of logistics adoption are better response to customers' needs and reduction of total costs (2, 12).

When considering factors affecting adoption and implementation within industries, (and, in particular, the automotive industry), the literature points out that major factors are marketplace pressures from customers and competition (11). Particularly in the automotive industry, time becomes a vital issue as companies operate under time-based competition. As effectiveness and efficiency of logistics adoption by industry was reviewed, it was found that there was a strong relationship between SCM adoption and organisational effectiveness (8). The literature revealed that world-class companies in the U.S. and European automotive industries have been widely using at least one logistic or supply chain

technique (11, 2). This study should encourage Thai automotive companies to adopt and implement their own logistics and SCM strategy.

The literature revealed that even though adoption of logistics techniques provides higher performance to companies, the most problematic step is how to integrate implementation into the organisational structure, processes and culture. Further the literature suggested that companies need to identify and effectively control these factors that inevitably affect the effectiveness of adoption and implementation of SCM. Finally, the literature reveals there is a definitive gap between the issues of needs and implementation, and concludes there is a need to examine factors affecting the SCM implementation phase and influencing its organisational effectiveness. This review, therefore, proposes a theoretical framework (Figure 1) as derived from the literature (14).

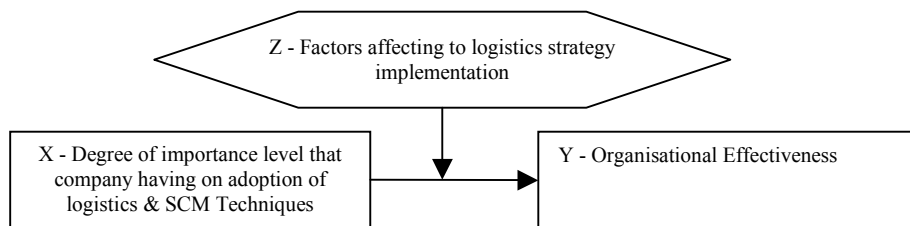


Figure 2-1. Theoretical Framework

Figure 2- 1 shows a theoretical framework of variables in this study. The literature review revealed that world-class companies have widely adopted logistics and supply chain techniques and strategies. Successful companies put high priority and importance on the adoption of the techniques and strategies. The research showed that the more importance given on adoption of the techniques, the more an organisation enhances its effectiveness, with the main objectives being operational cost reduction and improved customer service levels. However, there are other factors, for example, fuel costs, intense competition and organisational culture, which influence implementation.

The figure shows the relationship between variables (*X, Y, and Z*). **Variable X** (*the independent variable*) is defined by the degree of importance organisations give the adoption of logistics and supply chain techniques.

Variable Y (*the dependent variable*) is defined as an organisation's overall effectiveness, and is focused in organisational level (*variable Y*). Variable Y is directly affected by X.

However, **Variable Z**, (*the intervening variable*) affects both X and Y. Variable Z is defined by organisational culture, organisational structure, and external pressures. These factors intervene – or have influence – on both independent and dependent variables. It is therefore assumed that the level of intervening factors contribute to, or impede, adoption and implementation of SCM as well as overall organisational effectiveness.

3. RESEARCH METHODOLOGY

This paper initially conducted a *literature review* of issues related to using current logistics and SC techniques and strategies, as well as how to effectively formulate and implement logistics strategy in industries. *Exploratory study* was also used to discover types of logistics techniques and strategies using in the Thai automotive industry.

After this review, seven strategies were listed: **JIT, QR, ABC, EOQ, E-commerce, MRPI, Lean**. The aim of this study was to investigate the

relationship between variables related to adopting logistics and supply chain strategies in Thai automotive companies, as well as to gauge their effectiveness. It explored the current status of adopting logistics strategies and techniques, how companies have sufficiently given an importance level for implementation of these strategies, and what effectiveness has been demonstrated after companies have implemented strategies by considering overall business performance.

In-depth interview surveys were used jointly with questionnaire surveys in order to obtain deeper insight from Logistics Managers at Thai automotive companies. To obtain this data, the study used sample companies within the Thai automotive industry (a total of 115 companies located in Amata Nakorn Industrial Estate, Chonburi, Thailand). The final sampling size was 110 companies. To achieve this number, questionnaires were issued by a randomly stratified sampling. The rate of response generated was very good with 89 respondents or 80.9 percent in total. The data collection period took one month. The conceptual framework was derived from theoretical studies (14).

3.1 Research Questions

The following research questions were utilized:

1. What are the roles of logistics and SCM for enhancing an organisation's competitive advantage?
2. What status are Thai automotive companies giving to the adoption of logistics and SC techniques?
3. What is motivating interest to adopt logistics and SC techniques?
4. What factors are influencing the adoption of logistics and SC techniques and strategies in the Thai automotive industry, and how?
5. How do other factors influence or contribute to organisational effectiveness?

3.2 Research Hypotheses

According to studies (9, 12), a strong relationship lies between the level of importance organisations give to adopting logistics and supply chain techniques, and the effectiveness incurred. This study therefore explored relationship of the variables under the following hypotheses:

H1 = There is a relationship between the degree of importance that organisations place on adoption of logistics and SC techniques and their functional effectiveness.

H2 = There is a relationship between the degree of importance that organisations place on adoption of logistics and SC techniques and their organisational effectiveness.

H3 = There is relationship between success of adoption of logistics technique and strategy and factors influencing to logistics strategy implementation.

3.3 Population & Sampling Procedure

This study used companies that were members of the Thai Automotive Institute (TAI). The TAI is a non-profit organisation with 115 members, which was established to support Thai automotive companies to be leading companies in the world (TAI, 2007). A total of 110 questionnaires were randomly distributed to the targeted companies. After a month, there were 89 questionnaires returned making a response rate of 80.9 percent.

3.4 Data Collection

The paper collected data in *two dimensions*. First, a *literature review* was conducted in various fields related to logistics management, supply chain

management, and supply chain optimisation. Secondly, *survey method* was used to examine the relationship between variables in the research questions.

The questionnaire was conducted in Thai language. First, pre-testing carried out through thirty-six respondents found that Cronbach's alpha equaled 0.904. There were some minor changes (e.g., some ambiguous wordings, adjusting for long sentences) in items of the questionnaire. After three weeks, the second pre-testing was conducted through thirty-five companies within the same population with Cronbach's alpha equaling 0.945. The result revealed that the research instrument had a high acceptable degree of reliability.

In each organisation, the respondent was asked to evaluate and rate on a five-point, Likert-type scale the relative level of importance given by each firm to its success or effectiveness.

No	Channel	Distributed	Responded	Response Rate %
1	Postal mail	100	Nil	Nil
2	Face-to-Face	100	80	0.80
3	E-mail	10	9	0.90
	Total	110	89	80.9

Table 4-1 Data collection in channels and response rate

Of the 100 face-to-face questionnaires conducted, 80 were successfully completed for a rate of return of 80 percent. Finally, the new form of data collection – email questionnaires – were distributed to 10 companies in the directory with nine successful returned. The final results, with *89 total respondents*, showed a very good response rate of *80.9 percent in total*. The data collection period, including the pre-test study and the final survey, was one month in total.

3.6 Data Processing

After questionnaires were returned, they were classified by source and coded and edited for data entry (13). The SPSS for Windows version 10.0.5 was used to analyse the data.

4. RESEARCH FINDINGS

The result shows the type of respondents. The greatest number of respondents in the samples came from OEMs at 92.0 percent, followed by REMs at 8.0 percent. The study reflected a reality within the Thai automotive industry, showing that OEMs are playing a major part. When considering to duration of their business life, the survey points to an interesting ratio within the Thai automotive industry. It shows that most of respondents (71.4 percent) have been operational for 10 years or less, while only 28.6% have been doing business for over 10 years. This ratio is consistent with the rapid growth period the Thai automotive industry has experienced in the last decade.

It also reveals the rate of usage of logistics systems by business activities. It showed that a large percentage of respondents (46.4 percent) have been widely adopting logistics and supply chain techniques for inbound material management activities. More than a third of respondents (34.5 percent) were using them for outbound physical distribution activities. The results also show that Thai automotive companies are giving a much lesser degree of importance to the adoption of logistics techniques for reverse logistics.

The motives influencing the adoption of logistics and supply chain techniques and strategies in the Thai automotive industry were examined. The study asked respondents to rate what motivations are influencing the adoption logistics techniques. The study revealed that better response to customer needs (4.63) was the most important motive, followed by pressures to reduce total operational costs (4.52). However, it also found that companies gave a lesser degree of importance to increasing market share.

The study identifies intervening factors that influence the adoption of logistics and supply chain techniques and strategies in the Thai automotive industry. This study found that the complex and sophisticated demands of customers was a major influence (32.0 percent), pressuring suppliers to adapt to rapidly changing demand. This was followed by pressures from intense competition (28.0 percent) and organisational culture (18.0 percent). Due to intense competition, this result showed that Thai automotive companies have been trying to adapt to market changes, especially customer demand.

When considering to the perception of the Thai automotive companies as to the level of importance they give the adoption of logistics and supply chain techniques and strategies. The results revealed that automotive firms have been widely adopted the following techniques: Quick Response (QR); Just-In-Time (JIT); Material Requirement Planning (MRP), and; Economy Order Quantity (EOQ). Most respondents gave a higher degree of importance to adopting the quick response technique (4.46), followed by JIT (4.35) and MRP (4.14) respectively. The firms identified efficiency and effectiveness occurred after the adoption of logistics and supply chain techniques. The responses show that successful adoption of the techniques does improve organisational effectiveness. They also show that effective logistics adoption assisted firms in responding to customer needs (4.35), followed by improvement in service levels (4.19), and reduction in total logistics costs (4.10). Moreover, these results reflect why Thai automotive companies should be giving high priority to the adoption of logistics techniques.

Table 4.2 Summary of Testing Hypotheses and Relationships between Variables

Variable		Correlation	p-value
Independent	Dependent		
X	Y	0.762	0.000
Z ₁	X	0.654	0.000
Z ₂	X	0.770	0.034
Z ₁	Y	0.454	0.000
Z ₂	Y	0.670	0.004

Table 4.2 is a summary of testing hypotheses and measuring relationships between variables. The overarching hypothesis to be tested was that the adoption of logistics and supply chain techniques (X) would create organisational effectiveness and efficiency (Y) as well as improve competitiveness. Organisational **effectiveness** includes improving service levels and productivity, as well as responding better to customer needs. Organisational **efficiency** relates to reducing total logistics costs and improving profitability.

Moreover, this study also tested the hypothesis that *intervening factors* (Z) would have an influence on the adoption of logistics and supply chain techniques (X) and organisational effectiveness (Y). The intervening (Z) factors

were divided into two groups. First, high fuel costs, pressures from customers and intense competition were included as an *external factor* (Z1). Organisational culture and logistics plus supply chain knowledge and skills were included as an *internal factor* (Z2). The factors (Z1 & Z2) should influence, to varying degree, the success of adoption of logistics techniques (X) as well as organisational effectiveness (Y).

After testing the hypotheses, the results showed that there was a significant relationship between the variables. It found that there was a very strong relationship between the adoption of logistics and supply chain techniques (X) and building organisational effectiveness and efficiency (Y). Further, it also found that there was a correlation between external factors (Z1) and the adoption of logistics techniques (X), while internal factors (Z2) had a higher correlation with organisational effectiveness and efficiency (Y).

5. DISCUSSION AND RESEARCH IMPLICATIONS

This study revealed each respondent's kind of businesses and period of business life in Thailand. The result showed that 92 percent of sampled businesses were OEMs, and the rest were REMs. It inferred how the Thai automotive industry is an important base for car assembly in South East Asia. Most of the firms had just established their business in Thailand (within one to ten years) to support the rapid expansion of the automotive industry here. The results reflected that OEMs have become a major player in the Thai automotive industry. On the other hand, the proportion of REMs has not grown as much since replacement equipment is mostly imported from lower-cost countries.

The result revealed that Thai automotive companies have widely employed logistics and supply chain techniques in both functional and organisational activities. They employed the techniques to improve the flow of goods and information in material management and physical distribution activities. However, some very important activities, for example, reverse logistics and order processing, have been ignored, even though they are considered to have increasing roles in enhancing an organisation's competitiveness.

The study also reflected that Thai companies gave highest priority to the activities of material management and physical distribution, respectively. Why have these companies focused on inbound and outbound activities? The reason was the adoption of logistics techniques for these activities was simpler and more widely deployed within the industry.

The next issue was to identify the main motivations for adoption of logistics techniques by Thai automotive companies. The study pointed out that these firms were being pressured by *external intervening factors*, like rising fuel costs, the dynamic demands of customer service and intense competition. It also showed these external factors as the highest motivation to adoption. External factors, like increasing fuel costs, inevitably affected adoption and implementation to a degree. However, *effective implementation* of logistics techniques was shown to be affected more by *internal intervening factors*, like organisational culture and logistics knowledge and skills.

The study identified the SC techniques being used by Thai automotive firms: just-in-time, quick response, activity-based costing, economic order quantity, e-commerce, material requirement planning, and lean concept. However, it also showed that firms were using the techniques only at a functional level and not across the whole organisation. One organisation, for example, was only using just-in-time for their purchasing and production, while other

departments were using older methods inconsistent with a modern SCM approach. Most firms placed their highest priority on time-based activities. This reflected how responding to customers quicker at reasonable prices – not the lowest prices – became a key to success in this industry. The study showed that firms widely used quick response, just-in-time and material requirement planning strategies. These SC techniques assisted firms to systematically compress shorter lead time, or order cycling time, and improve efficiency.

Effective adoption and implementation of logistics techniques did translate to higher performance. Most of firms agreed that effective implementation would help them better respond to customer needs and improve service levels, including cost reductions. As a result, they could improve customer satisfaction, which would lead to an enhanced competitive advantage over competitors.

However, the adoption and implementation of logistics techniques have been influenced by external factors. Fuel cost, for example, is a major expense in transportation. Higher fuel prices inevitably pressure firms to survive by adopting logistics techniques, for example, just-in-time and quick response. These techniques are needed to effectively control transport management. The study also found that internal intervening factors (organizational culture, SCM skill and knowledge) had a more direct affect and influence on the success of implementation of logistics techniques and their organisational effectiveness.

In summary, the main research finding reveals that:

- Effective adoption and implementation of logistics techniques (X) have a strong relationship to organisational effectiveness (Y).
- External factors (Z_1) related to external environments have moderate influence on achieving a higher degree of organisational effectiveness (Y). Companies should increasingly focus and give higher priority to these factors (Z_1).
- Internal factors (Z_2) have a high influence on organisational effectiveness (Y). These same factors had a more moderate correlation and influence on the effectiveness of SC techniques already in place at functional or organisational levels. Companies should increasingly focus and give higher priority to these factors (Z_2).
- The study reveals that factors (Z_1) strongly influence adoption and implementation of logistics techniques (Y). They are uncontrollable, external variables for firms, and seem to cause the most problems for adoption and implementation of logistics techniques.
- Finally, factors (Z_2) showed a moderate influence on the adoption and effectiveness of implementation of logistics techniques (Y). They are controllable, but still may cause problems when adopting and implementing logistics techniques.

6. CONCLUSION

This paper explored issues related to the adoption of logistics and supply chain techniques in the Thai automotive industry. It also examined factors influencing the effective implementation of logistics and supply chain techniques. The *literature review* provided a foundation by clarifying the conceptual framework and research objectives. Rigorous methodology was utilized to generate a reliable and valid measurement instrument. Questionnaires and in-depth interviews were the major tools for data collection. The sampling was randomly chosen to ensure that it represented characteristics and attributes of the population. The obtained data was analyzed using SPSS (version 11.0.5).

The study revealed that most firms were OEMs and were small-to-medium sized enterprises (SME). Many had employed one or more logistics and supply chain techniques in response to pressures from customers or competitors. In this industry, time-based management has become a critical success factor. Quick response and just-in-time were popular strategies which firms had adopted. The study confirmed that there was a direct relationship between the adoption of logistics and supply chain techniques to higher performance and effectiveness.

In conclusion, most Thai automotive companies have an understanding of the importance of logistics to operations. However, it was found that these companies also have limiting factors to the development and design of logistics strategies that will fit well with their environments.

These limitations include low skill levels and knowledge related to logistics implementation. The importance of external and internal factors that influence logistics adoption and implementation have been greatly ignored. Further, companies lacked the right internal culture – with proper processes or innovative adoptive systems – to support a systematic implementation of logistics activities. In addition, many lacked efficient and effective integration of activities related to physical and information flows. Therefore, Thai automotive companies urgently need to develop and improve their understanding and knowledge of logistics. This study should also encourage them to rapidly adopt new logistics and SC techniques and management.

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LEAN HEALTHCARE: A PROCESS IMPROVEMENT CASE STUDY

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ABSTRACT

This paper reports a study that aimed to apply the concept 'lean' to the analysis of a health care system. This study applied lean methodology to identify the problem areas as well as identify value for the patient. The existing process was analyzed based on the layout of check-up of the clinic called the Health Promotion Center of Bangkok Hospital. The process and layout were then redesigned to optimize the lead time of the system. There are 3 main stages: *data collection, data analysis and data comparison*.

INTRODUCTION

"Lean" or "lean thinking" is most commonly associated with Japanese manufacturing, particularly the Toyota Production System (TPS). Much of the TPS way of thinking is based on the work of quality guru Edward Deming, who taught, among other things, that managers should stop depending on mass inspection to achieve quality and, instead, focus on improving the production process and building quality into the product in the first place. The basic goals of a lean initiative can be summed up in three points:

1. To improve quality of products and services, in other words, to make products or service attributes conform to expectations and requirements.
2. To eliminate waste, that is any activity that does not add value in the production process.
3. To reduce lead time, (which is the total time taken to complete an array of tasks in a process.)

RESEARCH METHODOLOGY

The current study has been carried out within Health Promotion Center (HPC) in a public listed hospital called the Bangkok Medical Center (BMC) in Thailand. This research looked into the improvement of operational processes by applying lean thinking and modeling. The scope of the study was to identify value and eliminate or reduce non-value-adding (NVA) activities from the selected processes.

Study Design

This case study will follow the most common case study methodology described by Yin (2003) and service process improvement in the light of lean principles. The proposed improvement in the system is based on simulated rather than actual changes, with some lean tools and applications. The Primary data will be collected through Observation and Interview. And secondary data derives from the existing Hospital Information System (HIS) database named MEDTRAK. In the next section lean methodology will be outlined.

Lean Methodology

In a lean methodology the current system is studied in terms of process and layout. This is done by studying the nature of service, product and service variation and demand, in order to develop a flow chart of the process. The best way to see the big picture is a service blue print. After drawing the service blueprint, critical processes were identified for a time and motion study. Based on that study, value and non-value activities were identified, focusing on operation, transportation, delay and inspection. A value stream map of the current state was constructed. Next, analysis of the data using lean techniques was used to eliminate or minimize waste activities like bottlenecks and points of dissatisfaction. Then a value stream map was drawn for the future process. In the final stage data was simulated and compared to see the improvement. The main lean improvement will be measured by cycle time reduction. Figure 1 below elaborates the current process of ultimate female check-up.

ANALYSIS AND FINDINGS

Identifying Value

In order to identify the value, we have to find the value adding and the non value adding activities in the process. A detailed time study and categorizing waste can help identify the value of the process.

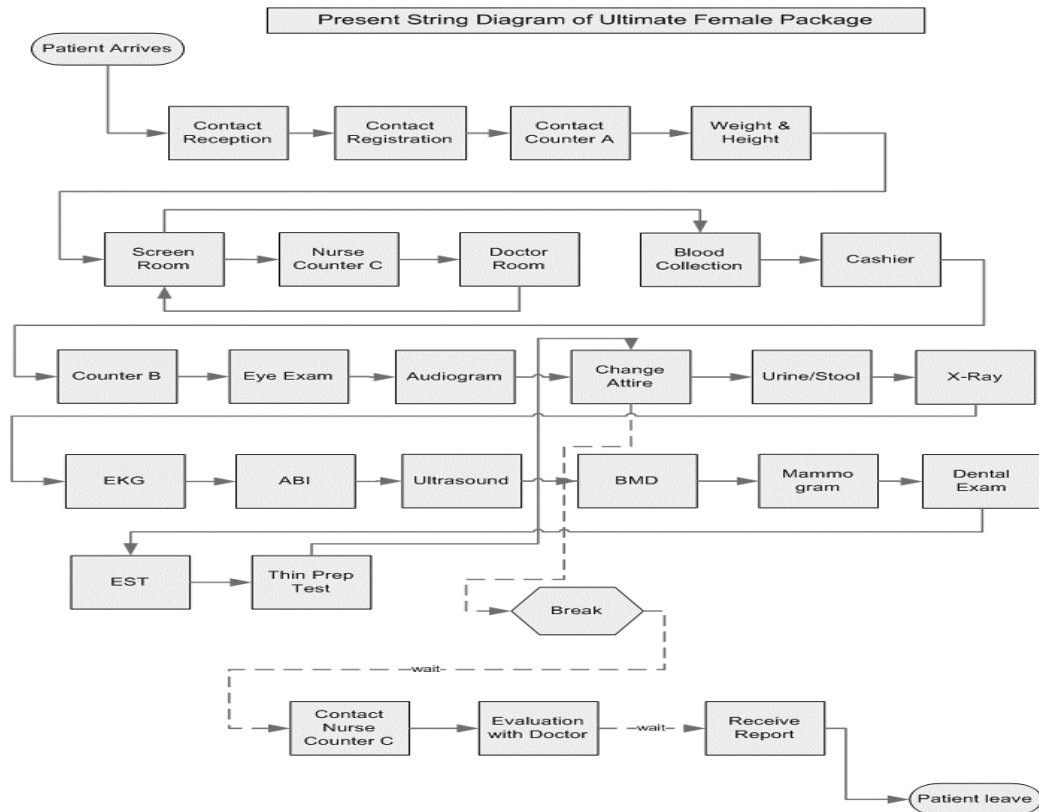


FIGURE 1: CURRENT STRING DIAGRAM OF ULTIMATE FEMALE PACKAGE

Time and Motion Studies by PROCESS CHART

The most critical part of the present study is a time and motion study of particular processes. Motion study is the systematic study of the human motions used to perform an operation or process (Chase, 2004). Recording was done for 2 consecutive weeks to estimate the average time per patient to finish the process. A process chart is an organized way of documenting all the activities performed by a person, machine or workstation, with a customer or on materials (Krajewski, 2007). In this case study, our study specimen is the patient. All recorded data was used in the format of a process chart.

Timing Method: Probabilistic Time Study

There are many methods of timing operations. To avoid biased timing the researcher chose a probabilistic time study (Russel, 2006). The researcher analyzed the flow and traffic of patients at different times of day and also on different days of the week. Patient traffic was studied during a week and also at a specific date. These data have been collected from a database and analyzed to choose which timing categories are most appropriate for this study.

In table 1 detailed explanation of the timing are elaborated, another way to interpret the three timings are best, standard and worst case scenario for Ultimate Female package completion time. From Table 1 we can see that in best case the patient will finish the package in 3.93 hours, in the usual case the patient will finish in 5.76 hours and in the

worst case 7.76 hours. And calculating the mean time using the probabilistic formula gives a result of 5.81 hours. In the current hospital standard, 4 hours completion time is considered to be satisfactory. But the check up procedure cannot normally reach this standard in the present set up, except in the best cases. The researcher noted this situation and sought ways to minimize the time taken and to bring it down below 4 hours on average.

Probabilistic Time Study: PRESENT MEAN TIME for Ultimate female Package								
No.		Description	Distance (m)	Time			t=1/√(a+4m+b)	
				Optimistic	Most Likely	Pessimistic	EST. Time	Variance
1	A	Walk 2 reception counter	5	0.18	0.25	0.33	0.25	0.0006
2		Contact receptionist		1.40	2.00	2.60	2.00	0.0400
3	B	Walk n take escalator to 1st floor	20	0.70	1.00	1.30	1.00	0.0100
4		Walk 2 Registration Counter	10	0.35	0.50	0.65	0.50	0.0025
5		Contact Registration Officer		1.40	2.00	2.60	2.00	0.0400
6		Fill in Patient Info form		5.60	8.00	10.40	8.00	0.6400
7		Take Picture		1.40	2.00	2.60	2.00	0.0400
8		Photo copy ID Passport		2.10	3.00	3.90	3.00	0.0900
9		Wait 4 Key in completed form		3.50	5.00	6.50	5.00	0.2500
10		Verify info with Patient		2.10	3.00	3.90	3.00	0.0900
95		Doctor key in & write report in paper		3.50	5.00	6.50	5.00	0.2500
96	W	Walk to check up counter A	32	1.12	1.60	2.08	1.60	0.0256
97		Wait for the medical report in Waiting Area		18.00	30.00	45.00	30.50	20.2500
98		Receive report and book		2.10	3.00	3.90	3.00	0.0900
			575.0	236.08	347.25	465.43	348.42	45.3
				3.93	5.79	7.76	5.81	0.8

TABLE 1: PROBABILISTIC TIME STUDY PRESENT MEAN TIME CALCULATION

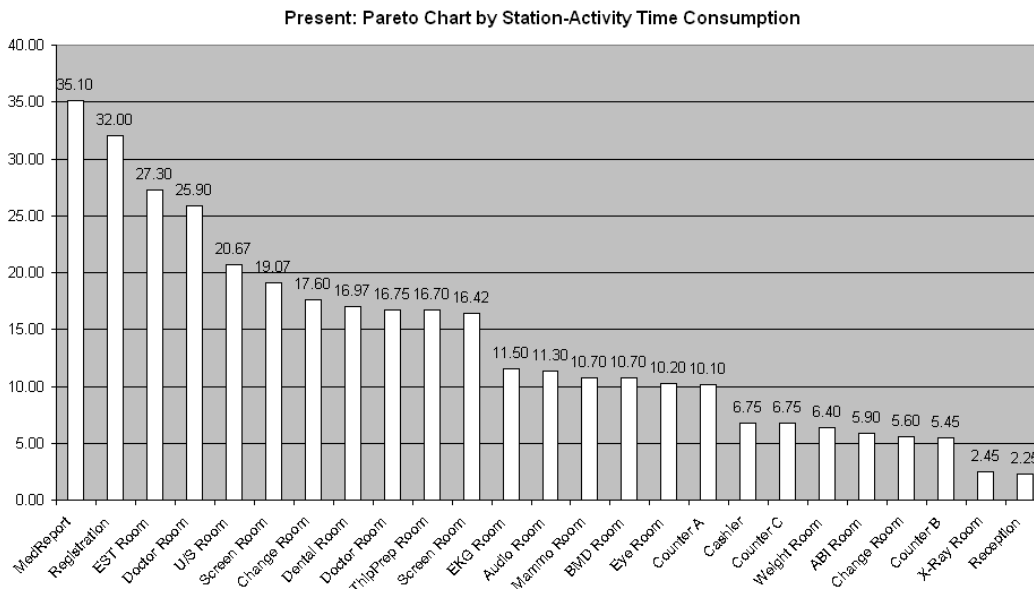


FIGURE 2: PRESENT PARETO CHART BY STATION – ACTIVITY TIME CONSUMPTION

Process Chart Summary of Current Ultimate Female Package process

The process chart of the Ultimate Female package has constructed a spreadsheet. It is further grouped in the registration, prescreening, screening and payment, diagnosis, doctor evaluation and medical report collection. A timing summary was made. Processes

were categorized as process, transportation, delay and inspection, which can be explained as follows:

- **Inspection:** If the task was done properly, then inspection is unnecessary.
- **Transportation:** Movement of material within a process may be a necessary evil, but adds no value.
- **Delay:** An asset sitting idle and taking up space is waste.
- **Operation:** Operation is the only event where the patient sees value.

All data has been converted in man-minutes (number of minutes to do that activity) to come to a common term.

Summary Table of Activity Time and Distance Traveled

Total 38 operations take about 207.83 minutes, 32 movements take 28.75 minutes, delay occurred 18 times causing 88.83 minutes of delay and inspection occurred 10 time accumulating 23 units.

Value and Non-Value Added Activities

After completing the process chart, the researcher grouped value adding time and non value adding time. Apart from time devoted to actual operations, all time was considered to be non value adding for the patient. That means transportation, delay and inspection all are non value adding. After sorting the activities, total value added time is 207.83 and non-value added time is 140.58 minutes. This was further broken down into registration, prescreening, screening and payment, actual check up, doctor's evaluation and medical report collection. Distance for each stage is also recorded. Time distribution by stages has been shown in Figure 10. Most time is consumed by screening and doctor's evaluation. Medical report collection also takes unnecessary time.

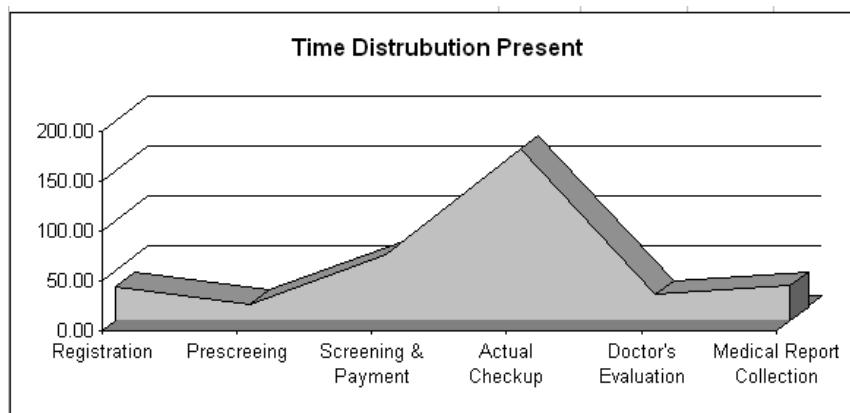


FIGURE 3: PRESENT TIME DISTRIBUTION BY STAGES

Value Stream Mapping: Current State

After calculating the process chart for the Ultimate Female package it was sorted for value and non value and further divided into 6 stages. They are Registration, Prescreening, Screening and Payment, Diagnosis, Doctor's Evaluation and Medical Report Collection. In the Figure 4 shows the value adding and the non value adding time in each part of this process.

PROCESS ANALYSIS

Looking at the service blueprint, string diagram and analysis process chart and value stream mapping the current state we can summarize the current problem of the process. Analysis can be conducted using a cause and effect diagram (fish bone diagram) and analyzing service blueprint failure points, calculating from the process chart in time and

motion studies and the current state map. Moreover, from an initial interview with the head nurse, staff members and patients we can find some obvious causes of the process problems. The common complaint was the long procedure time for health check up. Here are some steps followed to analyze the current system and redesign the process:

1. Draw fish bone diagram for cause and Effect
2. Identify fail points in service blueprint and do fool proofing (Poka Yoke)
3. Summarize the waste categories and apply lean method
4. Redesign process flow
5. Redesign physical layout
6. Simulate process chart with new probabilistic estimated time
7. Calculate value and non value
8. Draw value stream map future state map

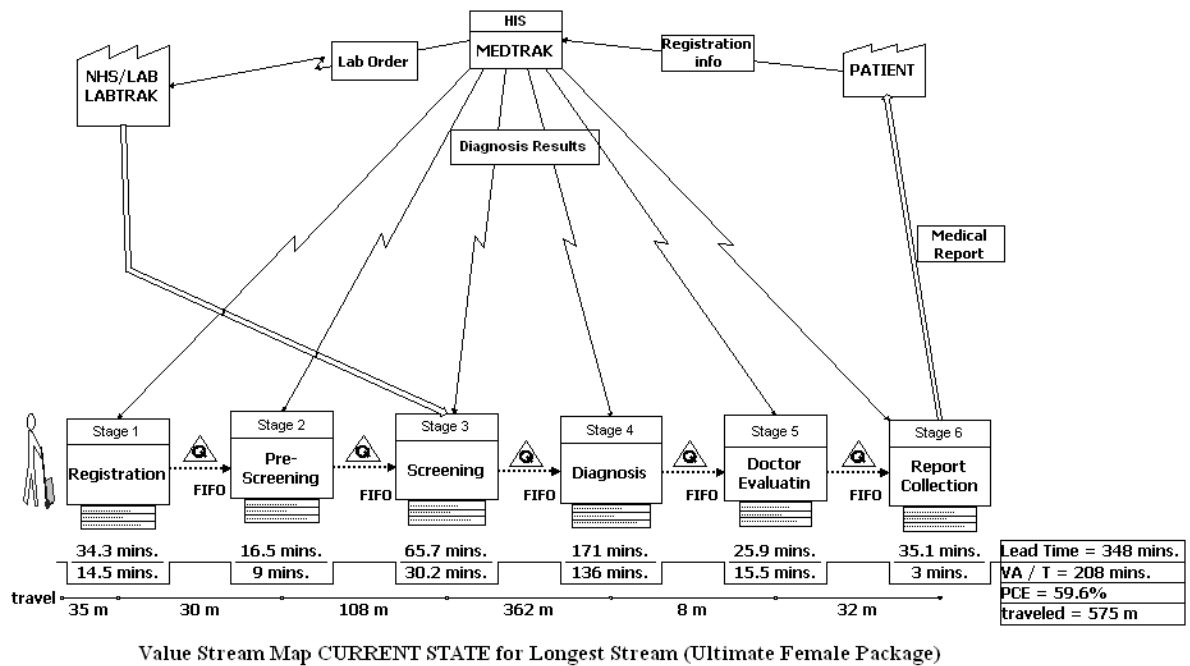


FIGURE 4: VALUE STREAM MAP (CURRENT STATE)

Redesign Process

After analyzing the old process, the researcher redesigned the process as shown in Figure 15. In the figure 15 the stages have been combined from 6 steps to 4 steps. The detail string diagram of the redesigned Ultimate Female package is shown in Figure 5.

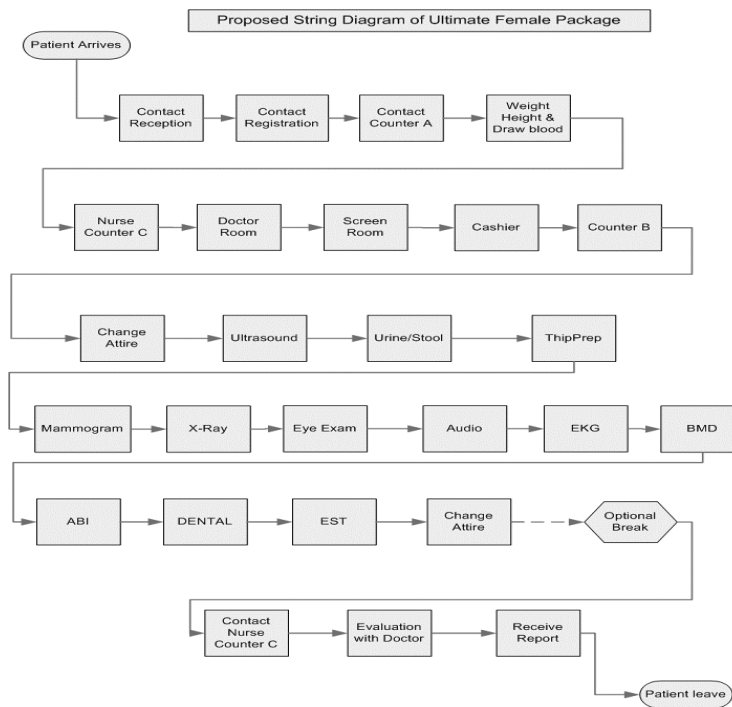


FIGURE 5: PROPOSED STRING DIAGRAM FOR ULTIMATE FEMALE CHECKUP

Summary of Process and Layout Redesign

Lean principles and philosophy have been used to redesign the process and layout. The most significant concepts used are (Gabow, 2005):

- Eliminate waste
- Minimize inventory
- Maximize flow
- Pull production from the customer demand
- Meet customer requirements
- Do it right the first time
- Empower workers
- Design for rapid changeover
- Partner with suppliers
- Create a culture of continuous improvement.

Table 2 summarized the proposed process:

Proposed Process: Summary of Value an Non value Added Activities					
	No. Act	Time	%		
Value Added Time	37	183.52	0.80		
Non Value Added Time	39	44.93	0.20		
		Time	VA	NVA	Distance
Registration		17.05	12.50	4.15	53
Prescreeing		13.90	10.50	3.80	16
Screening & Payment		24.74	22.00	2.74	55
Actual Checkup		141.74	125.50	16.24	255
Doctor's Evaluation		18.40	12.00	6.40	8
Medical Report Collection		12.62	1.02	11.60	32
Total Mins		228.45	183.52	44.93	419
Total Hours		3.81	3.06	0.75	

TABLE 2: SUMMARY OF VALUE/NON-VALUE ADDED TIMING OF PROPOSED PROCESS

Figure 6 shows that there has been a decrease in the proportion of time devoted to non value adding activities. The new process has 80% value adding and 20% non value adding, which is a dramatic improvement from the current process.

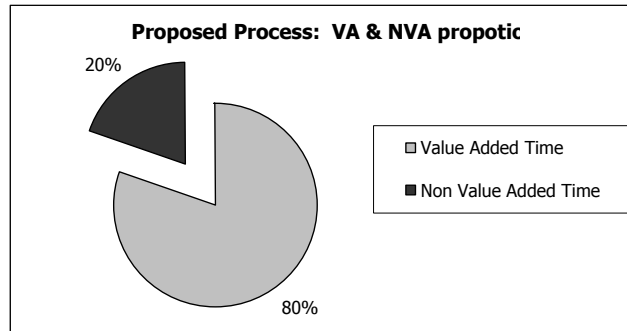


FIGURE 6: PROPORTION OF VA & NVA ACTIVITIES

Value Stream Map: Future State

Based on the information above now we can draw the Value Stream Map for the future state, as presented in figure 7. The researcher has tried to minimize the number of delays, search, inspection and sequence of the activities and tried to maximize the value added time. Most of the non value added activities are removed except for those which are necessary. The future state map also uses first in first out or first come first served methods to receive patients but has a reduced number of stages: Registration, Screening, Diagnosis, and Doctor’s Evaluation and Medical Report. Lead time is now only 228 minutes, value added time 184 minutes and distance traveled is reduced to 417 metres. Most importantly the process cycle efficiency (PCE) is now 80.4%, much higher than the current state map. The future state map has all electronic flow from stage to stage. More efficient use of Medtrak and Labtrak has been designed and movement has been reduced. The design of the future state map is based on the sorting and analyzing of data from the proposed process chart (see Table 18). Before drawing the value stream future map careful consideration has been given to improving the process efficiency and also applying all the lean principles (Liker, 2005). The future state map has been drawn using the software called IGrafx (Corel, 2006). This is the last steps of the data analysis part of the methodology.

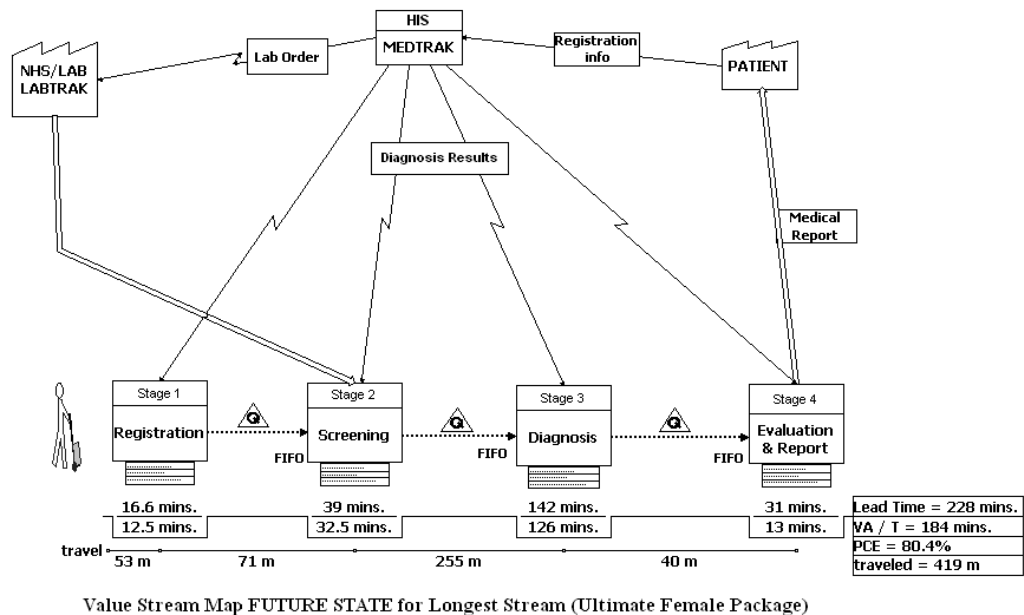


FIGURE 7: VALUE STREAM MAP (FUTURE STATE)

Data Comparison Stage

Data comparison is the final stage of this case study. Our main objective has been to reduce the cycle time of the current process. However, we can show the comparison in three ways. They are as follows:

1. Cycle time reduction and process efficiency
2. Estimated financial improvement
3. Confidence level in the old and new process on the part of the manager.

Cycle Time Reduction and Process Efficiency

Process chart, value and non value proportion, comparing the process, transport, delay and inspection, distance covered, percentage of process cycle time efficiency are some of the ways that can be used to compare the time issues. Table 4 shows the comparison by activity (operation, transport, delay, inspection). The total number of man-minute saved is 159 minutes, a significant number indeed.

In the case of non value adding activities the proposed system utilized the time better and even reduced the operation time. This could be achieved because of automation of some processes like registration, less paper work, and a reduced number of steps. In case of value adding time we see similar improvement and it is noticeable that value adding time is better used. In Figure 8, Pareto diagram has been used to compare in detail the use of all the station time. Doctor rooms, medical report screening rooms and registration have shown great improvement, causing a reduction in the overall time. We can see the effect of 80/20 rules, where only a few stations take a longer time and reducing those times significantly increase the efficiency of the system. Table 5 shows the total Lead Time and Value Added Time of the process as well as the Process Cycle Efficiency (PCE). The formula for PCE is Value Added Time /Total Lead Time.

	Over All Comparison			
	Before	After	Diff.	% save
Registration	34.25	16.65	17.60	51.39%
Prescreeing	16.50	14.30	2.20	13.33%
Screening & Payment	65.73	24.74	40.99	62.36%
Diagnosis	170.93	141.74	29.20	17.08%
Doctor Consult	25.90	18.40	7.50	28.96%
Medical Report	35.10	12.62	22.48	64.06%
Total Mins:	348.42	228.45	119.97	34.43%
Total Hours	5.81	3.81	2.00	34.43%

TABLE 3: OVERALL TIME COMPARISON

	Present	Future
Lead time	348	228
VA/Time	208	184
PCE	59.60%	80.40%
Traveled	575	419

TABLE 4: DATA COMPARISON OF VALUE STREAM MAP

In conclusion, based on the cycle time comparison we can see satisfactory improvement in reducing cycle time by 2 hours (5.81 hrs to 3.81 hrs average time).

Financial Comparison

Financial aspect is also another view to look at. In the business world they say time is money, in light of that we can show opportunity for service. We can convert saving time can give opportunity to serve more patient hence generating more income for hospital. There are actually many ways to generate income by improving processes of services. However, here the researcher has shown the opportunity for the service to save by reducing inventory and costs. Below is shown an annual calculation of the saving from just one product line, the Ultimate Female package. But the same lean technique can be

applied to all areas to improve the process. Obviously this could generate other savings or generate more income by expanding capacity.

MANAGERIAL IMPLICATIONS

This study will be a beneficial source of information to all the parties involved in healthcare management in Thailand and abroad. Moreover anyone coming across this study, to a certain extent, gain an insight into the implications of lean healthcare. This report demonstrates that the concept that has been so successful in manufacturing can also be a success in the healthcare industry. As in business at large, increasing levels of competition, patient service alternatives, joint ventures, mergers, acquisitions and quality initiatives provide evidence that dramatic changes are taking place in health care organizations. Through this research healthcare providers can recognize the need for a management approach that takes maximum advantage of those forces driving changes in both the industry and the organizations within the industry. The present research contributes in the following ways:

- In healthcare identifies shortcomings in the way processes have changed, and shows that without appropriate change systems cannot take advantage of advances in information management.
- Through lean healthcare the present project shows how to deliver value without waste, with high quality, at a low cost to patients.
- It shows how to optimize the usage of resources in healthcare service operations.

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ICT SUPPORT FOR TRADITIONAL MANUFACTURING SMES TO PARTICIPATE IN GLOBAL SUPPLY CHAINS – A REQUIREMENTS ANALYSIS

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ABSTRACT

Small- and medium-sized companies (SMEs) are the backbone of the manufacturing industry. Despite the size of SMEs, today they are taking a more and more important role in global supply chains. Competing in global supply chains requires much effort from SMEs in the areas of information sharing, logistics and marketing. The resources of time, skills and money are limited in SMEs, but somehow these companies survive in global competition. One possible solution for supporting SME's survival in global business is the effective utilisation of information and communication technologies (ICT). Information should be seamlessly available for enterprises as a whole, for individual employees' needs, as well in many cases for other companies in supply chain. The markets offer many different information systems for manufacturing companies. Solutions are, in many cases, independent without communication links between them, and solutions are too expensive and complex for SME's needs. Our approach in this research project is to fulfil the needs of SMEs in global supply chains with the development of a new innovative supply-chain -oriented information platform. This paper describes the business and technology requirements collection phase of the project.

INTRODUCTION

There are around 23 million small- and medium-sized enterprises (SMEs) in the European Union, which is 99% of all enterprises, and they provide two-thirds of all private sector jobs (European Commission, 2007). About 98 % of companies in manufacturing industry are SMEs (Eurostat, 2006). SMEs are the backbone of Europe's economy (European Commission, 2007), but how will European manufacturing SMEs survive in a global context? As the business environment is becoming more and more global, SMEs should also compete in global supply chains (e. g. Hvolby and Trienekens, 2002). Global large scale manufacturers are moving their operations to low-cost countries, like China and India, to lower their operational costs. There are, however, many manufacturing operations that will still be carried out in Europe. Large scale companies are still using SMEs as sub-contractors or suppliers. There are two ways for manufacturing SMEs to take part in global supply chains: 1) as a supplier / sub-contractor for globally acting customers, or 2) produce their own products for global markets. If a company is a supplier for large sized customer, it is in many cases the easiest way to take part in the global supply chain. It is easier, because the SME then has a clear

distribution channel from its own production to the customer's site. In many cases, large scale customers provide an ICT tool for management purposes (delivery information, production forecasts, warehouse information, etc.). This paper discusses the challenges of manufacturing SMEs when competing in global supply chains and which kind of solution is suitable for such a company with limited resources.

METHODOLOGY

Our methodology is based on multiple case studies (Yin, 2003). Three manufacturing SMEs and one small-sized logistics service provider are involved in the project, which are setting the ICT requirements for the Manufacturing Information Portal. The analysis of business requirements begins with business process analysis in the case companies. The basis of the analysis is the developed Process Reference Model (PRM), whose aim is to help the analysis of business processes in companies and process relations to each other. Parallel to the Process Reference Model, we utilise the developed Information Reference Model (IRM). IRM is used to analyse the information tools in use and data types shared between business processes. The interviews of supply chain professionals on end-user companies will be conducted to collect business requirements. The literature review defines the state-of-the-art of manufacturing SMEs in global supply chains, and which kinds of challenges academics have observed. The literature review also aims to find out which kind of ICT solutions there are used by manufacturing SMEs. The development of MIP will be started according to the results from the requirements analysis phase. One of the project members is an enterprise application provider, who is willing to have a complete solution offering for manufacturing SMEs. The developed MIP will be implemented and evaluated within the case companies.

MANUFACTURING SMES IN GLOBAL SUPPLY CHAINS AND ICT SOLUTIONS

Manufacturing SMEs are in many cases family-owned, with a long tradition in the business. The product or production process could be very innovative in these traditional businesses, which makes them alive. Manufacturing SMEs are more flexible than large companies and they could introduce new manufacturing technologies quickly (Lefebvre and Lefebvre, 1992). They are mostly focused on some niche area, or they could be just resource providers for large customers. Levy and Powell (1998) have analysed that most SMEs tend to produce one or two standard products for a narrow range of customers. SMEs could also have some obstacles because of old traditions and because of their size. For many SMEs, as an example, the utilisation of ICT (Information and Communication Technology) to support business functions is not common.

European manufacturing SMEs are currently trying to find a competitive edge through different development actions. The activities for maintaining the manufacturing operations in Europe could be, for example, the cost reduction, process automation, innovative products or effective information flows. On the other hand, the development actions could focus on increasing the quality, and increasing the profit by addressing the needs and performance of several things, such as supplier relations, supplier selection, purchasing negotiations, operations, transportation, inventory, warehousing, third-party vendors, electronic commerce, recycling, supply chain management software, customer relations, etc. (Kovacs and Paganelli, 2003).

The effective information flow is one of the key issues in global business. The use of modern ICT has the potential to improve firm performance and bilateral relationships between companies (Hvolby and Trienekens, 2002). Morgan et al. (2006) argues that ICT is a critical factor in the effective operation and prosperity of modern organisations. Manufacturing SMEs are facing the challenge that they need an ICT solution to support both internal and supply chain level information flows, but they do not have the resources to purchase any. Morgan et al. (2006) continues that the problems of implementing ICT in many cases for SMEs are the cost of equipment and lack of suitable expertise with which to exploit it. Manufacturing SMEs should integrate procurement, operations, and logistics from raw materials through to customer satisfaction (Kovacs and Paganelli, 2003). The successful management of those mentioned processes requires the exploitation of ICT. In most cases, the applications in markets are not suitable as "plug and play" solutions and most kinds of tailor-made solution are likely to be too expensive for SMEs (Kovacs and Paganelli, 2003). Levy and Powell (1998) argues that SMEs are implementing single information systems and are then expanding them. They continue that SMEs have a number of incompatible systems which are difficult to network (Levy and Powell, 1998). There is a huge need for a new ICT solution focused on manufacturing SMEs, their requirements today and in the future. SMEs need an approach and the related IT solutions to integrate existing system environments and which are flexible to their needs.

REQUIREMENT ANALYSIS

This paper is about the research and development project to develop a supply-chain -oriented production management framework for manufacturing SMEs. This framework aims to support decision management while reinforcing customer- and supplier-orientation. This framework will act as an integrative environment to interface and interconnect different units of manufacturing SMEs and the related existing operative systems (PPS, CAM, CAD, etc.) in order to make information seamlessly available according to overall enterprise strategy and, also, to individual employees needs. The project will demonstrate this approach through an innovative prototype - called Manufacturing Information Portal (MIP) adapted to the needs of manufacturing SMEs. The result of the paper is the analysed set of requirements for the ICT tool (MIP) from the business environment and from the internal business processes of SMEs. According to the results of the requirements analysis, main features of the Manufacturing Information Portal will be defined.

Our requirement analysis is based on the end-user company interviews and discussions about challenges in their everyday business. Two end-users are from Finland, and two from Germany. Three of these end-user companies are traditional manufacturers and one is a logistics service provider. All manufacturers have their own products and production.

End-user 1 is focused on designing and manufacturing drive units and control systems for industrial doors and gates. End-user 1 is one of Europe's largest manufacturers in this line of business. The product range covers standard products for all kinds of overhead doors, roller shutters, swing gates and sliding gates, folding doors, sliding doors, and rapid rolling doors. The factory is located in Helsinki, Finland, and the products are marketed all around the world. The

competitive edge of end-user 1 is to provide fast product changes and tailor-made products according to the specifications of the customer, both for drive units and control systems. By implementing ICT tools, end-user 1 aims to enhance the productivity of its internal processes and its customer relationship activities. ICT tools are the main enablers supporting this aim. According to the information reference model and the business process analysis, the most challenging topic for end-user 1 is email information sharing. Because of the company size of about 50 employees, it is not clear what information is important for everyone. Usually employees send an email to everyone, regardless of whether the topic is important or not. Some kind of filtering or clustering is needed inside the organisation, or rules for information sharing. For example, all of the daily information about operational work at the floor level is not necessary for the company CEO. The establishment of an Intranet for internal communication will also be needed in the future, which will reduce the amount of email sharing. The second topic is document management. They send huge amounts of data as attachments by email and every receiver makes their own storage and file structure for data. Some kind of common data warehouse is needed for the manufacturing portal. One issue about documents is product drawings version management. It is not always clear which drawing is the latest one because everyone could have different version on their file system. Document management steers operations towards a "paperless office". The use of ICT tools is aimed at reducing the amount of documents and enhancing internal communication. The third topic is sales and procurement management. The contact information, meeting, minutes and contact information in cases of sales and procurement functions are not managed well. A CRM-related solution should be one feature of MIP, which will give better opportunities to increase market reach and provide services to the customers.

End-user 2 is one of the leading producers of ropes in Germany. The company currently has production in two factories, and many customer centres, not only in Germany. The multi-site operation needs coordination and management to achieve all of the advantages of production. End-user 2 has over 15,000 m² manufacturing capacity at two of the most modern international rope production plants. The company produces a selection of modern synthetic-fibre ropes, which contributes to the company's total of over 3,500 different products. End-user 2 has specially-designed machinery and high technical standards to ensure its quality and service. End-user 2 has an enormous amount of product variations, which creates a challenge for document management. Currently, sales data, design data and production planning / logistics data for the order entry, are not linked together. Document management is the main requirement to be developed for the MIP. End-user 2 has challenge also in customer relationship management, when they have both consumers and companies as customers. Contact information management is another requirement for MIP, but also company level information sharing via emails. End-user 2 has similar challenges to end-user 1 concerning the sharing of emails internally. The new MIP should have some features for managing quality information in the manufacturing process. End-user 2 has high quality manufacturing processes and final products, but that information should be collected during the process and be published through the Quality Management solution. The multi-site operation is also challenging for a small-sized manufacturer: how to get all of the relevant

information to every employee level in the company. MIP should be configured for multi-site operation.

End-user 3 is a specialist manufacturing company, printing industrial labels for multinational manufacturers in many industrial sectors. End-user 3 is a market leader in the design and manufacturing of technical label solutions. They have a multi client environment, where it is crucial to have a clear system for customer contacts in every format: emails, phone calls and visits. The overall contact information management is a challenge for end-user 3, which is the first requirement for MIP. A multi-client environment also means challenges in the field of document management for end-user 3. Each product is different for end-user 3, so product variations create a big challenge for document management. End-user 3 has multi-site production, which creates requirement for the utilisation of ICT in different locations. ICT should be web-based and available in different locations. The general requirement is that the new MIP should be easy to install, easy to operate and act as an integration tool for existing solutions.

End-user 4 provides logistics services for different businesses (logistics service provider, LSP). The main areas of operation are outsourcing solutions for inbound, outbound and in-house logistics, employee leasing, recruiting services and consulting. The demand for logistics activities has grown strongly during recent years, particularly the demand for full service offerings. Logistics activities need to be integrated into the customer's manufacturing and planning systems, which creates a big integration challenge for the logistics operator of ICT systems. Logistics operators are trying to find new business opportunities in the field of procurement services. The idea is that LSP could purchase materials for the customer and, in some cases, even be responsible for the supplier selection, etc., phases of procurement. Procurement needs full integration into the customer's product and production planning. LSP, with its many different opportunities to provide for the customer, needs a management application for Customer Project Management. Project management means the controlled way of taking care of customer processes. LSPs usually act in different locations, at the customer's premises or in their own warehouses. The multi-site requirement is also obvious for LSP. For a small-sized company, the maintaining of an ICT system is not part of the focus and sometimes it is not even possible to handle with limited resources. The Application Service Provider (ASP) model is a requirement for the new MIP. The new MIP should be easy to install, easy to operate and act as a cheap integration tool for existing solutions, and provide a "dashboard of everything" for management purposes.

Table 1. The requirement focus areas.

	Document Mgmt	Contact information mgmt	Quality Mgmt	Multi-Site operation	Sales	Cust. Project Mgmt
End-user 1	x	x			x	
End-user 2	x	x	x	x		
End-user 3	x	x		x	x	
End-user 4		x		x		x
Focus Areas	X	X		X		

The end-user company businesses are quite different when compared to each other. However, the most important requirements for MIP are similar. Our information reference model included many different processes and functions, and Table 1 above shows the most important focus areas and needs. Our information reference model also included the priority question, which has been the basis for the conclusion of focus areas. The most important issue for manufacturing SMEs is document management. There are many document management solutions on the market, but our end-user companies have noticed them to be too complicated or expensive for an SME's needs. There is a need for a simple but working solution, which supports the storing and sharing of product-, production- and customer-related documentation. The second focus area is customer contact information management. That challenge is relevant particularly in cases of a multi customer environment, which was common for our case companies. The third focus area is the support for multi-site operation. That could be possible with a web-based solution.

CONCLUSIONS

Manufacturing SMEs today are part of global supply chains. They operate in multiple locations, which is a great challenge for top management and operations management. Globally-operating companies should have information about all of the supply chain processes (purchase, making, delivering and planning) to ensure the efficient management and a cost effective business. Customers are giving more responsibilities to SMEs all the time, and in the future they should be more active in the supply chain. SMEs have limited resources, which means that all support systems might be helpful, but, at the same time, systems should be easy to implement and use. All these mentioned topics make their own kinds of challenges for ICT tools for manufacturing SMEs. Nowadays SMEs have many individual solutions, without integration to each other. Our Manufacturing Information Portal aims to provide a new platform for integrating existing solutions.

It was interesting to discover that there are cultural differences in Finland and Germany in the operation model of the ICT tools. Finnish end-users are willing to have an ASP (Application Service Providing) solutions service, without any need for maintaining the system. While in Germany, the ASP model is mostly used only in large companies. Smaller German companies are willing to operate systems by themselves.

The development of MIP is based on the business processes analysis, ICT requirement analysis and a literature review of the existing solutions targeted at manufacturing companies. The findings and conclusions from the process analysis and the literature review have had an influence on the operational and technical requirements of MIP. These basic requirements presented in the requirement chapter above were the main focus areas of the development. Our research also includes the analysis of the extended product and knowledge management issues in the manufacturing companies. The extended product concept is about to extend the offerings of the company from the products towards the provision of value (Expide project, 2008). The extension could be tangible or non-tangible. MIP development will include the definition for the extended product module. Another issue that will be defined as a feature of MIP is knowledge management. One of the key resources of a typical manufacturing

SME is its skilled manpower and their knowledge (Huin et al. 2003). However, SMEs are losing a large amount of their knowledge because of the lack of systems to support internal knowledge (Huin et al. 2003). The requirements of extended product and knowledge management are the focus of further research.

Manufacturing companies are currently experience healthy times, when order books are full for many years to come. The strong growth of business sets a big challenge for information management. However, who knows how long this growth in business will continue? Now it is time to invest in information technology to support successful business, otherwise it could be too late.

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A SYSTEMIC-CONSTRUCTIVIST PERSPECTIVE ON THE ESSENCE OF LOGISTICS

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ABSTRACT

This paper pins down the essence of logistics, taking a systemic-constructivist perspective on logistics. It derives that logistics – in its essence – transforms objects in space and time. Thereby, logistics presents itself as an autopoietic (i.e. a living), but non-human system, which operates on an allopoietic technological system and is embedded in a social system (organisations) that decides about the logistics activities.

The paper informs the current debate on epistemological suppositions and methodologies employed in logistics and advises researchers in logistics to decide upon their methodologies according to their respective object of study.

INTRODUCTION

Since the 1990's, researchers within the discipline of logistics and supply chain management (re-)started to ask for more solid and stronger theories and theory testing in logistics (Arlbjørn & Halldorsson, 2002). This has been already requested by Morgenstern in the 1950's where – in one of first articles on 'business logistics' – he grieved over "the lack of a rigorous and generally accepted theory of logistics" (Morgenstern, 1955, p. 129).

More than 50 years later, we still lack a universal theory of logistics (Mentzer, Min, & Bobbitt, 2004). Some researchers even go as far as to ask, what research in logistics ought to be on: "When we look at research in logistics, including the knowledge provided, it seems as if everything can be discussed within the discipline" (Arlbjørn & Halldorsson, 2002, p. 26). To complicate things, the "strategic discipline title re-engineering" (New & Payne, 1995, p. 60) with its adherent discussion on Marketing vs. Physical Distribution vs. Logistics vs. Supply Chain Management vs. ... (cf. Cooper, Lambert, & Pagh, 1997; Lambert & Cooper, 2000; Tan, 2001; Svensson, 2002; Larson & Halldorsson, 2004; Gripsrud, Jahre, & Persson, 2006; Ballou, 2007; Larson, Poist, & Halldorsson, 2007) seems never ending.

But, so far only an epistemological discussion within the field broke out: Some researchers ask for more rigorous research within the area of positivistic logistics research (e.g., Mentzer & Kahn, 1995; Kent, Jr. & Flint, 1997; Solem, 2003). Others question this approach searching for new ways of creating knowledge in logistics research (e.g., Arlbjørn & Halldorsson, 2002; Johannessen & Solem, 2002; Solem, 2003; Gammelgaard, 2004; Nilsson, 2004; Craighead, Hanna, Gibson, & Meredith, 2007; Kovács & Spens, 2007; Windt & Hülsmann, 2007). And yet others analyse research methodologies employed in logistics research

(e.g., Halldorsson & Aastrup, 2003; Frankel, Naslund, & Bolumole, 2005; Kovács & Spens, 2005; Spens & Kovács, 2006; Sachan & Datta, 2005; Craighead et al., 2007).

We reason that such sole epistemological discussion is in vain as the object investigated in (i.e., logistics) is – still – puzzling.

For example, Arlbjørn and Halldorsson (2002) formulated the 'hard core' of logistics, drawing on Lakatos's "Falsification and the Methodology of Scientific Research Programs" (Lakatos, 1962), to be

directed towards the flow of materials, information and services; along the vertical and horizontal value chain (or supply chain) that seeks to; coordinate the flows and is based on; system thinking (a holistic view), where; the unit of analysis is essentially the flow. (Arlbjørn & Halldorsson, 2002, p. 25)

Here, 'flow thinking' is considered the most central element to logistics. However, it is a mere metaphor: It only provides a vague idea or construct of what logistics ought to be about or how logisticians should think about problems. For example, flow thinking may be interpreted for logistics in terms of (i) consistent flows of objects within value chains; (ii) load balancing different flows; (iii) aligning organisational structures along flows; (iv) flexible, as in flowing, organisational structures; etc. (cf. Bruns-Vietor, 2004, p. 49) – 'flow thinking' lacks a concise lead. Thus, it can not indicate how research in logistics ought to be approached; it can not help us to understand and direct research in logistics – 'flow thinking' does not strike the heart of what logistics constitutes.

This paper first tries to pin down the essence of logistics, employing a systemic-constructivist perspective on logistics to abstain from the prescriptive epistemological discussions on logistics, existing definitions of logistics, and attitudes towards the role of logistics in business. Based on these findings, the paper outlines implications for researcher in logistics. The summary highlights the key findings and points to further research questions.

A SYSTEMIC-CONSTRUCTIVIST DERIVATION OF LOGISTICS

The radical constructivism postulates that there is no such thing as reality: Everything is a mere subjective construction of what we believe to be real. Thus, logistics appears as a sheer word, which has gained inter-subjective comprehension – more or less. However, even denying the existence of an objective reality, we find that 'logistics', in its essence, is more.

As a starting point, one assumption has to be made, which is true even from a radical constructivist perspective. Any living (as in biological) system depends on some input from its environment: "Exergonic metabolism is required to provide energy for the endergonic synthesis of specific polymers ... from the corresponding monomers, that is, for growth and replication" (Maturana & Varela, 1980, p. 9).

The first assumption implicitly requires that any system is subject to the dimensions 'Space' and 'Time': Time is essential for any development to occur and space is required for anything to exist (e.g. for growth).

It follows, that living systems need to transform something, which is required for their metabolism, in space and time. This is, in its fundamental form, logistics (e.g. Halldorsson & Aastrup, 2003, p. 326), or, using Morgenstern's words, a 'logistics operation':

A logistics operation consists in the supply of definite quantities of physical means and services for activities that according to their missions consume these means and services in order that the activities be maintained at particular present or expected future rates. The supplies come from a source and must be moved, i.e., *transformed in space and time*, by means of transportation to the activity. (Morgenstern, 1955, p. 130, emphasis added)

Thus, logistics, in its essence, transforms supplies (or objects) in space and time. Taking this definition as a starting point, logistics itself can be considered as an autopoietic, real system, such as social systems are autopoietic, real systems: Logistics, in terms of transportation (movement), storage (non-movement), and handling (the inducement of movement and non-movement) constitutes (i) a system, as it consists of elements (transportation, storage, and handling) and the relations between them (cf. Bertalanffy, 1950, p. 143); (ii) a system/environment difference, as movement can only be observed in an environment of non-movement and non-movement only in an environment of movement (Bruns-Vietor, 2004, p. 275); and (iii) an autopoietic system (cf. Maturana & Varela, 1980), as the elements of the logistics system reproduce themselves:

The production of elements in the logistics system produces at the same time again and again the logistical difference [setting it apart from its environment] as it alternates movement and non-movement, transportation and storage, linking the alteration with the impulse of changing in direction, that is handling.¹ (Bruns-Vietor, 2004, p. 279)

Thus, 'logistics' – as a system – exists by itself, depending only on living (biological) systems, which require some input to live.

LOGISTICS AS ALLOPOIETIC, AUTOPOIETIC, AND SOCIAL SYSTEM

Defining logistics as a non-human, but, living system entails two questions:

1. Who decides on the production of movement and non-movement?
2. How can we determine the system, as in how can we plan delivery times, stocks, etc.?

Both questions aim at Morgenstern's formulation of the 'logistical problem':

¹ Own Translation from German: "Die Produktion der Elemente des logistischen Systems produziert gleichzeitig immer wieder die logistische Differenz, indem es Bewegung und Nicht-Bewegung, Transportieren und Lagern, abwechselt und durch den Impuls zum Richtungswechsel, das Umschlagen, miteinander verbindet."

The logistical problem is to identify in detail the expected requirements of the activity, if the latter are described in a form that does not already contain the complete specification and enumeration of the needs. After the identification has taken place, the quantities, corresponding to the rates of the various component phases of the activity, have to be computed in such a manner as to make the entire supply plan an "optimum" ... under the constraint that the desired rates should be met – within stated time limits – with some specified probability. (Morgenstern, 1955, p. 130)

The answers to the above questions seem trivial:

- The logistical system requires some kind of deterministic system in order to compute and plan for an optimum of the logistical operation. These deterministic systems are the technologies that we use to transform objects in space and time: Trucks, warehouses, conveyor belts, etc. Thus, the logistical system requires allopoietic systems – trivial machines – to operate.
- The logistical system requires a social, or organisational system that decides on movement and non-movement. Bruns-Vietor (2004) describes the relationship between the logistical and the social (organisational) system as follows:

Both independent systems, on the one hand organisations, which produce decisions, on the other hand logistical systems, which produce movements, can henceforth identify themselves as a unit by supporting each another's functionally and using the production of the other system for the production of own system elements. An organisation requires an object to decide upon and a logistical system requires a decision, that it is about logistics.² (p. 300)

As such, logistics presents itself as a threefold system: (1) as an allopoietic technological system on which it operates; (2) as an autopoietic system that operates on the differentiation of movement and non-movement of objects between source (or sources) and activity (or activities); and (3) as a organisational system that decides about movement and non-movement between sources and activities.³

PRACTICAL IMPLICATIONS FOR RESEARCH IN LOGISTICS...

...CONCERNING THE EPISTEMOLOGICAL DISCUSSION

Halldorsson and Aastrup (2003) stated that "the core of logistics (being the flow of material and information, i.e. physical movements in time and space) is, from our viewpoint, a reason for not abandoning any element of realism in our line of

² Own Translation from German: "Die beiden eigenständigen Systeme, zum einen die Organisation, die Entscheidungen produziert und zum anderen das logistische System, das Bewegungen produziert, können sich nunmehr als eine Einheit ausweisen, indem sie sich gegenseitig funktional unterstützen und die Produktion des jeweils anderen Systems für die Produktion der eigenen Elemente nutzen. Eine Organisation benötigt einen Gegenstand, über den sie entscheiden kann und ein logistisches System braucht die Entscheidung, dass es sich um Logistik handelt."

³ These findings coincides with the systemic foundation of the 'St. Galler Management Modell', which subdivides organisations into the same three dimensions (cf. Ulrich, 1988); however, we assess that the implications for researchers in management science can not entirely be brought forward to research in logistics.

thought" (p. 326). In principle, our findings support their statement, but, put it into a broader perspective: Research into the allopoietic system of logistics does indeed justify, or even require, a positivistic/realistic position, because the object of study – trivial machines – follows immutable laws and mechanisms (cf. Näslund, 2002, p. 323–324). Here, logistics operates *within* a given organisational context (i.e. a spatially and timely scattered production due to the division of labour) and is charged with solving the 'logistical problem' (Morgenstern, 1955, p. 130), that is, to re-integrate the spatially and timely scattered production by bridging time and space.

However, researchers in logistics should be wary of realism if the research object extends into social systems, that is, organisations. Here, we need to distinguish between two types of inquiries: First, logistics research may inquire into 'logistics organisation', that is, the social system(s) within the allopoietic system of logistics (cf. Johannessen & Solem, 2002; Solem, 2003). Second, logistics research may inquire into its organisational context, that is, the social system embedding the logistics system. Concerning the latter, logistics drops out of its ancestral focus (bridging time and space in a given context) and concerns itself with challenging and designing its organisational context as such (e.g. the sources and activities that logistics ought to link). As we thus broaden our perspective to embrace more 'soft' problems, we need to adopt and accept more 'soft' paradigmatic suppositions, too.

Therefore, researchers in logistics should neither opt for realism nor relativism as epistemological supposition inconsiderately (cf. Kovács & Spens, 2007), but, should reflect upon their respective object of study and, thereupon, decide on paradigmatic issues. Moreover, as research in logistics increasingly adopts methodological pluralism (Craighead et al., 2007), it becomes important to justify paradigmatic choices for the research to be judged accordingly.

...CONCERNING THE OBJECT OF STUDY

As for the paradigmatic choice, researchers should be aware of their respective object of study. As we outlined above, researchers in logistics have investigated into vast topic areas, diluting the essence of logistics. Stock (1997, p. 515) asserts that "logistics research is primarily an outgrowth from the business disciplines of marketing and management, with some input coming from engineering." Although this might be true in terms of the discipline's academic development – but, certainly not for its historical (cf. Farris, 1997) – we find that logistics addresses, in its essence, a problem not simply stemming from business' problems. Yet, it addresses problems that originate in organisational contexts.

Still, researchers in logistics should certainly question whether organisational and/or managerial problems are of major concern for logisticians, and if, how can we add (e.g. via the metaphor of 'flow thinking') to the existing knowledge in the respective areas.

SUMMARY

This paper has tried to pin down the essence of logistics, thereby a systemic-constructivist perspective on logistics was taken, to abstain from the prescriptive epistemological discussions on logistics, existing definitions of logistics, and

attitudes towards the role of logistics in businesses. Based on two assumptions, that are conform even with a radical constructivist perspective, we derived that logistics, in its essence, transforms objects in space and time. Logistics presents itself as an autopoietic (i.e. a living), but non-human system, differentiating itself from its environment via movement (transportation), non-movement (storage), as well as the respective alteration with the impulse of changing directions (handling).

Furthermore, we found that logistics comprise three systems: (i) an allopoietic technological system on which it operates; (ii) an autopoietic system that operates on the differentiation of movement and non-movement of objects between source (or sources) and activity (or activities); and (iii) as a organisational system that decides about movement and non-movement between sources and activities.

Putting Halldorsson and Aastrup's (2003) assertion, that research in logistics ought not abandon any element of realism, into a broader perspective, we called for a more sophisticated exposure to epistemological, thus, methodological choices in logistics research: Researchers should clarify their respective object of study and accordingly justify their methodological choice(s).

Concerning the research object, we questioned whether logistics should be concerned with organisational and/or managerial problems. Logistics addresses, in its essence, not strictly business-related problems, but, 'independent' problems originating in organisational contexts, too.

Although this paper has strived to pin down the essence of logistics, the various objects of studies addressed by logisticians are still in vain. Thus, we propose further research to be conducted towards identifying and mapping the research objects that have been investigated in under the banner of logistics so far. Also, research into methodological usage in logistics should be reconsidered, reflecting not only on methodologies employed, but, on the respective 'fits' of methodology chosen and object investigated in.

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EVALUATION OF INFORMATION VISIBILITY BENEFITS DOWNSTREAM IN THE SUPPLY CHAIN: THE CASE OF FINISHED VEHICLE TRANSPORTATION

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ABSTRACT

Information and Communication Technology (ICT) has become an important element to support complex supply chain management and logistics operations. The adoption of ICT has made possible to experience levels of information visibility across the entire supply chain never experienced before. However, it has been argued that the full implications of information visibility on supply chains have not been fully explored, for example existing research has mostly addressed information visibility upstream. The use of advanced ICT solutions gives the possibility to achieve information visibility upstream and downstream to assist activities relying on complex logistics arrangements such as finished vehicle logistics by facilitating access to more reliable information that can be used to generate better forecasts as well as the creation of synergies for better use of logistical resources.

INTRODUCTION

In the 21st century, supply chain management and logistics have emerged as leading and complex fields dependent on information. Main factors that have contributed to the emergence and complexity of supply chain management and logistics include: globalisation, outsourcing, contract manufacturing, shortened product life cycles, pressure to reduce carbon-emissions, multi-channel distribution and the need for adequate return channels.

Information and Communication Technology (ICT) plays a key role in managing today's supply chain management-related activities. For example, data availability has become a principal element to the responsiveness of an organisation. Therefore the supply chain and its associated logistics operations have become heavily dependent on ICT, both at the intra and inter-organisational levels. ICT has made possible to build communication links between enterprises and for many organisations around the world. The global web-linked environment of today has emphasised the importance of ICT in logistics.

ICT has provided the links where information flow is used to control the flow of materials. According to Barrat and Oke (2007) industries such as in the retail sector have recognised the critical role of supply chain management and the need to effectively manage the flow of materials, money and information across the supply chain. Moreover, Sahin and Robinson (2005) acknowledge that the creation of external linkages based on the sharing of information to gain increased visibility of customers and suppliers is a growing trend experienced by

many organisations. Information visibility in the supply chain is a concept that has drawn lots of attention and has been top of the list in the agenda of researchers and practitioners (Mason-Jones et al., 2002).

Despite the growing support of ICT to supply chain management activities, still there are issues regarding information visibility and the use of ICT that are not entirely clear. For example, some academics have indicated that information sharing is not directly linked to improved performance (Barrat and Oke, 2007), despite the fact of numerous studies focusing on achieving visibility to improve decision making and operational performance (Kulp et al., 2004). Academics have highlighted that it is in the hands of the recipient to determine whether the information initially shared is accurate, useful, timely, trusted and in a format ready for use (Whipple et al., 2002). Also in terms of information visibility, the implications of it have been investigated mainly using an upstream approach (Lyons et al., 2005). That means studies on supply chain bullwhip effect have studied the implications of demand amplification between the OEM and upstream suppliers.

The research presented in this analysis looks at the case of finished vehicle logistics to illustrate the need for information visibility that uses both upstream and downstream approaches especially when multi-modal arrangements are involved. It also discusses how the use of innovative ICT developments in the form of vehicular networks, Dedicated Short Range Communication (DSRC), promises to enhance visibility in the supply chain to new levels.

ICT AND VISIBILITY IN THE SUPPLY CHAIN

It is generally agreed that in recent years ICT has had a major impact on logistics and supply chain management, making possible to experience levels of visibility, control and connectivity. Organisations have invested heavily in sophisticated internet-enabled applications such as Enterprise Resource Planning (ERP) and modules such as Advanced Planning Scheduling/Optimisation (APS/APO). According to APICS (2006) these types of applications have resulted in benefits that cover: flexible systems that are responsive to changing needs; customer-oriented business models; greater focus on trading partner collaboration; reduction of barriers that add cost or cycle time; responsive manufacturing methods such as Build-to-Order; internet-enabled communications for data transfer and collaboration; responsive warehousing methods such as real-time coordination of cross-docking and determining optimal storage locations. Overall, the benefits above are the direct result of information visibility provided by ICT.

The use of mobile ICT has also contributed to enhance the impact of information visibility. Here it is possible to find Internet-based applications that include web services, and technologies such as Radio Frequency Identification (RFID), cellular networks, GPS-enabled devices, Wi-Fi and 3G among others. As an example of the impact of ICT on logistics and supply chain management in road transportation, applications based on WiMax, cellular infrastructure, Bluetooth and Wi-Fi have been adopted to provide certain level of connectivity. For example, by using the cellular infrastructure to reach the Internet network an

embedded mobile phone in a given vehicle can get access to the network by using GPRS from a network operator¹.

Is the widespread use of internet-based mobile applications and technologies like the ones described above that have opened the possibility to maximise the impact of visibility on supply chain performance. The topic of information visibility has been addressed by several researchers in recent years because the impact it has on the performance of logistics and the supply chain. Ubiquitous access to information has been identified behind the mitigation of demand visibility problems such as excess inventory levels, poor supply chain synchronisation and the bullwhip effect (Coronado and Lyons, 2007). On the other hand, the approach followed in the analysis of visibility is mainly upstream, that means from the OEM to the first-tier supplier, from the first-tier supplier to a second-tier supplier and so on. In fact, information visibility has a downstream component that seldom gets attention. An integral approach to information visibility will have to look at both upstream and downstream ends of the supply chain. Figure 1 represents the concept of information visibility permeating upstream and downstream in a supply chain in the automotive sector.

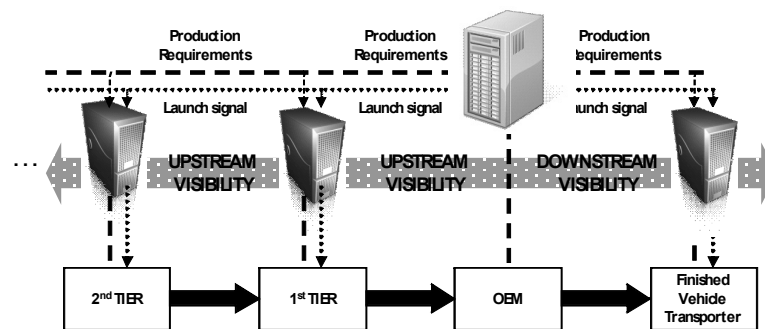


Figure 1. Information visibility – upstream and downstream

FINISHED VEHICLE LOGISTICS: MULTIMODAL AND AFFECTED BY INFORMATION VISIBILITY

An example where information visibility has considerable implications upstream and downstream in the supply chain is in the automotive sector, and more specifically in the logistics of finished vehicles. Being a complex logistics operation and a key activity of automotive supply chains, finished vehicles can be transported by land, rail, air and sea. Of these four modes currently in use, road transportation is still the most common mode of transport. However, transportation by sea within Europe has started to receive significant attention. For finished vehicle logistics, sea transportation is fundamental for the future of the sector in Europe, as it is expected to experience substantial levels of growth in the coming years. According to the European Commission (2007) short sea routes between neighbouring countries today offer high quality regular services that can be combined with other transport modes to provide efficient alternatives. The importance of short sea routes and road transport feeding port operations is clearly depicted in finished vehicle logistics, a principal business activity in the automotive industry. According to Finished Vehicles Logistics

¹ <http://www.onstar.com>

magazine (2007) of the 65 million new cars built worldwide in 2005, 15 million were exported by ship.

The growing importance of sea transportation of finished vehicles is aligned with the governments and private organisations' rejuvenation and business plans where infrastructure is a major component. For example, in Northern Europe, the European Commission in 2007 (Motorways of the Sea, 2007) recognised the importance of short sea routes between neighbouring countries; these routes offer high quality regular services that can be combined with other transport modes to provide efficient alternatives. According to the European Commission (2007), these efficient alternatives involve principal infrastructure elements such as port infrastructure, infrastructure for direct land and sea access as well as facilities comprising electronic logistics management systems, facilities to ensure and enhance safety and security and facilities to simplify administrative and custom procedures.

INFORMATION VISIBILITY DOWNSTREAM: ITS IMPORTANCE IN THE CASE OF FINISHED VEHICLE LOGISTICS

Previous research studies on information visibility have mainly focused on an upstream perspective; that means from the OEM to first-tier suppliers, to second-tier suppliers and so on. Finished vehicle logistics can be seen as an example of an economic activity directly impacted by downstream supply chain visibility, as it is illustrated in figure 2. Finished vehicle logistics has become a multimodal activity, involving road transportation and port operations (sea transportation).

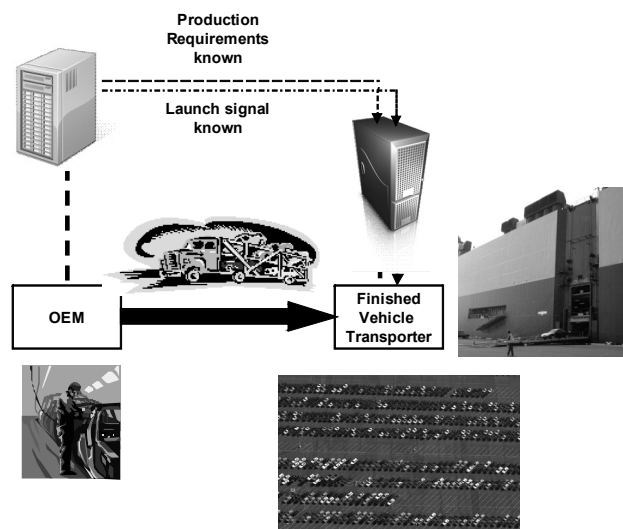


Figure 2. Information visibility in finished vehicle logistics

The scheme illustrated in figure 2 suggests another dimension in terms of the benefits of information visibility downstream in the supply chain, beyond the OEMs' finished goods. The use of this scheme has the potential to expand the knowledge of the principles of information visibility in a growing business sector such as finished vehicle logistics.

Information visibility involving finished vehicle logistics providers is a relevant topic, as it has been identified by the European Sea Ports Organisation (ESPO) that the increasing movements and global shifts of car flows have lead to traffic in ports and in a shortage of car carriers. The latest reports suggest there is a ten percentage shortage of car carriers today (Finished Vehicles Logistics magazine, 2007). Other problems arise due to the use of older vessels which are not adequate for vehicle transportation. This situation has been aggravated by the importance of emerging markets, as growth and production in Asia, South America, Eastern Europe and Russia is leading sea trade to put more focus on these markets.

INFORMATION VISIBILITY IMPLICATIONS DOWNSTREAM IN THE SUPPLY CHAIN

The enhancement to ICT infrastructure through the adoption of vehicular networks can contribute to better information visibility downstream and upstream in the supply chain which for a business like finished vehicle logistics translates into better planning and forecasting, achieving shorter lead times, faster movement of vehicles and ensuring up to 100% transportation (vessel) availability. Innovative logistical arrangements associated to this comprise synergic schemes illustrated by automakers sharing vehicle transporters operated by the same finished vehicle logistics provider. Figure 3 shows the benefits of visibility upstream and downstream if information is available on both sides of the OEM.

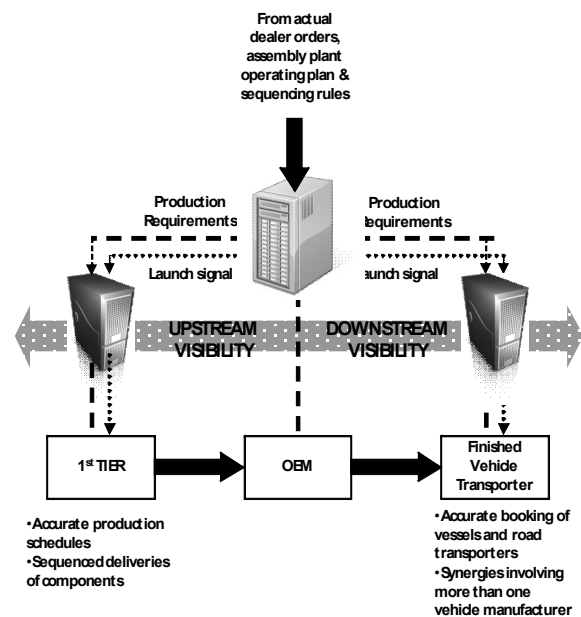


Figure 3. Impact of visibility to a first-tier and finished vehicle transporter

In figure 3 the OEM generates production plans to first-tier suppliers based on actual dealer orders, assembly plant operating plans and sequencing rules. Access to that information enables the first-tier to generate its own accurate production schedules and meet the requirements for the sequenced delivery of components/modules to the OEM. To a finished vehicle transporter, information visibility will provide the possibility to generate better forecasts for the booking of vessels and road transporters as well as enabling the creation of synergies for

a more efficient use of resources (e.g. sharing schemes of road transporters involving more than one vehicle manufacturer).

In general, the benefits of information visibility to finished vehicle logistics can be translated into better forecasts for booking vessels and transporters, the creation of synergies and collaboration with car manufacturers and shipping companies, as well as expanding product postponement activities such as fitting of accessories. Information visibility is a “must have” functionality of modern information system in downstream supply chains, especially when it comes to better planning and forecasting and product postponement capabilities.

DEDICATED SHORT RANGE COMMUNICATION TECHNOLOGY AND APPLICATION TO FINISHED VEHICLE LOGISTICS

Despite the significant advances in the form of connectivity and accuracy provided by sophisticated ERP systems and its embedded modules such as APS/APO, still there are limitations, particularly in the area of mobile ICT technologies. Mobile ICT solutions are important to provide instant localisation and traceability and these solutions can be used to enhance information visibility in the supply chain. An example of this is the use of telematics technology in road transportation.

One of the current problems experienced include services having to hop between different technologies like cellular networks, Wi-Fi, UMTS, 4G and WiMax, resulting in reliability, connectivity and problems associated to limited range, scalability and security. Therefore, by using heterogeneous ICTs there is a high risk of experiencing performance downgrade to the solutions designed to manage road transport logistics.

Dedicated Short Range Communication (DSRC) is a technology that promises to overcome the limitations associated to the use of heterogeneous technologies such as security, breakdown in Internet Protocol (IP) mobility and lack of seamless handover (WAVE 2005). In logistics the implementation of DSRC has the potential to provide an environment with the highest degree of security, reliability and quality to manage road transport logistics acting as feeders of port operations. DSRC has the potential to assist sectors relying on complex logistics arrangements such as finished vehicle logistics by facilitating access to more reliable information for better forecasts as well as the creation of synergies for better use of logistical resources.

DSRC is based on the standard IEEE 802.11p which is designed to handle different types of service applications, including the transmission of both safety and non-safety messages into two modalities: vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). DSRC is allocated at the 5.9 GHz frequency band and is designed to support high vehicular velocities in a radio transmission range up to 1000 m with a data rate up to 27 Mbps (DOT NHSA 2005) per channel including two control channels and seven service channels. Elements of the DSRC include Roadside Units, On-board Units, Message Switch Units, Network Management, Certification Authority and Map Server (DOT NHSA 2005).

The implementation of DSRC will require first an identification of the present state of ICT for road transport, followed by the identification of the technical

characteristics of the elements of the DSRC network as well as estimation costs on the design of the network, documentation, deployment, testing, evaluation, training, scalability and maintenance. Overall, DSRC is a technology that can have a major impact on the visibility of supply chains. By creating a DSRC network serving road transportation it will be possible to replace the combined use of different technologies in road transportation such as cellular networks, Wi-Fi and 4G. DSRC has the capability to be used to process exchanged logistics-related messages between transport vehicles and the roadside DSRC fixed infrastructure (information exchanged may include destination, ownership, types of goods, weight, value, insurer, time-window restriction for deliveries, road warnings and traffic updates).

In the foreseeable future it has become evident that the use of new technologies will be required to gather the benefits associated to the high potential growth of short sea routes and on the other hand deal with the reliance of port operations' logistics on road transportation. In the particular scenario involving finished vehicle logistics (multimodal in most cases), it can be agreed that novel ICT has the potential to solve many of the challenges faced today, guarantee the future sustainability of logistics operations in a specific geographic area and contribute to the generation of synergies that might lead towards better use of resources and waste reduction. In Europe, organisations like ERTICO (2007) have recognised that the use of Intelligent Transport Systems and Services (ITS) combined with the appropriate investment in infrastructure, will result in reduced congestion and accidents while making transport networks more secure and reducing their impact on the environment.

FUTURE REQUIREMENTS OF ICT TO GUARANTEE VISIBILITY

Information visibility in automotive supply chains that also comprise finished vehicle logistics rely on the use of modern ICT solutions to achieve further benefits that include helping fleet managers adhere to anti-idling rules to reduce the carbon footprint of the supply chain while becoming an interlinking technology that enables seamless interoperability between tiers. By addressing information visibility in finished vehicle transporters there is an opportunity to measure the benefits of visibility downstream in the supply chain.

Information visibility is dependent on ICT which has become a transparent and principal element of the infrastructure that companies, regions and nations require today. Also, it is important to highlight that apart from the importance to achieve information visibility, ICT is today at the same level of significance as traditional infrastructure developed to provide essential functions to society and the economy for example transportation, water and energy. Moreover, the interaction of different actors and networks is dependent on the state of the ICT infrastructure. Hence, an ICT infrastructure in optimal conditions is key to facilitate the development of economic activities.

CONCLUSIONS

Information visibility is a concept within supply chain management that has not reached yet its full potential. The use of an upstream and downstream approach applicable to certain industries promises to improve the performance of entire supply chains while ensuring a better use of resources through the creation of synergies. Finished vehicle logistics constitute an example on the implications of

information visibility downstream. However, still there are windows of opportunity to investigate how other sectors can benefit from the use of the same approach.

Supply chain management and its related logistics operations are infrastructure-dependent economic activities that have become critical for the long-term profitability and sustainability of many industry sectors. However, the success of logistics operations relies heavily on the state of ICT. The importance of ICT will continue to grow in the coming years as it becomes critical to ensure the future operation and sustainability of supply chains.

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INTEGRATED ENTERPRISE RESOURCE PLANNING SYSTEMS FOR SUPPLY CHAINS

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ABSTRACT

The supply chain management (SCM) aims to improve the material flow between the linked enterprises by installing information systems and procedures that provide for a better coordination in the logistic chain. Planning the production and order quantities is a fundamental and decisive process for material flows in a supply chain. Therefore the coordination of strategies and decisions is of great importance to the efficiency and economy of the latter. One way to improve the coordination consists in the construction of an central supply chain ERP system. This shall complete existing ones used in the diverse enterprises in order to reach a better coordination of all. Thereby the distinct scheduling systems used keep their autonomy to a large extent. Akin to "service providers" they are used by the central supply chain oriented enterprise resources planning system (SC-ERPS), which in this respect offers an information system that loosely links different ERP systems. The architecture, necessary for that, the needed data and the functionality are introduced and discussed. The paper will focus on the module for the production planning process, because it determines the material flow in the complete supply chain.

INTRODUCTION

Practice and experience in recent years demonstrated a need for supply chain management (SCM) (Handfield, Nichols, 1999, pp. 1 et sqq.). An integrating view throughout the entire logistics chain "from your supplier's supplier to your customer's customer" (Supply-Chain Council, 2002, p. 3) would present an enhanced potential for rationalization (Cooper, Ellram, 1993, p. 15 et sqq.; Cooper, Lambert, Pagh 1997). The whole process would benefit from greater flexibility and reduction of inefficiencies as there would be greater coordination by the participating enterprises in the value chain (Corsten, Gössinger, 2001, p. 83.). A critical point in individual ERP-systems especially for the production planning which should be improved by SCM is the potential deviation from the valid future market situation from the market situation represented in the primary requirements plan. An effective SCM should provide – with better and earlier information – a more precise picture of sales developments. One cannot wait until actual customer orders take place before deciding about the acquisition of raw materials and production of components because the lead times in the production and purchase are relatively long in terms of acceptable delivery times from the customer's point of view. The necessary planning horizon (Lackes, 1994, p. 410 et sqq.) is dependant on the total lead time and the typical range of orders. The longer the planning horizon is the more uncertain becomes, in

general terms, the data of primary requirement. This effect will be intensified in dynamically changing markets. In order to realize a SCM in a logistics chain modifications are possible in the business information systems concerning the data, in the decision making process of each participating enterprise (on a methodical level or a normative level) as well as in the data interchange and communications behaviour between them.

SUPPLY CHAIN ARCHITECTURE

The following shall demonstrate the realisation of an SCM by providing a central information system for the purpose of coordinating the enterprises involved in the supply chain (Lackes, 2004, p. 416). First of all, a formal architecture model is designed and we shall focus afterwards on the manner of action of a central supply chain production planning. The requirements for the needed data and the data interchange will be discussed.

Formalising the supply chain architecture with regard to the production management interrelations it requires more than just examinations on enterprise level. An enterprise E_n ($n=1, \dots, N$) can be defined – from the perspective of their produced parts – as 5-tuple $E_n = (P_n, TS_n, t_{Dn}, w_n, v_n)$ with

- the set of the parts $P_n = \{P_{n1}, P_{n2}, \dots, P_{nM_n}\}$, $M_n \geq 1$;
- the parts structure illustrated in a gozintograph $TS_n \subseteq P_n \times P_n$, whereas $(x, y) \in TS_n$ shall mean that part x goes directly into part y ;
- the lead time $t_{Dn} : P_n \rightarrow \mathfrak{R}_0^+$;
- the production coefficient $w_n : TS_n \rightarrow \mathfrak{R}^+$;
- the forerunning time displacement $v_n : TS_n \rightarrow \mathfrak{R}_0^+$.

A gozintograph is – for a parts manufacturer typical for the industry – a quasi-hierarchy and therefore does not possess any cycles in the flow of material (Fandel, François, Gubitz., 1997, p. 164 et sqq.). This shall be assumed below. Thus, a disposition level $DS : P_n \rightarrow N_0$ can clearly be calculated recursively.

$$DS(P_{nm}) = \begin{cases} 0 & \text{if } P_{nm} \text{ is a final product, i.e. } \nexists (P_{nm}, P_{n\tilde{m}}) \in TS_n \\ 1 + \max\{DS(P_{n\tilde{m}}) \mid (P_{nm}, P_{n\tilde{m}}) \in TS_n\} & \text{else} \end{cases} \quad \text{for any } \tilde{m} \in \{1, \dots, M_n\}$$

The set of final products $EP_n \subseteq P_n$ covers all parts P_{nm} with $DS(P_{nm}) = 0$.

The set of external parts $FP_n \subseteq P_n$ covers all parts P_{nm} implying:

$$\nexists (P_{n\tilde{m}}, P_{nm}) \in TS_n \text{ for any } \tilde{m} \in \{1, \dots, M_n\}$$

The set of final and external parts does not necessarily need to be disjoint like in e.g. commercial enterprises. The supply relation between the enterprises is constituted by the delivery of the materials which are final products for the supplying enterprise and external parts for the enterprise supplied.

$$SUP \subseteq \bigcup_{n=1}^N EP_n \times \bigcup_{\tilde{n}=1}^N FP_{\tilde{n}} \text{ where } (P_{nm}, P_{\tilde{n}\tilde{m}}) \in SUP, P_{nm} \in P_n \text{ and } P_{\tilde{n}\tilde{m}} \in P_{\tilde{n}}$$

$$\text{with } n, \tilde{n} \in \{1, \dots, N\}, n \neq \tilde{n}; m \in \{1, \dots, M_n\}, \tilde{m} \in \{1, \dots, M_{\tilde{n}}\}$$

SUPPLY CHAIN PRODUCTION PLANNING

Let us follow the basic idea that decisions should be oriented at the overall

optimum within the supply chain (regardless of the effects on the enterprises involved). It is therefore advisable for those enterprises to improve the coordination by combining the individual decentralised ERP-systems into one central supply chain ERP-system. The reliable philosophy of gradual planning may be kept. A prerequisite for the supply chain production planning would be a central high-level gozintograph reflecting the constructive composition of all parts among the entire logistics chain. The intersections between the enterprises are the respective external parts of the enterprise supplied and the final products of the supplying enterprises. Fig. 1 illustrates a corresponding example.

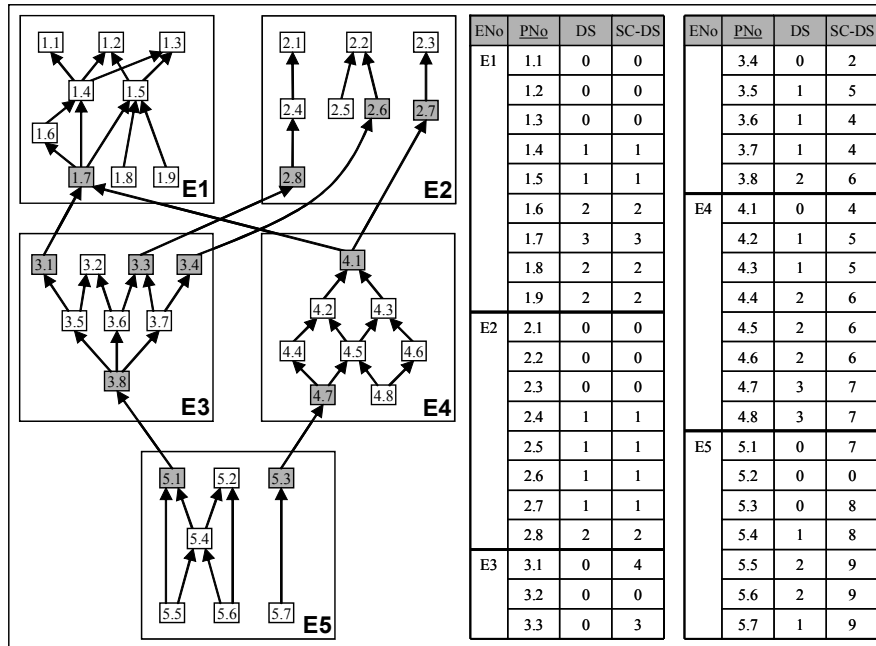


Fig. 1. Supply chain gozintograph

Formally, an SC-gozintograph $SC-GOZ = (P; K; sc-w; sc-v)$ is obtained for the combination of all company-own gozintographs whereas

- P the total set of all parts $P = \bigcup_{n=1}^N P_n$,
- K the relation of the material flow $K = \bigcup_{n=1}^N TS_n \cup SUP$,
- sc-w the production coefficient $sc - w : K \rightarrow \mathfrak{R}^+$ with $sc - w(k) = \begin{cases} \alpha(k) & \text{if } k \in SUP \\ w(k) & \text{if } k \notin SUP \end{cases}$

where

$\alpha : SUP \rightarrow]0,1]$ is the share of a bought-in part on the total required quantity of the customer; $\alpha(P_{nm}, P_{\tilde{n}\tilde{m}}) = 1$, if E_n is sole supplier to enterprise $E_{\tilde{n}}$ with regard to product $P_{\tilde{n}\tilde{m}}$.

- sc-v shows the forerunning time displacement $sc - v : K \rightarrow \mathfrak{R}_0^+$ with

$$sc - v(k) = \begin{cases} v_n(k) & \text{if } k \notin \text{SUP} \\ t_{Tr}(k) & \text{if } k = (P_{nm}, P_{\tilde{n}\tilde{m}}) \in \text{SUP and } t_{Tr} = \text{time to deliver product } P_{nm} \\ & \text{to customer } E_{\tilde{n}} \text{ (} n, \tilde{n} \in \{1, \dots, N\} \text{)} \end{cases}$$

The set of nodes of the SC-goZintograph is gained from the total set of nodes of all individual goZintographs representing the respective parts. Therefore, the intersection parts are multiply represented in different nodes. The connections of the material flow combine the individual goZintographs by their material supply relationship.

At the intersections between the enterprises linked together in the supply chain new production coefficients have to be generated. They correspond to the share of the quantity of an order of the product in question which belongs to the supplier looked at. If there are further suppliers outside the supply chain, the sum of those "production coefficients" does not have to add up to 1. A dynamically changing "production coefficient" illustrating the respective order strategy is certainly also possible. It is not a question of a technically determined but an economically determined factor. The forerunning time displacement $sc-v$ at the newly created intersection edges corresponds to the concerned product's transportation time between supplier and customer. In a decentralised system the agreed delivery time is used for a definite order on the part of the customer. However, in this case the time of the order is not relevant. Instead, it is the time when the finished product must be available at the latest. Therefore, the forerunning time displacement can only be the transportation time.

Let us concentrate on non-cycle structures of the material flow as they are typical for the industry so that even the SC-goZintograph is quasi-hierarchical in the supply chain. The SC-disposition levels being used as criteria for the sequence of the material requirement planning are calculated as follows:

$$SC-DS(P_{nm}) = \begin{cases} 0 & \text{if } P_{nm} \in EP_n \text{ and } \nexists (P_{nm}, P_{\tilde{n}\tilde{m}}) \in \text{SUP} \\ 1 + \max\{SC-DS(P_{\tilde{n}\tilde{m}}) \mid (P_{nm}, P_{\tilde{n}\tilde{m}}) \in K\} & \text{else} \end{cases} \quad \text{for any } \tilde{n} \in \{1, \dots, N\}; \tilde{m} \in \{1, \dots, M_{\tilde{n}}\}$$

According to the sequence dictated by the SC-DS, the material requirements calculation starting at level zero would, therefore, be carried out at the final products of the entire supply chain. The necessary data is to be found for the most parts in decentralised information systems and only for intersection products in the central information system. The algorithm for the material requirements calculation with a gross-net calculation and lot-sizing is only affected by modifications in the following aspects:

1. Primary requirement planning.
2. Treating of the intersection products.
3. Different lengths of sub periods in the period break-down.
4. Relevant planning horizon.

(1) Primary requirement planning: Starting point of the material requirements calculation is the data of the primary requirement plan which is set up for the marketable products. When considered individually, these are the final products and the marketable semi finished products of the individual enterprises. This means slight modifications for the production planning of a supply chain. Final products of the supply chain are only those products P_{nm} with $SC-DS(P_{nm})=0; n \in \{1, \dots, N\}; m \in \{1, \dots, M_n\}$. These are the final products which are at the very end of the material flow of a supply chain. Their customers for this

product are therefore not administered within the supply chain. The originally final products of supply chain enterprises being delivered to other members of the supply chain fail, in the view of the supply chain, to be final products. They are "internal" nodes of the SC-goZintograph and no longer need a primary requirement plan. If all customers are members of the supply chain, the secondary requirement resulting from the supply of the customer replaces the original decentralised planned primary requirement for these products. Is there additionally a customer demand for this product outside the supply chain, it corresponds to the character of a marketable semi finished product in the view of the individual enterprise. In that case, external sales for these products must be planned separately as individual primary requirement. A similar phenomenon in the opposite direction can be found in the parts not entirely to be obtained from suppliers within the supply chain. They are therefore, from the view of the supply chain, internal parts as well as bought-in parts. This must be considered separately for the lot-sizing within the material requirements disposition.

(2) Treatment of intersection parts: If the material requirements disposition for part $P_{nm} \in FP_n$ obtained from at least one supplier of the supply chain (i.e. $(P_{\tilde{nm}}, P_{nm}) \in SUP$ for at least one part $P_{\tilde{nm}} \in EP_{\tilde{n}}$), is carried out, the hereby implied demand for requirements explosion is to be calculated after the lot-sizing for all bought-in parts) concerned. For this, it is necessary to go back to the forerunning time displacement $sc-v(P_{\tilde{nm}}, P_{nm})$ and the production coefficient $sc-w(P_{\tilde{nm}}, P_{nm})$. Furthermore, it is to consider that parts of the order may come to a supplier external to the supply chain. In this case, a respective plan of procurement orders must be made out. Only the supply within the supply chain is treated like a production order. If the algorithm meets a part $P_{\tilde{nm}} \in EP_{\tilde{n}}$ which is to be delivered to at least one customer of the supply chain (i.e. $(P_{\tilde{nm}}, P_{nm}) \in SUP$ for at least one part $P_{nm} \in FP_n$), the secondary requirement resulting from the supply chain needs to be determined. This can be done with a period suitable summation of all demands of requirements explosion already calculated from customers. In addition, it needs to be considered for those parts that an individual primary requirement can be included into the planning if there are also customers outside the supply chain.

(3) Different lengths of sub periods of the period break-down: Although it would be certainly most convenient for a SC-ERP to insist on that all companies involved should use the same unit of period break-down, one will mostly meet, for autonomy reasons, differently structured unit of sub periods. Therefore, a transformation of the customer's planning data must be made according to his unit of period break-down into the unit of period break-down of the supplier at transitions between the enterprises linked directly within the material flow of the supply chain. If the supplier's screening is finer, the highest flexibility is secured by assigning the amounts to the last sub period which is still completely in the sub period of the period break-down of the customer. If the screening is rather rough, we have an aggregation.

(4) Relevant planning horizon: One very critical point is the fact that the relevant planning horizon – on same conditions – will be much larger in a supply chain than in an individual single scan as it is inter alia the lead time of the complete material flow in the supply chain that needs to be considered. There will be enterprises in the supply chain that have had more valid forecasted sales than

they needed for their individually relevant planning horizon but abstained to integrate the data into the primary requirement plan for cost reasons. For those, the demand for a longer planning horizon will not be critical. It will be harder for the companies with a more dynamic market as this represents more difficulties for estimations over a longer period. Depending on the decrease of the reliability of the forecasted sales with a growing planning horizon, the dispositions' quality in the supply chain and therefore the convenience of an SCM will decrease as well. Here, we find the restrictions of a SCM.

Another feature of production planning in a supply chain is the question if one should waive the lot-sizing for intersection parts on the part of the customer in order to avoid a double lot-sizing (namely a second time at the supplier's) and to allow the supplier a greater flexibility. However, this could be a disadvantage for the customer as one may differ from his minimal cost purchasing batch. A compromise could be to provide both the information – with and without lot-sizing.

INFORMATION TECHNOLOGICAL REALISATION OF A SC-ERP

It needs to be taken into account, for the information technological realisation of a SC-ERP, that a completely centralised solution in the form of a global information system for all companies of the supply chain is not eligible. Not only cost reasons but also the following facts are against it:

1. In most parts, there are already working decentralised information systems in place which are adjusted to individual needs.
2. Apart from business partner within the supply chain external customers and suppliers have to be considered as well.
3. Enterprises may be integrated into several different supply chains and such an extensive abandoning of autonomy cannot be expected.

For the above mentioned reasons, the SC-ERP needs to be constructed as a mainly virtual information system laying down the basic conditions and the rules for the process and supporting the necessary data interchange between the parties involved in the supply chain. The question is if a direct immediate interchange of the data about requirements and planned orders between customer and supplier is preferred or rather an indirect one via a central section which could also take on functions like aggregation and converting.

Depending on the outcome of this question, relevant data should be administered centrally but separately to the intersection products (e.g. for identification of corresponding part numbers, production coefficients, forerunning time displacement, SC-disposition level, perhaps even of inventory etc.). Alternatively, the data may – after a single calculation or classification – be integrated into decentralised information systems (e.g. the SC-disposition level). Additional service functions are imaginable to be organised centrally like for example converting the different measurements of products (e.g. customer one: pallets, customer two: kilogramme, supplier: per item) and assigning different planning period break-down or collecting controlling data relevant for the whole supply chain. These centrally collected and analysed controlling data may help not only to identify weak points (the knowledge of these can be used for a reengineering of the supply chain) but also success and cost relevant factors serving as a basis for allocating savings achieved through SCM to the involved. But altogether the

SC-ERP will use the functionalities and data of the decentralised ERP-systems.

It would be ideal for the master plan of the supply chain if the material requirement planning was carried out synchronically. However, a standardised clocking of the planning moves may often be impossible to realise due to individual internal specifications. Therefore, both alternatives – synchronous and asynchronous processing – are to be demonstrated.

A synchronous sequence enclosing the whole supply chain – not embedded into a central SC-ERP for the program-based material requirements calculation but using the functionalities of the decentralised ERP-systems – needs definitions of product oriented planning sections (PS) for the enterprises joined in the supply chain. A planning section covers all parts within an enterprise being linked direct or indirect to each other by (internal) connections of the material flow. An enterprise may have several planning section. If the planning sections are arranged in the correct order, one obtains a planning system which is altogether consistent in itself.

Let E_1, E_2, \dots, E_N be the enterprises in the supply chain, whereas $E_n = (P_n, TS_n, t_{Dn}, W_n, V_n)$ with the final products EP_n as earlier defined ($n=1, \dots, N$). Definition for SC-goZintograph as above. Every enterprise E_n has the planning sections $B_{n1}, B_{n2}, \dots, B_{nR_n}$ ($R_n \geq 1$) ($n = 1, \dots, N$) with

$$B_{nr} \subseteq P_n, r = 1, \dots, R_n; B_{nr} \cap B_{n\tilde{r}} = \emptyset, r, \tilde{r} = 1, \dots, R_n, r \neq \tilde{r}; \bigcup_{r=1}^{R_n} B_{nr} = P_n$$

The disposition levels for the planning sections DSB_{nr} result from the maximum SC-disposition level of their final products, i.e.

$$DSB_{nr} = \text{Max} \{ SC - DS(P_{nm}) | P_{nm} \in EP_n, P_{nm} \in B_{nr} (r = 1, \dots, R_n) \} \quad (n = 1, \dots, N)$$

After all enterprises of the supply chain having determined their primary requirements for the planning horizon relevant to the supply chain the decentralised ERP-systems are called to carry out the material requirement planning. In order to have all data necessary for planning available at all times, the call is made in the sequence given by the disposition level of the planning sections DSB_{nr} (ascending, starting at level zero). This means that the first planning sections are those including the final products of the complete supply chain. Apart from the enterprise internal results of the material requirement planning, data also relevant for other areas of the SC-ERP are determined e.g. net demands planned for the complete planning horizon or planned procurement orders of the intersection parts within the considered planning section. They are required in order to be able to work off the next planning section. The necessary transformations with regard to measurement technology and time have been mentioned above. For the asynchronous processing the consistency may be waived. Instead, results of the decentralised ERP-systems – after they have been re-planned or revised – will be passed on to partners concerned in the supply chain via decentralised users. Those may decide on themselves under consideration of this new information if a revision is necessary or if they use only in the following planning cycle the at that stage latest data. One compromise could be to work asynchronous in normal case and to choose the more costly synchronous way at least after a longer period of time (e.g. every two months) in order to obtain constantly reliable planning data again.

CONCLUSION

Information is the essential ingredient for a successful supply chain management. Especially the availability and quality of information about the product's sales market at the end of the supply chain is a critical factor for its success. A concept for realising supply chain management in the operative planning phase is the supply chain production planning as described above. It combines existing ERP-systems of decentralized enterprises in a supply chain with a central coordination system.

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FLOW ACCOUNTING: EFFECTIVE PERFORMANCE ASSESSMENT FOR THE LEAN ENTERPRISE

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ABSTRACT

Conventional management accounting conventions do not support the Lean paradigm. Whilst numerous alternative accounting approaches have been developed since the 1980s and a particular Lean Accounting technique is currently in vogue, there is still dissatisfaction amongst academics and practitioners. This theoretical paper presents a theoretical framework for a new approach that the authors call *Flow Accounting*. This has been developed from five years of empirical research at a number of large test sites and is advanced as an improved management accounting approach for more effective performance assessment and operational decision making within the Lean enterprise.

NEED FOR A FLOW ACCOUNTING APPROACH FOR THE LEAN ENTERPRISE

A review of academic or practitioner oriented publications on the subjects of logistics, operations or supply chain management reveals the pervasive influence of the Lean (Womack and Jones, 1996) management paradigm. Conversely, a number of seminal works in the late 1980s and early 1990s (such as Johnson and Kaplan, 1987; Johnson, 1992; Cooper, 1995) have established that the origins of the standard costing approach within management accounting lie in the early twentieth century; being derived from, and hence most relevant to, the mass production concept. These works and others (*inter alia* Monden, 1989; 1992; Yoshikawa *et al.*, 1993; Hines *et al.*, 2002) have also characterised the deficiencies in decision-making that originate from this conventional cost accounting approach when applied to Lean environments.

Johnson (2007, p.1), for example, criticises conventional accounting systems for costing, inventory valuation and performance assessment "... [for promoting] *delay and discontinuity in operations, rather than flow and short lead times.*" He also criticises conventional accounting for not disclosing the potential financial benefits of adopting lean practices because it does not show directly the cost savings and financial opportunities that might arise from disposing of or redeploying resources made redundant by a successful lean initiative. Bicheno (2000, citing Ansari *et al.*, 1997) characterises four key areas of contention between such conventional management accounting approaches and Lean environments. These are that conventional accounting:

1. Assumes that costs vary with inputs such as material or are fixed over a set period of time, hence encouraging long production runs.
2. Stresses individual and departmental performance measurement and accountability. By contrast, Lean emphasises team and supply chain based measurement and rewards.

3. Is very concerned with inventory costing and control. Lean stresses simplicity and inventory reduction.
4. Emphasises labour and unit-based measures and costs. Lean places a greater emphasis on [reducing] indirect costs.

As a consequence of this dislocation between conventional accounting and the Lean paradigm, a plethora of alternative accounting approaches have been developed and applied since the late 1980s to better support effective performance assessment and decision making within the Lean enterprise. These notably include Activity Based Costing (Johnson and Kaplan, 1987; Innes *et al.*, 1991; Yoshikawa *et al.*, 1993), Throughput Accounting (Goldratt and Cox, 1984; Corbett, 1998; 2000), Target Costing (Monden, 1989), Kaizen Costing (Monden, 1992) and Quality Based Pricing (Hines *et al.*, 2006a; 2006b). However, each of these address only a subset of the four contention areas.

A comprehensive management accounting method, designed specifically to complement the lean enterprise has been called for increasingly. The resultant subject of *Lean Accounting* has perhaps become the foremost topic of discussion amongst Lean practitioners over the last two years. The term is becoming synonymous with the work of Brian Maskell (see Maskell and Baggaley, 2004), who also emphasises the application of lean techniques to the accounting department itself in the form of transaction analysis and radical reduction. However, this 'dominant design' of Lean Accounting method is not without its own critics. These notably include the distinguished Prof. Johnson, whose recent article in the *Manufacturing Engineer* (2007) is provocatively subtitled '*American industry must erase lean accounting before it destroys lean management*'. Johnson's argument is based upon the premise that [this form of] Lean Accounting "... reinforces the mistaken idea that managers can rely solely on abstract financial quantities to explain and control financial results" (p.2).

The purpose of this paper is to explain the theoretical framework of a new approach to the Lean Accounting issue that the authors call *Flow Accounting* (FA). This forms the first of a series of two related papers on this subject by the authors at 13th ISL (see Darlington *et al.*, 2008)). This FA methodology has been developed from empirical research at a number of large test sites by one of the authors (Darlington) over the past five years¹, and the second paper in the series details an application of the approach within the aerospace industry. In this paper FA is advanced as an improved management accounting approach for more effective performance assessment and operational decision making within the Lean enterprise, which amongst other aspects mitigates many of Johnson's (2007) criticisms of the prevailing Lean Accounting approach. Because of space constraints this paper concentrates on description and explanation rather than comparison with alternatives.

¹ The input of Kate Mackle and Roger Tame of *Thinkflow* is gratefully acknowledged.

FLOW ACCOUNTING

There are two key issues that confound most Lean improvement initiatives:

1) *"Why is it that so much improvement activity never hits the bottom line?"*

In operations and logistics we see a lot of lean initiatives fail because of the following reasons:

- Local efforts tackling isolated parts of the system to no overall effect.
- Poor understanding of demand and capacity with plants not being run to maximise the flow of materials through their bottleneck.
- Naïve application of Lean tools and techniques; often in the wrong place at the wrong time.
- Inappropriate delegation of leadership for the improvement initiative.

2) *Why do we have to fight the accounting and control system?*

Four high level contention areas were highlighted in the introduction to this paper. However, at an operational level more accounting barriers are encountered:

- Conventional accounting systems encourage overproduction by their clumsy interpretation of the "value added" principle.
- They do not recognise the importance of bottlenecks, constraints or pacemaker processes.
- They encourage local efficiency and so create "islands of excellence".
- They have little or nothing to say about lead times.
- They promote the idea that the bigger the batch the lower the unit cost.
- They encourage "cost reductions" which often prove to be "mirages".

The FA methodology was developed as a response to these two issues, with its specific goal being to help the organisation make more money by defining the scope for supply chain improvement in terms of money; focussing the organisations on improvement initiatives that hit the bottom line; and encouraging the 'right' lean behaviours at all levels in the organisation. This methodology was developed by Darlington as a result of his personal experience as a Finance Director, Plant Manager and Kaizen Director in the automotive and forging industries. It was also highly influenced by his training as a Lean and Six Sigma expert and Theory of Constraints (TOC) 'Jonah' (see Goldratt and Cox, 1984). He coined the name Flow Accounting itself because this captures the essence of a lean enterprise: to make products flow as close to real demand as is possible and keep them flowing from one value added step to the next with no delay (Womack and Jones, 1996).

The Flow Accounting Framework

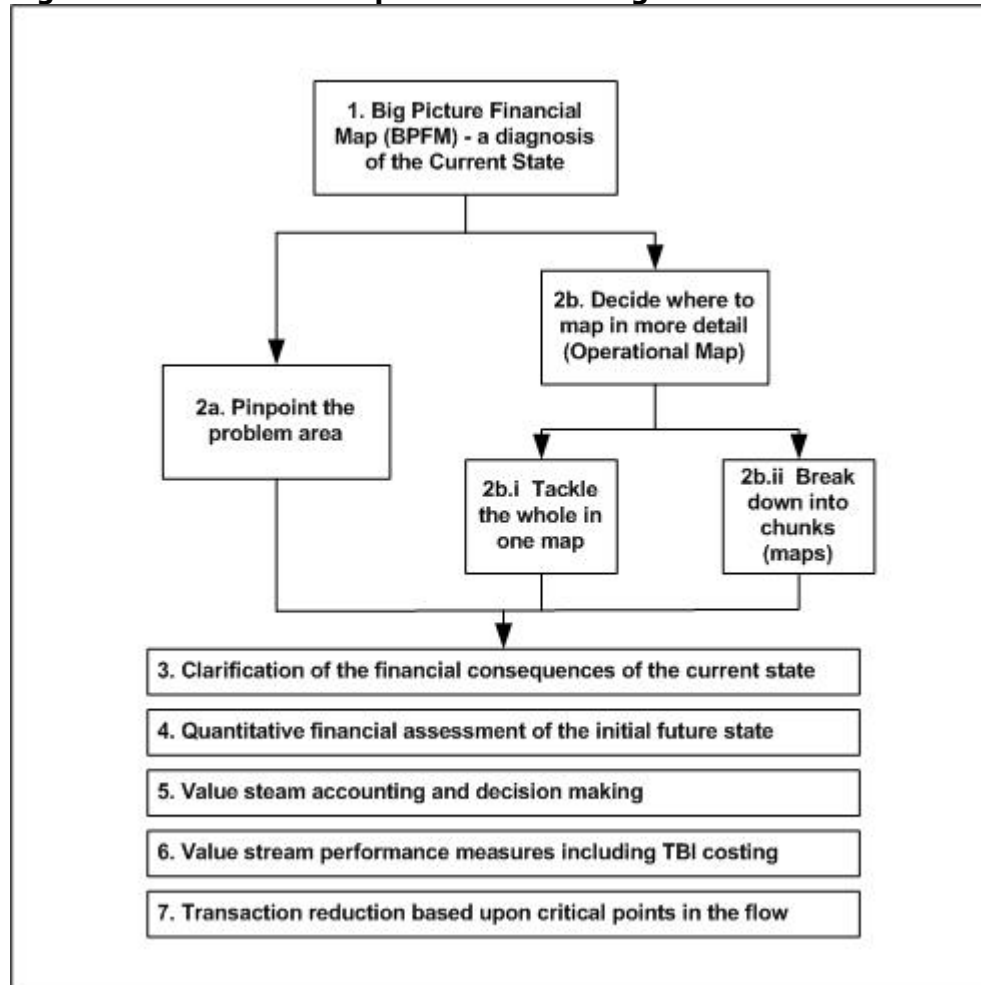
Many Lean practitioners have engaged in the mapping of the current-state of a focal value stream with a view to this forming the blueprint for a subsequently improved future-state of that same process. Conventionally, the Learning to See Mapping (LTSM) approach advanced by Rother and Shook (1998) is used. However, this technique suffers from two significant design limitations. First, it is bereft of financial data and provides no financial insight into the map configuration. Second, it also suffers from irrelevance (gross over-simplification) as only a single product is detailed for the value stream, when in fact the very problems originate from the contention for shared resources by products often

numbering into their thousands. Such maps consequently provide no insight into shared resources (e.g. a large presses, paintshops or ovens such as autoclaves through which multiple value streams pass). The best we see in lean accounting to address such issues is to call shared resources “monuments” (Maskell and Baggaley, 2004), a term of derision indicating that these resources should actually be duplicated to avoid problems of “sharing”. Of course there is an issue with shared resources ONLY if you have a local optima level measurement such as OEE or unit cost.

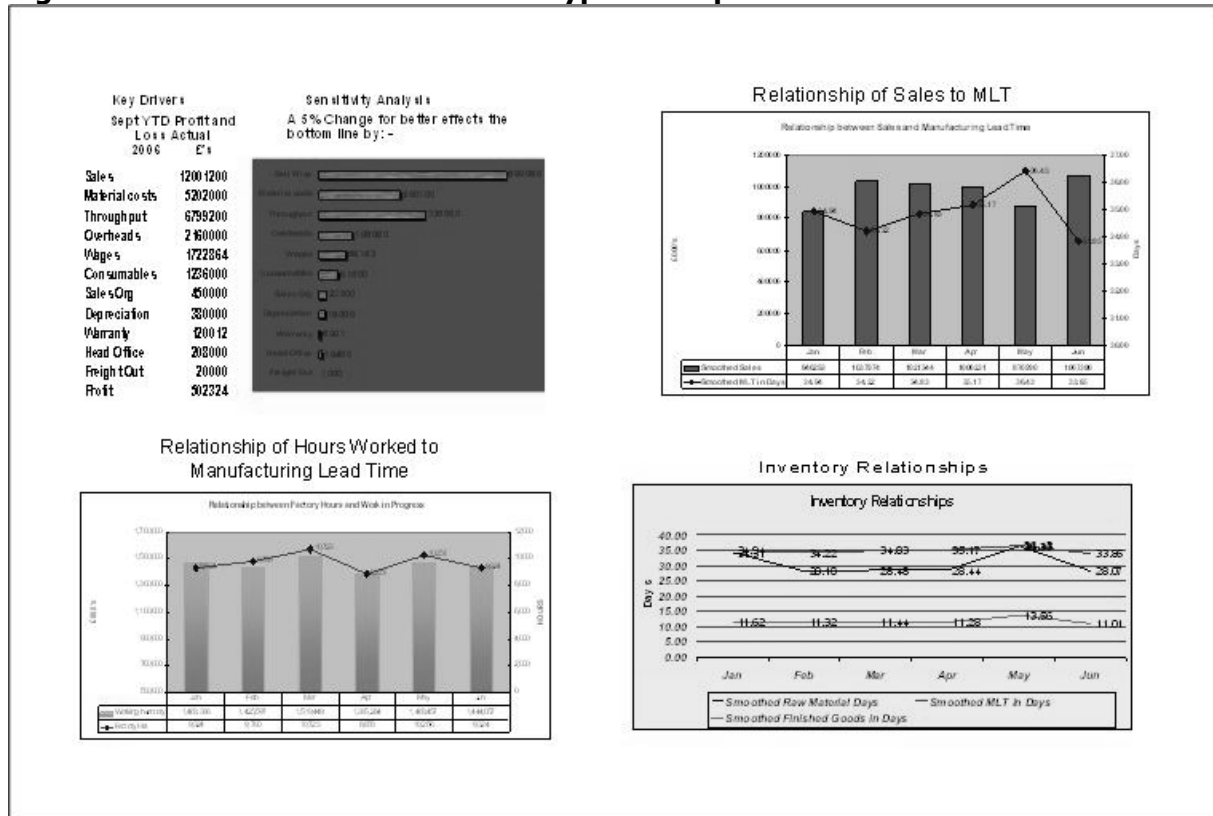
The application of the LTSM technique often also compounds its inherent design limitations. Typically, the mapped material flow tells us little about the total manufacturing lead time and order lead time to the customer, for all value streams. In addition, the mapped information flow provides no insight into capacity management and material allocation policies. As a consequence, such mapping projects degenerate into just another time consuming method of generating a list of scatter gun improvement activities.

Figure 1 schematically represents the seven-step FA framework that is designed to focus improvement activities and hence avoid these conventional mapping pitfalls. The first step is the construction of a Big Picture Financial Map (BPFM), which is a representation of the current state of the whole organisation, as opposed to a single value stream. The BPFM illustrates key product contracts, operational areas, inventory buffers (sales coverage in days) and manufacturing lead time. It also illustrates the main material flow routes per contract between these buffers and areas, along with key financial data such as operating expense (*and not product cost*) per area and sales revenue per contract. The purpose of the BPFM is to provide a Pareto analysis of the most important aspects of the organisation, along with insight into its overall capability to fulfil the demand placed upon it in terms of *money*. The aim of BPFM is therefore to provide an analysis for the relative of emphasis [in TOC terminology] of throughput, inventory, lead time and operating expense (Goldratt and Cox, 1984).

Step 2: Once constructed, the BPFM will either enable the major performance problem area to be pinpointed immediately, or else determine the area of the BPFM that will need to be mapped in more detail to establish this. In the latter case, this might either result in a single *operational map* or a sequence of ‘mapping chunks’ to establish the necessary insight. Again in contrast to the LTSM approach, this more detailed operational mapping provides detailed customer order and manufacturing lead time data along with a greater elaboration of the information flow (encompassing capacity and material allocation data).

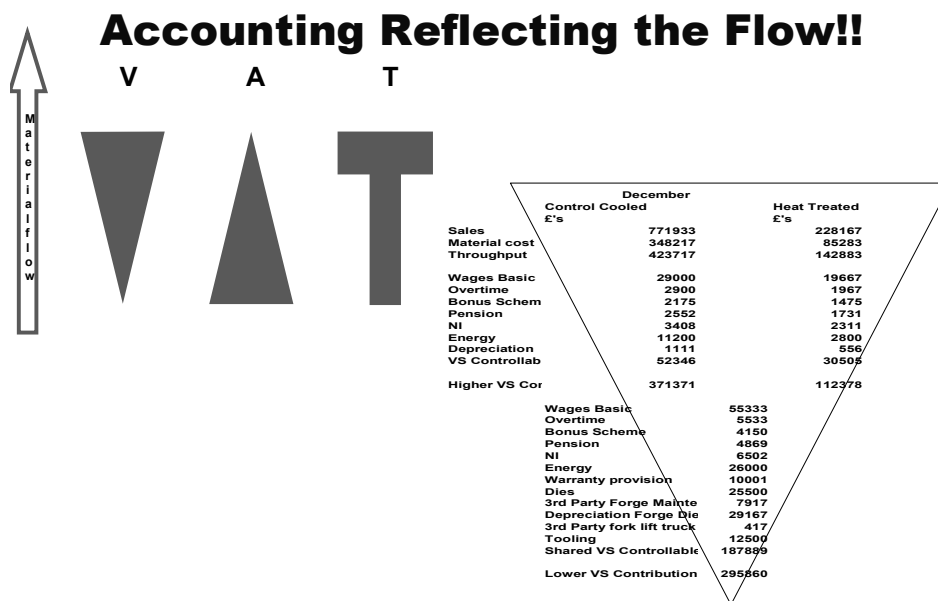
Figure 1: The Seven Step Flow Accounting Framework

Step 3: It is next necessary to establish the *financial* consequences of the current-state, in an easy to understand format (for example “it costs you £100K/ month to provide a 42 day manufacturing lead time for this business”). This in turn requires the compilation of the necessary detailed financial data and hence the active involvement of a management accountant/s on the project team. The intent here is to explore trends and relationships [pertinent to the Lean enterprise] within this data that may not have been explicitly explored previously because of conventional accounting practice. A non-exhaustive list of analyses includes: sensitivity to making money, working capital profile, inventory in terms of days of sales cover, stock age profiles at different parts of the system, trends in labour hours and WIP, trend lines for overall performance and working capital (debtor and creditor days). The formats of typical outputs from this exercise are provided in Figure 2.

Figure 2. Financial Current-State – Typical Outputs

Step 4: By contrasting the above financial analysis with the desired level of business performance (i.e. 'what if' using spreadsheet analysis), it is possible to understand the level, rate and sequence of improvements necessary to achieve this goal. This translates into one or more future-state models; each of which is conceived as a coherent and quantified financial entity (for example "if you were to implement a CONWIP pull system [of this design] between these two resources it costs you £90K/ month to provide a 15 day manufacturing lead time for this business").

Step 5: The value stream concept embodied in the LTSM is an attractive proposition. However, the BPFM will underline that shared resources do exist in practice, and very often it is common sense to do so (e.g. is there capital and space available to have a dedicated paint plant per value stream?). The fifth step of the FA framework involves re-designing the accounting information system to reflect this point. This exercise uses the overall "shape" of the bill of materials and routing as the basis for the presentation of the resulting accounting information; a visualisation technique to allow staff to better understand their role in flowing products and services to the end customer. There are three generic manufacturing plant shapes; V A and T (see Goldratt and Cox, 1984 for an explanation). An illustration of a FA statement for a V-plant is provided in Figure 3.

Figure 3. Flow Accounting Statement for a V-Plant

Step 6: The sixth step is guided by the old adage “*tell me how you are going to measure me and I’ll tell you how I am going to behave*”. The behaviours we are trying to induce in this case are those that which is conducive to the Lean enterprise; to stimulate and maintain product flow. We therefore require the design of a set of performance measures that are holistic in this sense (induce a ‘global’ optima rather than a series of local efficiency optimums) and are mutually supportive rather than mutually exclusive (all pulling in the same direction) – with the common denominator being to maximize product throughput or velocity through the supply chain or plant. One such component measure could be the *time based indicator* (TBI). FA attempts to remove indirect costs from the decision making process because of the vagaries of overhead allocation policies. However, based upon the fact that 90-95% of throughput time is composed of delay and queuing time (Goldratt and Cox, 1984; Womack and Jones, 1996) FA stresses an overhead allocation policy based on inactivity (in effect *Inactivity Based Costing!*). The TBI logic states that the longer a product takes to move through a production and distribution system, the more exposed it should be to the operating costs of running that system (ie the more expensive). This should in turn induce increased velocity through that system.

Step 7: The primary justification for employing accountants should be to produce good information for decision making; it is not to do with shortening the “month end closure” or reducing the “transactional burden”. So only at this point post identification of the truly critical information points is it worthwhile considering applying Lean principles to the accounting system itself. Any application which does the 5S in an accounts department without reviewing whether any of the output truly stimulates lean activity is not only missing the point, it is entering the dangerous territory of self congratulation that they have “become lean”. Although intuition suggests that many accounting transactions are wasteful, the question is “which ones to eliminate”? FA again turns to VAT

analysis to inform this decision. “V” plants are process oriented, where capacity dictates flow (eg most primary manufacturing – including steel mills). “A” plants are characterized by many components and sub-assemblies arriving at one or very few end part numbers (eg aircraft manufacturing). “T” plants are modern day lighter assembly businesses where common components can be put together in different combinations to make a very large number of end part numbers (eg many automotive sub assemblies). Does it make sense then to treat these widely differing businesses as though they had the same accounting transaction issues, as per the Maskell and Baggaley (2004) approach? Logic would suggest not. Only after reviewing the transactions that promote good flow in each such scenario are in a position to rid ourselves of the excess.

CONCLUSIONS

This paper has explained the theoretical framework of a new approach to the Lean Accounting issue, which strongly suggests that the operations and supply chain communities need to embrace their accountants as integral continuous improvement team members. In such a short space it is not possible to elaborate further upon this new technique. However, it is hoped that this short paper has spurred some interest.

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FLOW ACCOUNTING IN APPLICATION: BIG PICTURE FINANCIAL MAPPING IN THE AEROSPACE INDUSTRY

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ABSTRACT

This is the second of a series of two papers submitted to this year's ISL conference that discusses the new Flow Accounting technique for supporting the application of Lean thinking within supply chains. Whilst the first paper is theoretical and details the Flow Accounting framework, this paper presents an empirical case study of an application of the technique within the aerospace industry. In particular, it discusses the findings derived using a new holistic mapping technique called Big Picture Financial Mapping that helps target improvement initiatives and quantifies the financial potential.

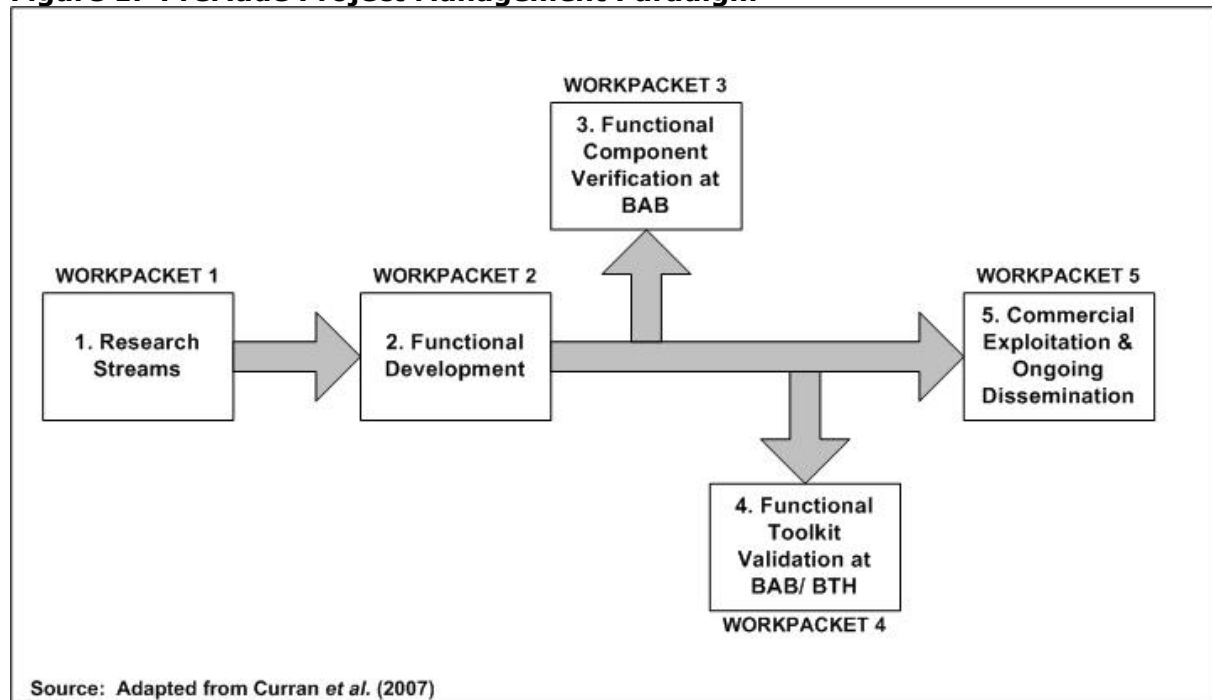
INTRODUCTION

The implementation of 'Lean Accounting' in support of Lean (Womack & Jones, 1996) supply chain improvement initiatives has become an extremely topical subject amongst practitioners and academics over the last two years. This paper is the second of a timely series of two submitted to ISL08 that discusses the new *Flow Accounting* (FA) methodology advanced by the authors as the most effective approach to the Lean Accounting issue. Its purpose is to elaborate upon the theoretical FA framework provided in the first paper by summarising an empirical application of this new approach within the aerospace industry (see Darlington *et al.*, 2008). This was conducted under the aegis of a project entitled *Precision Concept Design Model of Manufacturing for Competitive Advantage* (PreMade).

PreMade is a three year, £2.5m project funded by the UK Department of Trade and Industry, now called the Department of Business, Enterprise & Regulatory Reform, that started in January 2006. It involves a consortium of ten industrial and two academic partners; the latter being the Lean Enterprise Research Centre (LERC) from Cardiff University and the School of Mechanical and Aerospace Engineering at Queens University Belfast. The aim of PreMade is to develop a digital manufacturing tool and wider supporting application methodology that is based upon the DELMIA software suite. This tool is to facilitate digital manufacturing assembly line layout and configuration for new products prior to their production. It is to embody Lean manufacturing process design principles; hence becoming a Digital Lean Manufacturing (DLM) tool. The idea is to develop a digital manufacturing environment that will enable competing assembly line configurations to be evaluated and optimised in terms of lead time and cost prior to undertaking any conventional physical layout activities, and hence ultimately increasing competitive advantage via time (responsiveness) and cost reduction for the firms concerned.

The PreMade project management paradigm involves five distinct 'packets' of work (Figure 1). Workpacket1 (WP1) was the initial project planning element that involved refining the individual workpacket deliverables and timescales. WP2 was the functional development of the DLM tool components and supporting methodology. This was conducted at Bombardier Aerospace Belfast (BAB) who are the lead industrial partner. BAB design, manufacture and support fuselage, engine nacelle and flight control surface structures for the firm's small and medium sized regional aircraft series such as their Learjet, Challenger and Global Express ranges. These are then fully assembled into complete aircraft at the firm's North American plant. WP3 entails the [internal] verification of this functionality by means of an alternative test application within BAB, whilst WP4 is the [external] validation of the generalised functionality in a new industrial application. WP4 is planned to involve train manufacture and maintenance at the Bombardier Transportation (BTH) plant in Derby. The last workpacket is the ongoing dissemination and commercial exploitation of the project deliverables by the academic partners, of which the papers in this conference form a part.

Figure 1. PreMade Project Management Paradigm

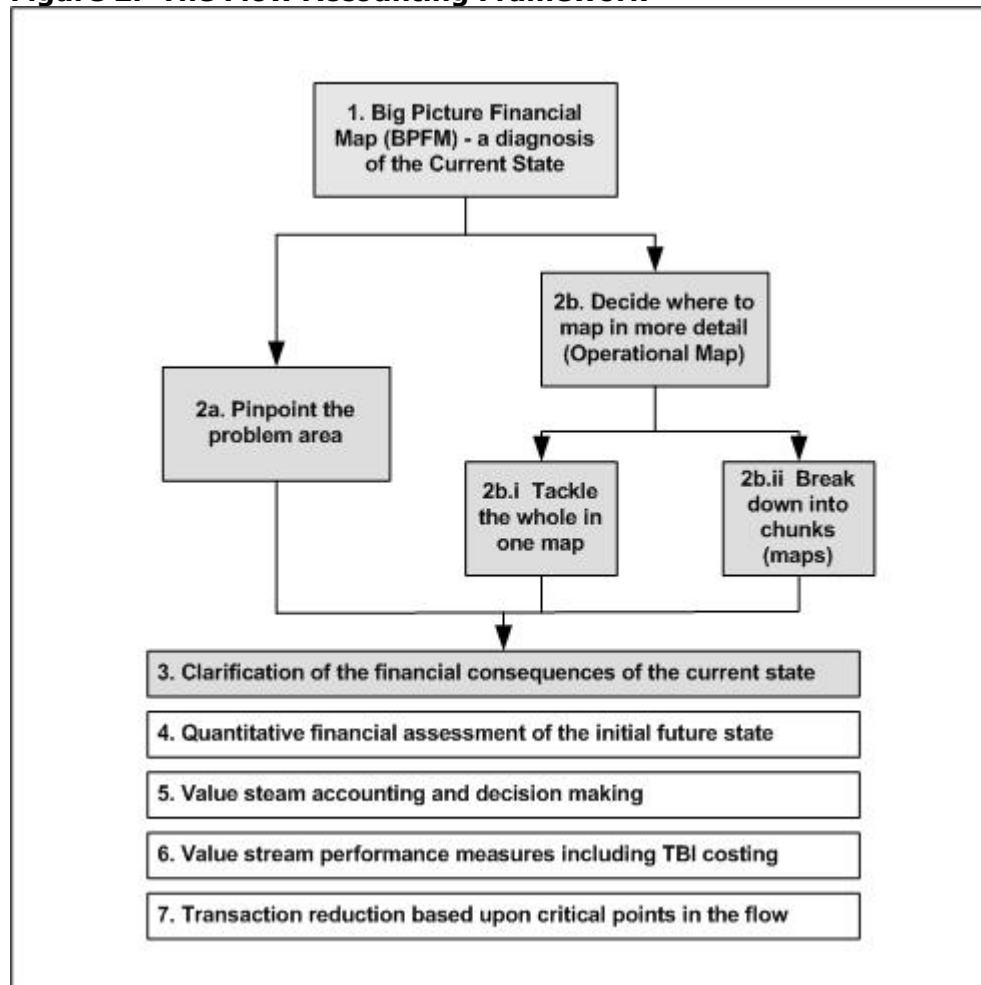


RESEARCH METHODOLOGY

The empirical study reported upon in this paper was the WP2 project conducted by the LERC research team in conjunction with Queens University Belfast at BAB between July 2006/7. This amounted to the implementation of the Big Picture Financial Mapping (BPFM) steps of the Flow Accounting framework; the highlighted boxes (steps 1-3) illustrated in Figure 2. The research strategy adopted to conduct this was the case study approach promoted by scholars such as Yin (2003) and Eisenhardt (1989), and advanced as an appropriate methodology for logistics and supply chain research by proponents such as

Ellram (1996). Data collection involved primary and secondary research. Primary data collection instruments included semi-structured and unstructured interviews. Document and archival analysis was used for the secondary research, and particularly for establishing the financial data used in the construction of the BPFM. The resultant data is disguised in this paper in the interest of commercial confidentiality. Steps 4-7 on the following figure form LERC's verification (WP3) project at BAB, which is ongoing at the time of writing and will be the subject of a future paper.

Figure 2. The Flow Accounting Framework



The above Flow Accounting framework is explained in more detail in the first ISL08 paper (see Darlington *et al.*, 2008). However, in summary the BPFM activity is intended to provide:

- The Pareto of the most important aspects of the business being studied.
- The overall capability of the system to fulfil the demand placed upon it (in terms of money).
- A 'feel' for the relative emphasis and importance in terms of throughput, inventory, lead time and throughput as a percentage of operating expense.

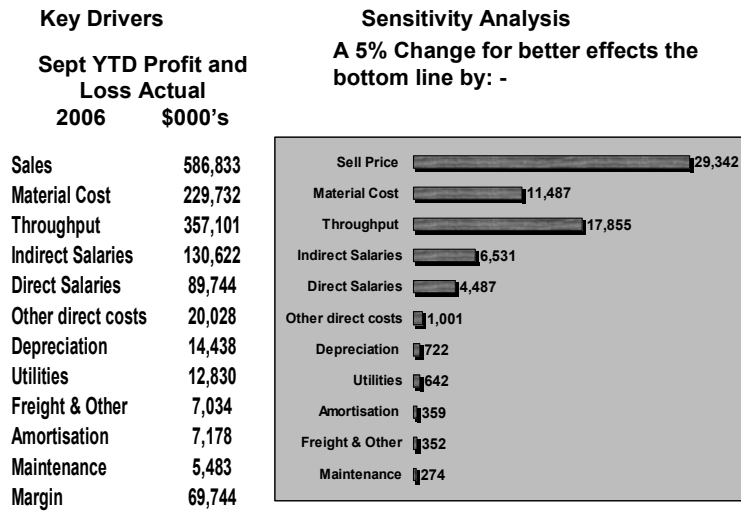
- An indication as to where [any] more detailed mapping activity should focus.
- An assessment of the required level of improvement activity, considering: customer demands, competitive pressure, group aspirations and the scope for improvement.

RESULTS

The application of the FA approach within BAB quickly revealed the comprehensive availability of data on "costs". Whatever the research team wanted to know about what was spent, by what department, on what item of expense was quickly and easily made available to them. By contrast, little data was available or thoroughly understood about lead times. Operational site performance measurements reflected this trend, with many of the most important measures being of a "unit cost" type (e.g. controllable overhead rate, controllable wrap rate, direct labour rate). Measurements influence behaviour (Hrebiniak and Joyce, 1984; Neely *et al.*, 1995), and therefore to many managers such unit cost measures mean "make as much as you can in the time available".

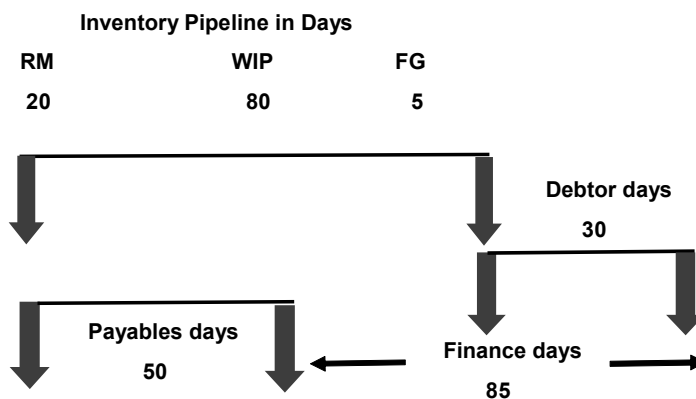
The team next assembled a profit and loss statement for the firm and for each entry explored the impact of a conservative [5%] improvement on the bottom line (Figure 3). The only unconventional entry in the format of this statement is "throughput", which is a Theory of Constraints (Goldratt and Cox, 1984) construct defined as Sell Price – Material Cost. To realise the improvement in sell price or material cost requires interaction and negotiation with the firm's external stakeholders; their customers and suppliers. This is always difficult. The sensitivity analysis reveals that the next largest opportunity is entirely internal, and lies in throughput reduction. However, the findings established that the firm's ongoing and sophisticated continuous improvement programme was premised upon cost reduction rather than lead time compression; and particularly targeted direct and indirect salary reduction in the final assembly area. All these preliminary findings were consistent and suggested that BAB are committed to competing almost exclusively on unit cost as opposed to a form of differentiation, such as responsiveness or service level.

Figure 3. Sensitivity Analysis



Further analysis explored the firm’s inventory relationships over a seven month period (February–August 2006) and established that the BAB inventory pipeline in terms of smoothed raw material, work in progress and finished goods ‘daysworth of sales coverage’ was 20, 80 and 5 days respectively. Based on prior experience of the aerospace industry, this level of inventory is the norm and can be explained in terms of the ‘A’ plant configuration of the deep bill of materials (Goldratt and Cox, 1984) and penalty clauses for late delivery that typify aerospace plants. The resultant working capital relationships of this current-state are summarised in Figure 4. This clearly illustrates the need to finance 85 days of working capital, with a typical month end inventory value of \$170m dollars; a lot of money. This finding again affirms the importance of throughput, as “inventory is time”.

Figure 4. Working Capital Relationships of the BAB Current-State

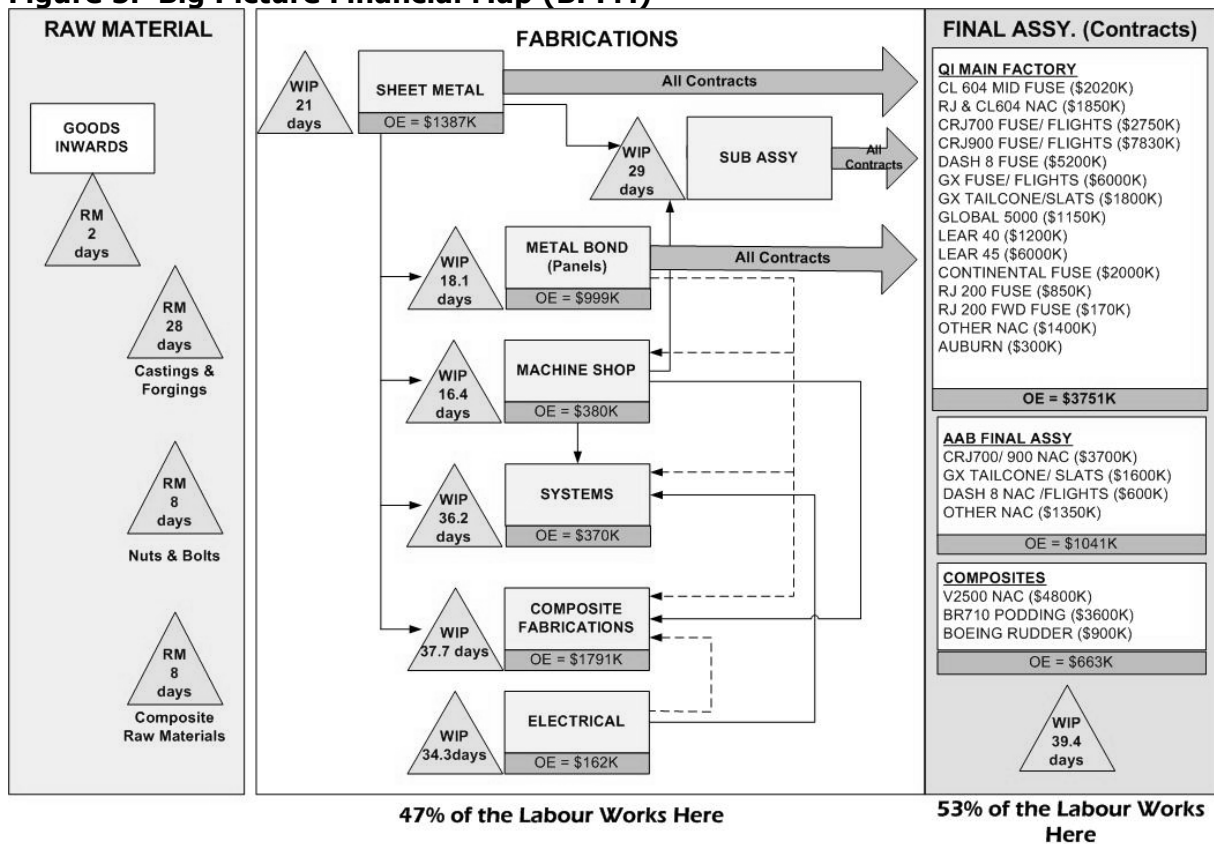


September End Inventory of \$170m

This preliminary information produced the platform for the production of the BPFM that formed the key deliverable of the PreMade WP2 study (Figure 5). The map provides a schematic representation of the raw material, fabrication and final assembly areas of the BAB operation. The researchers captured the total inventory value tied up at each stocking point in the system. However, this doesn't tell us much about whether this is 'too much' or 'too little' for the demands places upon it. Each value is consequently converted into a 'daysworth' (of sales coverage) figure. Each distinct centre or factory within the BAB operation is represented as a box, with its monthly operating expense (OE) displayed on the bottom. This is the fixed costs that are incurred in running that centre for the period, regardless of its production volume (and excludes any overhead allocations). Lastly, sales revenues per final assembly factory contract are also noted on the map.

This BPFM confirmed that the average lead time for the production of a typical aircraft fuselage was approximately 80 days. It also highlighted that nearly 50% of the labour was in upstream (Fabrications) operations as opposed to Final Assembly; the existing focus for the firm's continuous improvement and [labour] cost reduction efforts. With 80 days of lead time this means that components and sub-assemblies are actually queuing for over 97% of their time. This is difficult to reconcile with the firm's current emphasis on trying to keep its men and machines "busy". It would suggest this is "busy" for busy sake.

Figure 5. Big Picture Financial Map (BPFM)



CONCLUSIONS AND FUTURE RESEARCH

Trying to synchronize so many components and sub assemblies is extremely difficult. Based upon previous experience the performance levels indicated on the BPFM is not surprising or unusual for an aerospace business. The authors argue that this is all the more reason to try to develop the competencies to make significant reductions and thus compete on a different basis; that of short lead time response. This would also lead to the reduced costs sought by the case firm as they would not be activating work too early. The BPFM illustrates that the upstream resources from the dedicated assembly lines are not dedicated, but are in fact shared. This is significant as wherever one set of resources has to feed many, there is scope for a lack of synchronisation. In the BAB case this situation is aggravated by performance measurements that focus on local optimisation rather than the optimisation of the whole system.

The conclusion from the above is that the firm's ongoing [Lean] process improvement work on its final assembly lines can be *complemented* by efforts to synchronise work flows from upstream resources to drive lead time to significantly lower levels. The design and implementation of such a project is the subject of WP3 of the PreMade project. The BPFM would suggest that the most logical place to start this exercise would be the Composite Fabrications area given its WIP and OE figures.

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IDENTIFYING THE IMPLICATIONS OF MOST WARMING FOODS: A PILOT ANALYSIS

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ABSTRACT

Sustainable development is receiving widespread interest. However coverage is mainly centred on politically visible areas like transport and aviation. However environmental impacts from areas like agri-food supply chains – in particular livestock and dairy – have seen relatively little research interest, press coverage etc. This paper shows that agri-food supply chains offer a significant potential for environmental impact reduction in relation to surplus production, consumer waste and potentially from plant-based protein alternatives to meat and dairy production, supply and consumption.

KEY WORDS

Sustainable development, Greenhouse gases, Agri-food supply chains, Balanced outcomes – social, economic & environmental

INTRODUCTION

Popular interest in sustainable development is highly skewed towards areas that are politically visible, such as transport and in particular the evils of air travel. This situation is mirrored in the academic community with an explosion of articles on sustainable transport (an EBSCO web search yielded 552 academic references to Sustainable Transport while for example Sustainable Livestock provided less than 10% of that number¹). Nonetheless, only 14% of Greenhouse Gases (GHGs) actually result from transport, with as little as 2% coming from aviation, against 32% resulting from agriculture and land use – a major part of which can be directly attributed to the food chain (Stern, 2006). Moreover within the food system, certain areas such as livestock production are particularly problematic with meat and dairy products contributing more than 50% of the total GHGs emitted (Kramer *et al*, 1999). Another recent study in the UK shows that GHG emissions attributable to meat and dairy consumption are about 4 times more than the GHG emissions generated from fruit and vegetable consumption (Garnett, 2007).

"Over the next decade, the requirement is to ensure the costs generated by greenhouse gases across the economy are fully priced so that the polluter pays. That means greenhouse gases generated in producing food or in food miles need to be recognised in the same way as greenhouse gases generated in other industries" (Miliband, 2007). However, authors believe that key food production areas go largely unaddressed. While there are recent studies drawing attention to the impacts of the biggest polluters in the food system such as primary livestock production (Steinfeld *et al*, 2006, Garnett, 2007), there has been very limited input to policy makers and consumers. Consequently the Innovative Manufacturing Research Centre at Cardiff University launched a pilot project to

¹ Undertaken 16th July 2007 within Business Source Premier

understand, analyse and explain the potential policy, economic, environmental, technological and social (health/diet and ethical/welfare) impacts that a representative range of UK food consumption scenarios will have on helping to develop more GHG neutral agri-food supply chains. This paper reports on the purpose, underpinning thoughts, methodologies deployed, design and some of the early findings of this pilot. The authors identify in detail what the major policy and research gaps are and hence what research is required within the broad area of creating more GHG neutral agri-food supply chains. The novelty of the work lies not only in its holistic and multi-disciplinary approach but especially in its potential impact on sustainability of agri-food supply chains through shining the light on possible policy solutions and mitigation actions. Methodologies deployed in this project include interviews, ethnographic consumer behaviour study (consumer shadowing), scenario identification and scenario planning. The authors conclude by putting forward a framework that will equally guide future academic research, policy making and consumer behavioural change.

Literature Review

The world faces an uncertain future due to the effects of climate change (Stern, 2006). However, until very recently the issue has not been taken very seriously by the general public and arguably even now only at a lip service level (Webster & Riddell, 2006). As explained in the above, interest in sustainability is highly skewed towards transport (Robertson, 2007) and the situation is mirrored in the academic literature. However, according to the Stern Review (2006) only 14% of GHGs actually result from transport. So what about the other 86% that comes from areas such as industry, buildings and agriculture? A major part can be directly attributable to the food chain (Horrigan *et al*, 2002, Zhu *et al*, 2006, Risku-Norja & Maenpaa, 2007) with certain areas such as livestock production particularly problematic (Leitzmann, 2003, Pimentel & Pimentel, 2003, de Boer *et al*, 2006, Baroni *et al*, 2007).

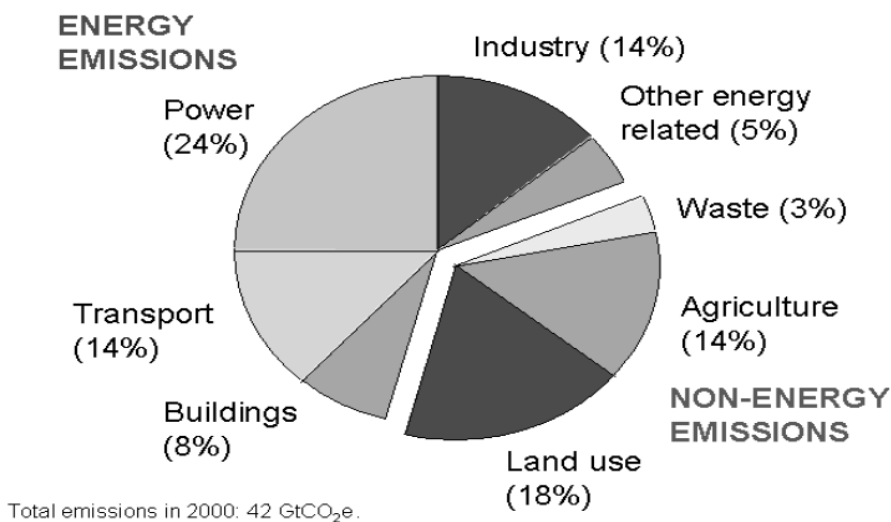


Figure 1. Global GHG Emissions Contribution (Source: Stern, 2006)

Research by the Food Climate Research Network (FCRN) shows that 8% of the total UK GHG emissions is attributable to meat and dairy consumption which is about 4 times more than the GHG emissions generated from fruit and vegetable consumption (Garnett, 2007). A similar study by Kramer *et al* (1999) shows that meat and dairy products contribute more than 50% of the total GHGs emitted from the food chain. However, at this point there is only a small body of academic literature addressing this point with only 51 references in our EBSCO search to Sustainable Livestock², i.e. less than 10% of the work done on sustainable transport. *"Over the next decade, the requirement is to ensure the costs generated by greenhouse gases across the economy are fully priced so that the polluter pays. That means greenhouse gases generated in producing food or in food miles need to be recognised in the same way as greenhouse gases generated in other industries"* (Miliband, 2007). Although the food miles issue has received much recent popular and academic debate, the larger food production area goes largely unaddressed (The Sunday Times, 2007, Knowles, 2007). Where there is a focus, it tends to be recent in nature and within deep but disparate and rarely inter-connected narrow pockets, for instance:

- By vested interest groups that arguably lack academic depth to their cases (Pye, 2002, Mohr, 2005, Animal Aid, 2007, grownupgreen, 2007, Imhoff, 2007, The Vegan Society, 2007, The Vegetarian Society, 2007)
- Academic dieticians or epidemiologists interested in diet and health issues (Horrigan *et al*, 2002, Pimentel & Pimentel, 2003, White, 2005, Allender *et al*, 2006, Baroni *et al*, 2007)
- Academic animal scientists (Ogina *et al*, 2004, O'Mara, 2004, Ominski & Wittenberg, 2004, Wright *et al*, 2004, Hegarty *et al*, 2007)
- Academic environmentalists (Leitzmann, 2003, Risku-Norja & Maenpaa, 2007, Shanahan & Carlsson-Kanyama, 2005)
- Academic agriculturists (Keyser *et al*, 2005, de Boer *et al*, 2006)

In addition to this there are two seminal reports on the area of sustainable agri-supply chains which pay particular attention to impacts of the primary livestock area (Steinfeld *et al*, 2006, Garnett, 2007). While such studies provide valuable building blocks for our research, their summary information requires further focused research to be able to provide specific input to policy makers and consumers. Moreover, this is a huge subject requiring further research covering the complete supply chain of farm input manufacturers (fertilisers, farm machinery etc), growers, primary and food secondary manufacturing, distribution and retailing (Hines & Samuel, 2007). As the implications are also at a policy level it concerns interest groups, industry bodies and government bodies. It is also likely to require academic input from a wide range of disciplines to review the technological, economic, industry structure, environmental, health, ethical, welfare and policy issues that are raised. Currently, the emphasis in UK policy circles is on areas that are laudable but arguably might have a lower impact on GHGs, such as Emissions Trading, Packaging, Food Industry and Household Waste than the broader issues we wish to address in this piece of research.

² Ibid

Research Framework and Methodology

The research began by creating a portfolio of all relevant academic and practitioner literature leading to a structured review which is on-going due to the field being in its infancy and new important work being published continuously. As expected, the literatures are in isolated silos. Also, an all-embracing stakeholder interview list was generated - a number have been interviewed so far with a larger number having been approached for interviews. The purpose of interviewing is to establish stakeholders views on the problem and their potential solutions and/or actions taken, e.g. the U.K. government, NGO's, academics and various parts of the food chain.

Discussion

The agri-food supply chain is shown schematically in figure 2. GHGs arise from activity in each of the main process blocks.

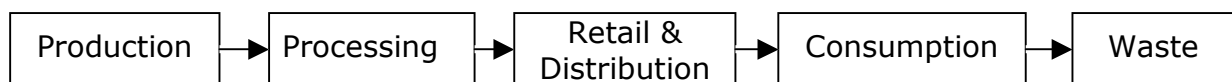


Figure 2. Agri-Food Supply Chain (Source: Authors)

Figure 3 shows where GHGs arise in detail in each livestock chain.

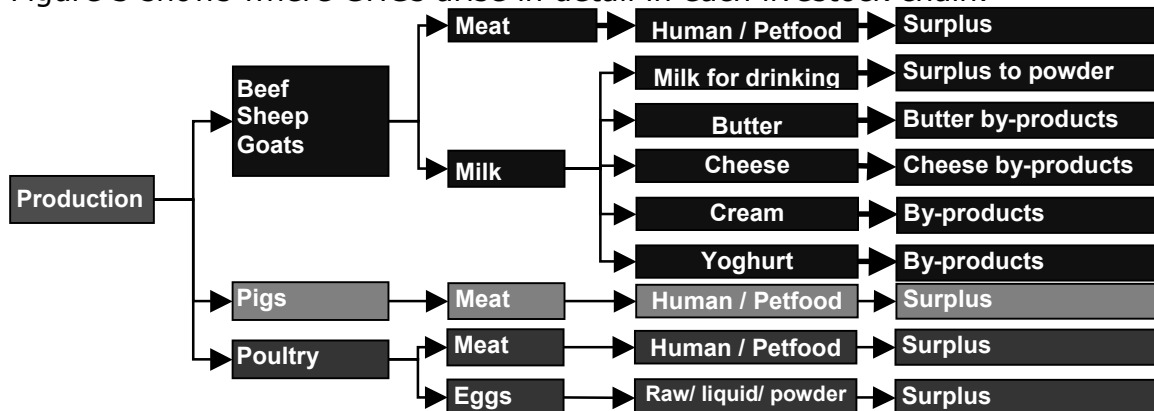


Figure 3. Meat and Dairy Supply Chain (Source: Authors)

What figures 2 and 3 imply is that GHGs are produced from 3 broad sources. First from efficient production of protein to sustain healthy and nutritious diet, secondly from wasteful overproduction such as surpluses and thirdly from consumer waste.

Figure 4 identifies where GHGs arise from inputs and outputs in the livestock and dairy supply chain.

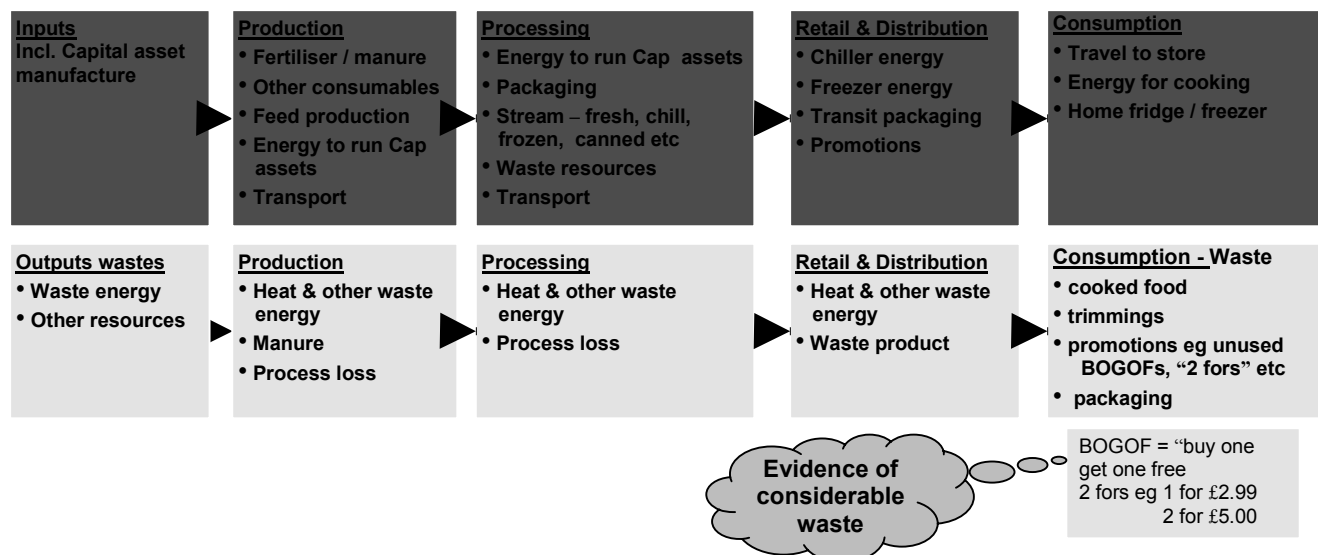


Figure 4. Meat and Dairy Supply Chain – Inputs & Outputs (Source: Authors)

Thus the critical need is for consumers to understand the GHGs associated with their consumption. Policy makers therefore need to provide consumers with the relevant knowledge to make behaviour change that is sustainable in a balanced way – measuring all social, economic and environmental outcomes. These potential contributions arise in three main streams namely

1. The GHGs intrinsic to the production of the “value-adding” portion consumed and which is that which provides the desirable health, dietary, nutritional outcomes whilst delivering other social and economic goals
2. To what extent 1. above could be achieved but with less environmental GHG impacts – for example through alternative plant-based protein diets used to reduce or replace meat-based protein
3. The GHGs associated with waste in the meat and dairy supply chain for example
 - a. Production and processing practices
 - b. Retail stream waste plus induced consumer waste from promotional purchases which are not ultimately consumed (eg “buy one get one free”)
 - c. Consumer waste

Figure 5 shows a methodology for the full research and analysis required to conduct a thorough examination of the agri-food supply chain and which is currently one of the major sources of GHGs.

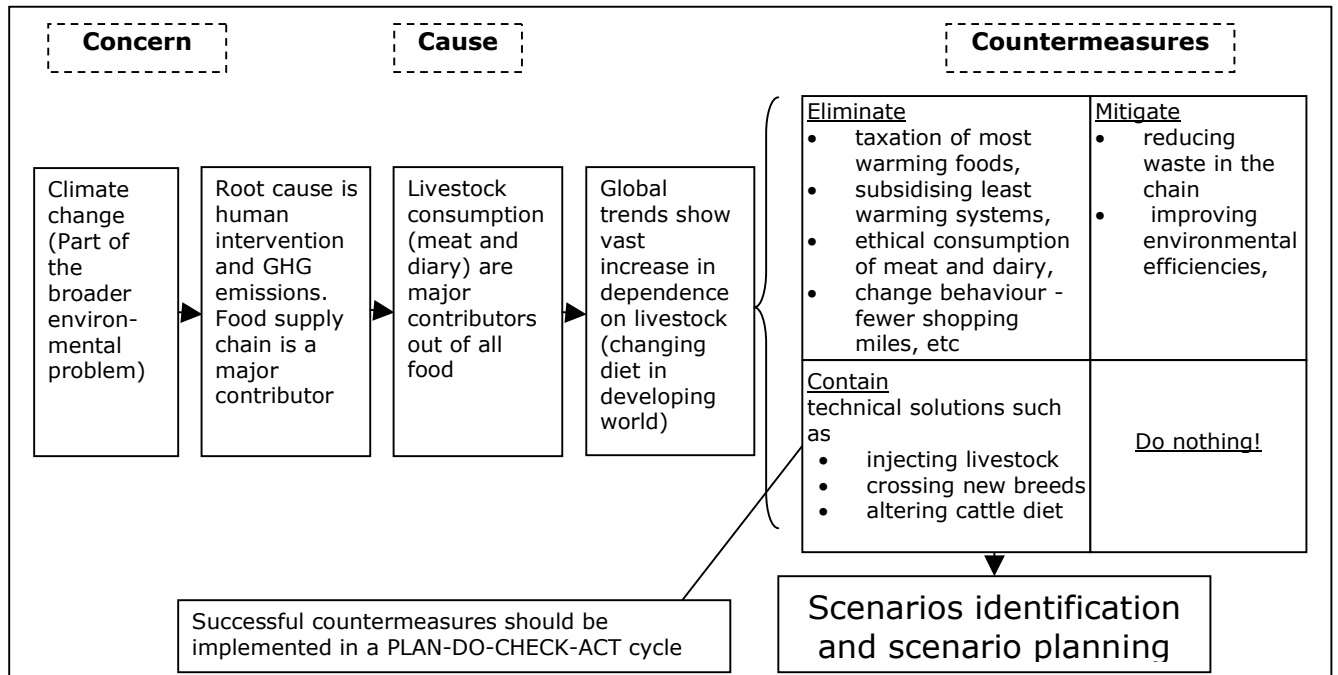


Figure 5. Research Framework (Source: Authors)

Figure 5 explains that countermeasures can be implemented at four different levels:

1. Eliminating part of GHG emissions generated by the food system by focusing high level fiscal and policy mechanisms on the most polluting foods. It has been suggested that the polluter should pay and that GHG emissions (CO₂ equivalent) should be treated as a secondary currency within the system. Simple mechanisms include taxation for the most warming foods and/or subsidising the least warming foods. Therefore, elimination largely depends on government intervention. Another solution is to influence the force field which shapes consumer behaviour in the food system such that behavioural changes in favour of more ethical consumption (reduced meat and dairy content, fewer shopping miles, etc.) is the result.
2. Mitigation is about reducing waste in the food chain and improving environmental efficiencies along the chain. Research by WRAP (2007) shows that equivalent to a third of the food bought in the UK ends up in the bin most of which could have been eaten. This is equal to £8 bn in retail value and contributes at least 15 mt CO₂ associated with food waste that could have been eaten. Reducing environmental waste and burden within food systems is a key strategy for mitigating against the existing global warming trends.
3. Containment: Various technical solutions could be devised to mitigate against GHG's emitted by livestock such as agri-science solutions (injection of livestock, crossing new breeds, altering cattle diet, etc.) and engineering solutions to reduce emissions at processing and logistical stages of the food chain.
4. Clearly the last possible scenario is to do nothing.

Conclusions and Further Research

Solutions to the problem GHG emissions from the food network are disparate and come from various disciplines. The only certainty is that certain parts of the system emit GHG's and that efforts to face the problem should be directed towards those areas, i.e. the upstream in the meat and dairy industries. The research team is currently interviewing various stakeholders to establish level of interest in the subject, scale of resistance against change, and effectiveness and availability of countermeasures. The team has particularly focused on ethical food consumption scenario development to inform policy makers. Several different types of food consumers were identified and then shadowed to understand their shopping and eating habits.

The next stage in this project is to gain a full understanding of each of the potential countermeasure streams - the "what" phase. This will then allow a "how much" phase namely a proper evaluation and prioritisation against reduction targets required, options versus other sources (non-food supply chain, transport, aviation etc). This in turn will enable an objective "delivery" phase in which consumers understand potential solutions and their role in achieving sustainable development.

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DISCIPLINE AND CREATIVITY IN LEAN PRODUCTION: CONTRADICTION IN TERMS?

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INTRODUCTION

One of the most important milestones in the extant literature on lean production (LP) is the book *The Machine that Changed the World* (Womack, Jones & Roos, 1990). It is said to have played a key role in the dissemination of the lean production concept throughout the world (Holweg, 2007). Although primarily focused on the technical aspects of the lean production system, the authors also devote some attention to the role of human beings in the system. In a section called "Is lean production humanly fulfilling?" they argue that LP systems should provide workers with the means and skills they need to control and improve their work environment while coping with the challenge of making the work go ever more smoothly, referred to as an atmosphere of "creative tension" in the workplace (Womack et al., 1990, p. 101-102). This requirement for the effective functioning of lean production appears to be in conflict with the primary aim of the lean philosophy, i.e. to remove all sources of slack from the system through rigorous discipline. Parker (2003) notes that research into the effects of LP practices on worker involvement and well-being has spawned inconsistent results and controversy among researchers. On the one hand this may be due to the fact that the lack of a standard definition implies that we do not know exactly what LP is in a theoretical sense. On the other hand the discussion also appears to have an ideological flavour, with advocates of lean production claiming positive results while opponents denounce LP as a regime of standardized work performed in short cycles giving the system a Taylorist image (Niepce & Molleman, 1998, p. 272). The central research question of this paper is how LP deals with the contradictory requirements of both discipline and the creativity needed for continuous improvement. The paper describes two practical cases exploring the contingencies in the design of LP systems that make discipline and the creative tension come about and work.

A FRAMEWORK FOR STUDYING THE EFFECTS OF LEAN PRODUCTION

In job design Hackman and Oldham's (1976) Job Characteristics Model (JCM) is a classic. The JCM holds that core dimensions of the job (skill variety, task identity, task significance, autonomy, and feedback) lead to critical psychological states (experienced meaningfulness of work, responsibility for the outcomes, and knowledge of the results) that account for personal and work outcomes (motivation, performance, satisfaction, and absenteeism and turnover). More recently, the JCM has been used to study the effects of lean production on human beings (de Treville & Antonakis, 2006; Parker, 2003). The fact that the JCM appears to be adopted as the central research framework will likely facilitate the study of the effects of lean production on workers in a consistent and systematic manner. This emerging consensus may enhance our insight into what LP *really* means in terms of employee and organizational outcomes. Figure 1, which is based on the JCM, presents the relationships between the basic practices of LP, and their consequences for job characteristics, workers' psychological states, and personal and organizational outcomes.

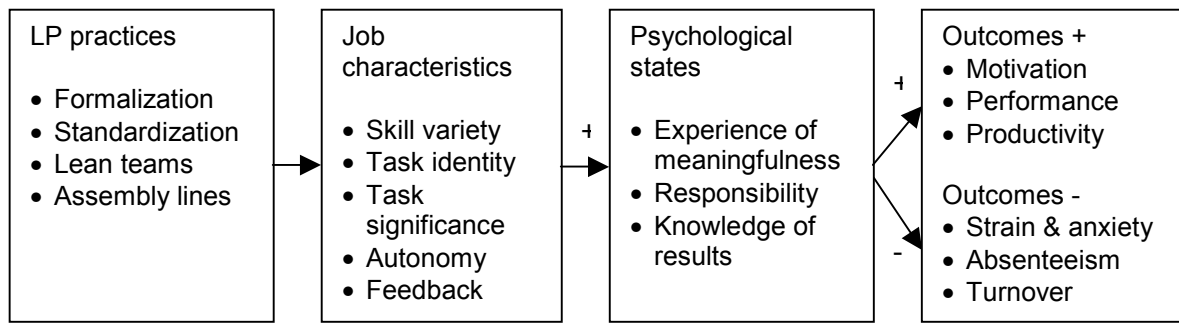


Figure 1. Relationships between Lean Production and personal and organizational outcomes (adapted from Hackman and Oldham, 1976)

JOB DESIGN IN A LEAN ENVIRONMENT

In the above mentioned, recently published articles (de Treville & Antonakis, 2006; Parker, 2003) a consensus in research design has emerged based on the JCM. This consensus facilitates the study of the effects of lean production on human outcomes in a consistent and systematic manner. The central hypothesis is that lean production practices, such as workflow formalization, standardization, team interdependencies, and assembly lines, are strong determinants of the characteristics of the job and through these on workers' psychological states and on individual and organizational outcomes. Thus, the effects of lean production can be operationalized and measured as shown in Figure 1.

Generally speaking, LP processes tend to have a fixed layout and positioning of equipment that organizes where what activities have to be performed. Every product follows a predetermined route through the system, and work is divided among the workstations to ensure a leveled workload. When a product arrives at the workstation, the worker is expected to check whether everything is all right. In case the product is deficient, he has to solve the problem before he starts doing his job/task on the product. If needed, a worker can stop the assembly line to solve the problem on the product. In addition, all problems are reported and analyzed. From these analyses it becomes clear which problems occur most and have the greatest impact on the flow interruptions. Management will assign the most frequent and disturbing problems to so-called kaizen groups, in which workers participate who are familiar with the problem because they work at the workstations involved. Solutions will normally be small improvements, rather than dramatic changes.

Key to such cooperative behavior is the worker's psychological state, which is directly affected by the job characteristics resulting from lean production practices. Three of the job characteristics, i.e. skill variety, task identity and task significance are positively related to experienced meaningfulness, autonomy is positively related to experienced responsibility and feedback is positively related to knowledge of results. The psychological states will affect the level of the outcomes at the individual and the organizational level. They are supposed to be positively related to the positive outcomes, such as motivation and performance, and negatively related to negative outcomes like anxiety and turnover.

De Treville and Antonakis (2006) raise the question: "could lean production job design be intrinsically motivating?" To answer this question, they modify the original JCM in that they skip task significance, add work facilitation, make a distinction between choice autonomy and responsible autonomy, and add a fourth psychological state: self-efficacy. Furthermore, they introduce a variable moderating the relationship between the job characteristics and the psychological states: degree of leanness. The authors distinguish three levels of leanness (just right, somewhat right, and too lean), each representing a specific configuration of job characteristics. In the 'too lean' configuration task identity and feedback are high, yet skill variety, both forms of autonomy, and work facilitation are low. However, the authors do not make clear what is meant exactly by 'too lean' and why the scores on these characteristics are the way they are? They speak of increasing leanness (p.108) and excessive leanness (p. 109) because in 'too lean' the work speed is increased all the time. This increase in speed results in a decrease of task variety if a critical threshold is passed because then worker participation, training and job rotation will be abandoned. The same reasoning is applied for the other characteristics with low scores.

This reasoning is problematic for various reasons. First, semantically speaking if too lean means too fast, than lean would mean fast. However, despite short cycle times the emphasis in lean is on smart, rather than on speed per se, and cycle time reductions result from moving along the learning curve based on continuous improvement. Second, increasing speed and neglecting improvement may be expected to create an imbalance between the need for discipline and the need for creativity. Workers would have to concentrate solely on the highly disciplined tasks and would no longer be able to spend time on the creative part of the job. The consequences of this imbalance would come quickly to the fore. For instance, if they are indifferent to the quality of inputs, they may create the need for re-work later on. Although such emphasis on the discipline-oriented aspects of lean production might be financially advantageous in the short run, it will have negative consequences in the long run. If the results of the operations become unpredictable, JIT practices can no longer be applied. Clients should receive products that meet quality standards, not products that need after-sales service re-work. Thus, in this article we suggest a more balanced approach to understanding the contingencies that account for reconciling both the discipline of a lean production system and the workers' motivation to make creative contributions to continuous improvement. We do so by carefully studying the effects of lean production practices in two Dutch manufacturing environments

METHODOLOGY

The cases are described as Case 1 and Case 2 and are theory driven, following the JCM model described above. For each case a team of researchers (company executive, master student and his university supervisor) collected the data. Data were acquired through personal observations and communication with workers, interviews with supervisors, and participation in kaizen events, and were analyzed by the researchers/authors and interpreted in the model. The master students gave feedback on their interpretations. Finally, conclusions were drawn.

CASE 1: DUTCH COMPANY MANUFACTURING SAFETY FOOTWEAR

Company background

The company is one of the leading brand-names in the footwear industry in The Netherlands and used to provide thousands of jobs at their production facilities. During the past decades the major part of the production was re-located to low wage countries, yet a small part of it was retained in the Netherlands. Now it concentrates on the safety footwear market segment. The production process of the shoes is centered around a robotized machine consisting of two devices that do most of the work automatically, but preparing the shoes before they are processed by the machine and finishing the shoes after they have left the machine is still relatively labor intensive work that needs to be done manually. The production process is organized in two shifts, the packaging of the finished shoes in one shift. Furthermore, the machine facilitates the production of any type of shoes in batch sizes as small as one, because upon entering the production process each shoe is equipped with a microchip and can be identified and processed according to the standard operating procedures applicable for that particular type of shoe. The workers' positions are divided in two categories: fixed positions and positions suitable for job rotation. The distinction was made because the fixed positions are staffed by employees with minor mental as well as physical deficiencies, who are deemed less fit for job rotation. Although the production process works relatively well, the production manager wanted an evaluation from a lean perspective.

Present situation

Problems occur in the production process at the stage where the shoes have left the machine. In a number of operations the shoes are finalized, i.e. redundant material is removed and they are polished. Paradoxically, the strength that large batch sizes are no longer required due to the level of sophistication of the machine, turns into a liability as the finished shoes are stored more or less in random order, waiting to get transported to the packaging area, and to be sorted and packed by the packagers who also have to equip the shoes with appropriate shoelaces. Especially the sorting process is very cumbersome and inefficient, due to the random storage. Moreover, the fact that flow is obstructed immediately after the shoes have left the production area offers employees who engage in job rotation an opportunity to not live up to their responsibilities. They can simply set the problematic cases aside leaving them for others to deal with. Thus, job rotation was not favored by many employees, because after changing to another workstation they often had to deal with the defects neglected by others. This frequently caused irritation and annoyance and a decrease in team spirit, individual job satisfaction and probably also in productivity, although this was never really measured. In addition, as responsibilities were suboptimally allocated, monitoring the system was rather problematic and feedback about the results was inadequate.

New situation

Basically, what happened in the new situation was that continuous flow was established all along the production line, including the packaging operations. That is, sorting and packaging were fully integrated in the production process. As an immediate consequence, interdependencies between the employees became stronger and more visible, which considerably reduced the possibilities for not

living up to responsibilities. Its consequences became visible right away to the next operator on the assembly line. This not only applied to intra-team cooperation and relationships, but also to relationships between teams. These changes were supported by replenishment of the workstations through the use of a Kanban pull system. The benefits for the packaging process were especially noteworthy, because the sorting problems were now virtually eliminated. In addition, as the physical distance between workstations upstream in the production process was reduced, communication between the workers increased, better monitoring was facilitated and, accordingly, more adequate feedback could be provided. Interestingly, we actually witnessed stronger social relationships as a result of the changes. Whereas in the past workers would get easily aggravated due to the defects caused by others, the reduced physical distance and increased interdependencies now induced them to adopt a more upbeat attitude toward each other and make jokes to "warn" against defective products not appropriately processed. Thus, the tight couplings now implemented in the production process and resulting in more pronounced team interdependencies caused an increased awareness of individual responsibilities. Shirking one's responsibility was no longer possible, and more satisfaction with job rotation, workers' perceptions of increased justice because workloads were now more evenly distributed, better team spirit and increased job satisfaction occurred. Workers started to contribute actively by suggesting further improvements to the system, something which was almost completely absent in the previous situation.

CASE 2: DUTCH COMPANY MANUFACTURING CAR CARPETS

Company background

The second company is a manufacturer of car carpets and truck interiors. It designs, develops and produces car carpets exclusively for the automotive industry. For this company the planning horizon is about three weeks at the most. The company has three large customers for which it can supply no less than 12.000 different types of car carpets. Price competition is fierce in this market, and buyers are in the position to enforce a fixed price reduction for the coming years. The product itself is rather simple and the production is a relatively straightforward and labour intensive process. Because of fierce price competition and the labour intensity of the production process, similar to the production of shoes, production of car-carpets is often moved to low-wage countries. However, so far management could retain the production site in the Netherlands. To reduce labour costs the company makes use of a flexible workforce and hires disabled workers. Because of a strong growth in production, the production of truck interiors was moved to another location. This presented the manufacturer with the opportunity to redesign the production process of the car carpets. Management wanted to improve the production process using lean production principles and practices.

Present situation

All products are made on the same production line. Although the organisation has only a few hierarchical layers it is a highly centralised operation. Workers on the shopfloor have one particular task to perform and are only responsible for their own work. They have no influence on the planning of their work. Furthermore, they do not have an overview and the ability to look beyond their

own workstation. In some cases this has led to low motivation in for instance the warehouse. For the smoothing of the production, instead of using cross-functionality, meetings take place between department leaders. However these meetings tend to cause a continuous struggle rather than a smoothing of production. Consequently, this has often led to sub-optimisation. The problems were manifold: unmet delivery dates and performance criteria, high level of work-in-progress, high level of rework, quite some non-value adding transportations, frequent overwork and a lack of stock control. Already for some time forms are used to report the problems but actions to solve the problems were not taken.

New situation

The company strives to level the workload but the demand fluctuations make it very difficult to achieve this. In order to increase the overview on the shop floor a cell lay-out will be introduced. Consequently, flows per client are implemented. On a smaller scale the company already experimented with this lay-out and employees appreciated the increased visibility of the process. The responsibility for the cell will be transferred to one employee per cell, making the cell somewhat autonomous. Internally, the cells act to some extent as self directing teams. Composing fully self directing teams is impossible because of the disabled workers taking part in the production. Multi-functionality of workers is increased but is limited to the full-time employed staff. Disabled workers cannot be multi-functional and to make temporary workers multifunctional is too expensive. The cell coordinator informs department leader about disturbances, who will take immediate action to remove their causes. Improvement action teams, consisting of department leaders and workers have been formed. These teams prepare proposals to improve the feed-back with regard to the production and the planning of the production process. Not only did it result in actually implementing improvements based on worker suggestion, but it also improved the speed at which workers identified flaws in the production process.

RESULTS

The results from the case studies have been summarized in Table 1. Structure is increased in both cases because the lay out becomes more clear through providing an ongoing flow of products which reduces responsible autonomy.

Firm > State, characteristics	Shoe producer	Car carpet producer
Meaningfulness		
*Skill variety	Job rotation, workers perceive it as positive	Job rotation will be introduced
*Task identity	Tasks and responsibilities are more visible	Task and responsibilities become more clear; client more visible
*Work facilitation	Lay out is more clear	Lay out is more clear; 'self supporting' cells
Autonomy		
*Choice autonomy	Reduced because of fixed sequence	--

*Responsible autonomy	Increased because of intra-team cooperation and increased interdependencies	Team has some supervisory tasks and is consulted before decisions are taken
Feedback	Improved both formally because of visibility; informally as workers inform each other	Becomes visible, real time

Table 1. Summary of the results from the case studies

However at the car carpet producer this is mitigated as some supervisory tasks were delegated to the team. Job rotation increases the skill variety whereas task identity increases in both cases as well. Tasks and responsibilities become clearer. In case of the car carpets the client visibility improves the identity even more. The improved clarity of the lay out enhances the work facilitation. The improvements with respect to these job characteristics have a positive effect on the meaningfulness of the jobs. The responsible autonomy increases in both cases. However, the choice autonomy decreases at the shoe producer. Nevertheless this improves the climate as in the past this form of autonomy was abused by workers which affected cooperation among the workers negatively. In sum, autonomy would increase. Feedback increases in both firms as well.

CONCLUSIONS, LIMITATIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

From these practical applications of lean thinking some interesting lessons can be learned, pertaining to the seeming contradiction between the need for discipline and the need for creative input from the workers to continuously improve the system. As it turned out in the safety shoes manufacturing process, changing the lay-out of the production system, whereby choice autonomy was in effect substituted by responsible autonomy (de Treville & Antonakis, 2006), resulted in improved employee outcomes, stronger team interdependencies, and better opportunities for continuous improvement. In short, we conclude that in this case a reduction of choice autonomy, which can be the immediate consequence of lean thinking applications in production systems, was shown not to be irreconcilable with continued creative input from employees to further enhance the quality of the system. In the car carpet production the change in layout and the implementation of production cells had consequences both for discipline and creative input. Because of the increased visibility of the process and the customer the task identity increases, while monitoring and control become easier. Employees contribute to improvements in the improvement teams and get responsible autonomy in the self directed teams in the production cells.

Wrapping it all up we argue that both cases suggest that discipline and creativity can indeed be combined in lean job design. The expected positive effects on outcome variables occurred indeed. Consequently, the question raised by de Treville and Antonakis (2006) can be answered in the affirmative, both conceptually and empirically. However, we studied only two cases and in these cases not all workers could fully benefit from the 'improvements'. Job rotation is not applied for the disabled neither at the shoe producer nor at the car carpet producer; because management assumed that they were not suited for it. This requires further research. Apparently, challenging job characteristics are not

positive in all circumstances. Hackman and Oldham (1976) use a moderating variable in their model: growth need strength. If growth need is higher, challenging job characteristics cause high outcomes. Much literature supports this claim. However, another question is whether the opposite situation, i.e. low growth need and low job characteristics, also causes high outcomes and whether an imbalance between the two causes low outcomes. Both managers and employees could benefit from the results of such research.

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ENERGISING AGILITY THROUGH TOOLS AND TECHNIQUES

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ABSTRACT

The extant meanings of "lean" and "agile" are explored through secondary research. The four material flow principles and uncertainty circle diagram are employed to analyse essential features of agile supply chains along with a brief discussion of industrial practice. Mastery of "lean" practices seems to be a precursor to "agility", but further research into the electronics industry is recommended as a means to expand the agile practice toolkit.

INTRODUCTION

The concept of agile systems was first developed in the early 1990s by Nagel and Dove (1991) and Kidd (1994) in response to increased volatility and uncertainty in the general business environment. Over the last 15 years, however, it appears that the diffusion of 'lean' has considerably outpaced 'agility' as a guiding principle of business improvement. The widespread adoption of 'lean' is, in some respects, due to the availability of well established analytical and diagnostic tools, originating from Ohno (1987) and appearing most recently in George et al's (2002) "Lean Six Sigma". Some of the procedures appearing in the various toolkits have an extremely long history, and can be traced back to Gilbreth and Gilbreth (1917). The development and implementation of industrial practices has also been an important facilitator of 'lean'. Womack and Jones (1996) list key techniques which include: pull-based material control, level production scheduling, takt time, set-up time reduction, mixed model scheduling and total productive maintenance. The establishment and dissemination of analytical tools and industrial practices has assisted the diffusion of 'lean', but what is the equivalent set for 'agile'? The purpose of the paper is to discover an equivalent set of tools and techniques for agile systems.

PRINCIPLES OF SMOOTH MATERIAL FLOW

Agility involves responding to volatility, but this is potentially expensive; as it involves buffering operations with either inventory or spare capacity. In this sense "smooth" is necessarily interpreted according to purpose i.e. material flow rates without any fluctuations beyond those emanating from the end customers. Towill (1997) has outlined four principles for enabling smooth material flow based on a review of existing theory and practice. Prominent contributors were Forrester (1961) and Burbidge, (1984), the former researching system dynamics from a conceptual viewpoint, the latter, whilst appreciating the virtues of such an exotic approach, was concerned with pragmatic implementation of solutions which would actually work in practice. Note that both sources regard synchronisation of activities as essential (Burbidge explicitly and Forrester implicitly). These four principles have now stood the test of time (Towill and Childerhouse, 2006) when assessing system effectiveness. This applies to both US style statistical evidence and European style case studies (McCullen and Towill, 2001).

All four established principles of:

- Time compression;
- Echelon elimination;
- Information transparency;
- Simple robust decision support systems (DSS);

apply equally well to individual processes as to complete supply chains. However, in the latter context there is much more opportunity to exploit them via such approaches as re-engineering, outsourcing, information systems (IS), and taking a holistic view. There is also a necessity to design and manage interfaces between echelons, as well as to understand the causes of 'game playing' and to align individual behaviours to contribute to the success of the extended enterprise (Lee, 2004).

FROM 'TRADITIONAL' TO 'MODERN' INDUSTRIAL ENGINEERING

Our stated goal is "effective engineering of the value stream for achieving purpose". Is this any different from the rigorous application of industrial engineering (IE) techniques dating back to the Gilbreths? In other words are Business Process Re-engineering, Lean Thinking, etc, etc, just variations on a theme? Yes (and no) is the answer. There is a historical common core, but modern organisation, IS, process technology, and systems integration allow a much more heliospheric perspective to engineer the integrated whole rather than just the individual tasks. This may be summarised as a three dimensional expansion (Towill, 2007) as follows:

- ***Width*** - which and how many flows (material, information, cash, and capacity) are to be considered?
- ***Length*** - how many discrete processes are coupled together and seamlessly controlled?
- ***Depth*** - provision of appropriate infrastructure encompassing skill requirements, technical, educational, and training support.

It is thereby possible to relate the method study main of many decades back concentrating on the individual employee performing a single task right through to the current many-faceted supply chain engineering currently in vogue. Such a situation is, of course, exacerbated by the rate of change of both processes and opportunities. This is much different from the relatively static method study scenario. The whole complex transition may be regarded as the transformation of "traditional" i.e. individualistic IE to "modern" (i.e. holistic) IE.

THE LEAN AND AGILE PARADIGMS

We strongly support the Parnaby (1995) contention that if the business is well engineered in accordance with system concepts that it is very likely to be effective for purpose. However, in seeking this goal then strategic considerations necessitate a review of lean processes and agile processes. For later consistency we shall use the definitions due to Narasimham et al. (2006), as shown in Table 1.

Paradigm	Definition
Lean	Production is <i>lean</i> if it is accomplished with minimal

	waste due to unneeded operations, inefficient operations, or <i>excessive</i> buffering in operations.
Agile	Production is <i>agile</i> if it efficiently changes operating states in response to uncertain and changing demands placed upon it.

Table 1
Definitions Used in Horizontal Survey of Low-Lean-Agile Industrial Performers
 (Source: As interpreted by Narasimhan et al. 2006)

Since the publication of the "Machine that Changed the World" (Womack et al, 1990) there has been much effort devoted to lean production, although the "lean process" was known to exist in World War II aircraft manufacture (Burbidge, 1995). What is of particular interest herein is the horizontal survey undertaken by Narasimham et al, (2006) on a sample of 281 US manufacturing plants. The authors employed statistical analysis to separate these into three groups of "traditional", "lean", and "agile" enterprises according to strict criteria laid down by Narasimham et al, (2006). Furthermore these groups could then be compared in detail via seven performance metrics. "Lean and "agile" plants were then compared against each other and with the "traditional" plants. There are two critical factors to understand when evaluating the results shown in Table 2. The first is their *significance* (or otherwise), and whether such *differences* are small or large. "Traditional" organisations come out badly along each performance metric. It is the comparison between "lean" and "agile" which is information rich.

Measurement Item	Attributes considered within the metric	"Winner" in 281 plant survey	Conclusions on current sample
Cost	Unit Cost Manufacturing Overhead Cost	"Lean" plants ahead of "traditional" and "agile" plants (small differences)	Lean plants perform best on "cost".
Design Quality	Product Overall Quality Product Reliability Product Features	"Agile" plants ahead of "lean" plants (small differences)	
Conformance Quality	Product Conformance Product Desirability		

Delivery Reliability	Accuracy (correct items delivered) Dependability (delivered on agreed date) Quality (condition of product after shipment)	“Agile” plants ahead of “lean” plants (large differences)	Unexpected results requiring further scrutiny
Delivery Speed	Availability (probability that items will be in stock) Responsiveness (short elapsed time)		Regard as fundamental aspects of “agility” to be engineered into process(es)
Volume Flexibility	Adjustment to Production Volumes Response to Changes in Delivery Requirements Ability to Customise Products Ability to Produce Range of Products		
Product Flexibility	Lead Time to Introduce New Products Number of New Products Introduced Each Year		

Table 2

Horizontal Survey Measurements to Compare Traditional, Lean, and Agile

(Source: Authors, following horizontal research investigation by Narasimhan et al. 2006)

APPARENT SUPERIORITY OF AGILE COMPANIES

Deeper inspection of Table 2 suggests the following conclusions from a business engineering standpoint:

- Cost/Design Quality/Conformance Quality – although differences between the “lean” and “agile” group are statistically significant they are small in magnitude, therefore both “lean” and “agile” show big improvements over “traditional” plants.
- Delivery Speed/Volume Flexibility/Product Flexibility – “agile” is both significantly different and markedly better than “lean”, and these are therefore the dominant characteristics of “agile”.
- Delivery Reliability – “agile” is both significantly different and markedly better than “lean”, a worryingly counter-intuitive result.

Overall we may safely say that enabling delivery speed, volume flexibility, and product flexibility are major goals in agile system design. These metrics thus indicate distinctive diagnosis and problem solving techniques needed in business design for such an environment. Why is “lean” bad at delivery reliability? Only a detailed case-by-case study can answer this question with any certainty.

However, as Matson and Matson, (2007) have discovered, in the US auto industry, applying JIT does not necessarily mean a successful outcome.

Norseman et al. also investigated the industrial practices and equipment and IS investments of the plants in the survey over 21 dimensions. The differences between the three groups for Advanced MRP/ERP and Supplier Certification were found to be small and not significant. "Agile" plants tended to dominate "traditional" and "lean" plants, leading the authors to conclude that "lean manufacturing and agile manufacturing share a common subset of manufacturing practices [and]... that lean manufacturing is a possible precursory position which is antecedent to agile manufacturing". This finding does not help us in the search for a set of distinctly "agile" industrial practices, and more survey work encompassing a wider range of practices would perhaps be useful here.

MARKET QUALIFIERS AND ORDER WINNERS

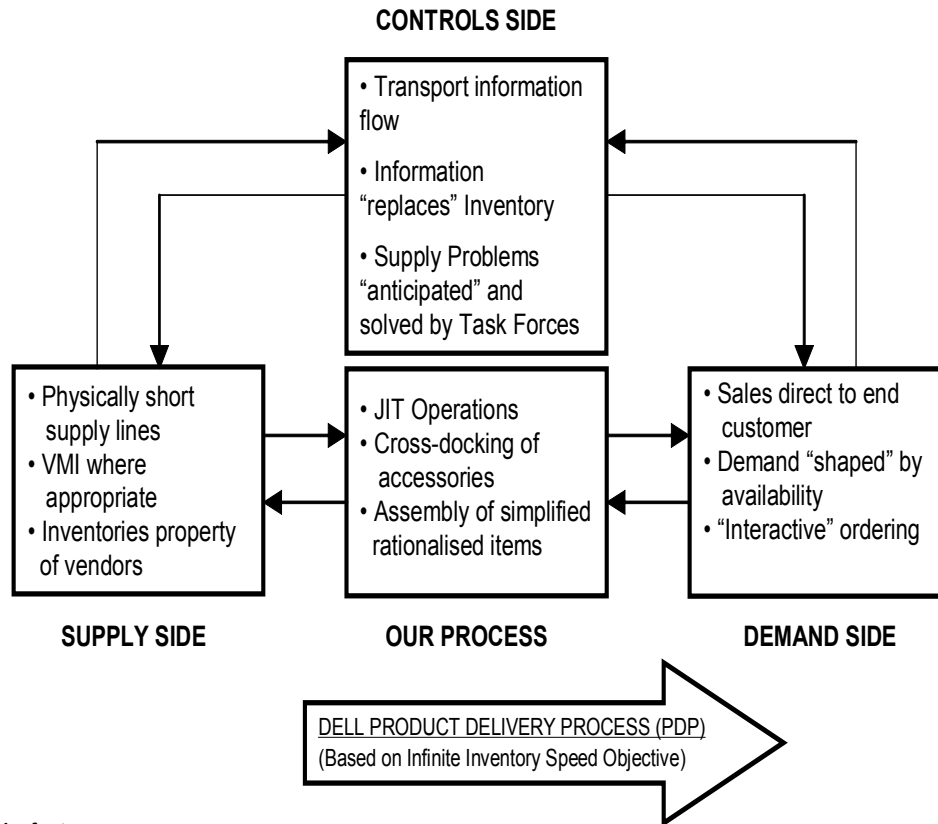
Businessmen may argue that there are many simultaneous requirements imposed by demanding customers which must be met before a sales transaction is successfully concluded. However, in practice there are just a few characteristics which ultimately influence the deal. The terminology varies a little depending on source, but there is general agreement that they group into a set of Market Qualifiers (MQs) which short-list the product (Hill, 1993; Naylor et al, 1999). Of these, one emerges as extreme importance to clinch the deal. This feature is termed the Order Winner (OW). A commonly used set (which may then fan out into constituents such as those identified by Johanson et al, (1993);

- Cost
- Availability
- Lead Time
- Quality
- Stock-turns

Furthermore the OW is not fixed, but varies with phase of the product life cycle (Aitken et al, 2005) and consequently affects the engineering and re-engineering of the value stream (Christopher and Towill, 2000). The MQ/OW concept is a key constituent in engineering supply chains based on product type and market scenario. This in turn requires the optimum combination of lean processes and agile processes which can be structured to advantage in a number of standard ways. (Towill and Christopher, 2007). At the interfaces between these processes will be located material flow decoupling points to buffer lean production against fluctuating demands elsewhere in the system. Hence stock and excess capacity provisions are built by design but only into the agile process.

THE DELL ROIC DIRECT MODEL

Dell is arguably the best known example of a supply chain which carefully integrates both lean and agile processes to make personalised products available (OW) with highly acceptable cost (MQ). The majority of supplies operate in a lean fashion (but need a short cycle time on many items) with adequate stock at the interfaces between them and the final assembler. Such systems can be simply summarised in the block diagram format of Fig 1 (Childerhouse and Towill, 2004). Thus from the Dell perspective there is "our (agile) process", the "supply side", "demand side", and overarching "control side" responsible for stock and production targets.



NB: Action's listed refer to Del ROIC as described in Holzner (2006)

Figure 1
The Dell ROIC Driven Direct Model Expressed in Uncertainty Circle Sectorial Terms
 (Source: Authors based on the model by Childerhouse and Towill, 2004)

Now careful scrutiny of the published literature exemplifying the Dell Infinite Inventory Speed Objective (Holzner, 2006; Dell and Fredman, 1999) allows us to illustrate the degree of supply chain engineering required to achieve this goal. Note that the applicability of the four material flow rules discussed earlier is self-evident in at least the following actions shown in Table 3 below.

Material Flow Principle	⇒	Industrial Practice
Simple Robust DSS	⇒	Use of VMI plus “shopping” demand
Information Transparency	⇒	Rapid information flow throughout
Echelon Elimination	⇒	Direct sales to end customer
Time Compression	⇒	JIT deliveries via short supply routes

Table 3. Dell model mapped against the four material flow principles

The possibility (probably limited) of shaping of demand is explored by the sales consultant subtly directing the end customer towards readily available product configurations. This "demand management" approach can reduce some of the volatility even in an agile process. Evidence that such practices exist is given by Papadakis (2003) with specific reference to the PC industry. This approach can also be exploited in masking the deleterious effect of non-delivery of critical components and sub-assemblies by "advising" the purchaser that the product which actually can be delivered is what they really do require (and not the model currently advertised and which was the subject of the enquiry).

CONCLUDING ON ENGINEERING AGILITY

The cost performance of an agile system depends, amongst other things, on the size of the decoupling buffers, themselves a function of volatility. It follows that systems should be designed to minimise bullwhip so that buffers can be sized to handle merely end-customer volatility (see McCullen and Towill, 2001), and it is here that the four material flow principles provide an important diagnostic tool.

The evidence presented here on agile industrial practices is limited. However, recent developments in personal computing supply chains (McCluney, 2007) provide some clues. Here, demand-driven supply networks are facilitated by multi-enterprise IS integration enabling visibility to all forecasts, inventories and real consumption data. Vendor Managed Inventory and Replenishment are operated within clear agreements regarding the acceptable demand variation, e.g. +200% variation will require a different level of buffering to +20% variation, and this must be handled 'up front' along with clear understandings on 'product freshness', inventory liability exposure and 'what happens in a downturn?'. The short product lifecycles and potential obsolete inventory exposure make the electronics industry a fertile ground for researching agile industry practice.

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GLOBAL MEDICAL DEVICE SUPPLY CHAINS: THE ROLE OF PRODUCT DELETION IN PRODUCT LIFECYCLE MANAGEMENT

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ABSTRACT

An ever-increasing product portfolio is an all too regular feature of global supply chains as various mergers and acquisitions have often left a burgeoning product range legacy in their wake. Product rationalisation is a multi-dimensional process that requires input from all functions within a company. Using a case company¹ we have adopted a multi-dimensional approach to design a product portfolio classification system to identify weak brands. A financial analysis of the brands has been done using sales volume growth, percentage share of total sales and contribution margin. Once brands are identified for deletion two scenarios are simulated and compared – 'Do Nothing' (i.e. let the brand die naturally) or 'Swap-Out' (i.e. replace the brand within a defined period). Key market variables influencing the decision were: customer retention rate, percentage of customers recovered and growth rate in customers. The main cost variables were lower production cost for replacement product based on incremental sales due to withdrawal of legacy product and lower inventory costs.

Key Words: Product lifecycle management, legacy products, medical device industry.

Introduction

Product deletion is an area that has received little attention in the literature. Increasing numbers of SKUs (Stock Keeping Units) has largely been addressed through increasing the capacity to offer variety rather than to question the need for, and indeed the return from, an increasing product range. Of course in Fast-Moving-Consumer-Goods (FMCGs) markets *leagile* approaches have increased the capacity to respond to increasing 'individual' customer demand. Notwithstanding the lessons from such an approach and the scope for adaptation of *leagile* across many industries, our experience in the medical device industry (orthopaedic implants) has prompted us to look to product lifecycle management and in particular retiring products. Our research aims to develop a business tool to assist in product range rationalisation in business-to-business markets. This paper is structured as follows: the next section briefly outlines key contributions from the literature and the methodology adopted, the following section sets out the industry and case company context, this is followed by an analysis of the case company product portfolio and on this basis a classification scheme is proposed. A decision-making framework for product rationalisation is developed and tested on one product category. The final section discusses strategic implications of the findings.

¹ For reasons of confidentiality we have not reported specific financial data, however all relevant factors and parameters are identified.

Literature and research design

As indicated above this area has been rather neglected in the literature (Harness, et al., 1998; Avlonitis, et al. 2000). The main work done has been in FMCGs, mainly food and personal care products (Quelch and Kenny, 1994; Byrne, 2007). While there has been some interest from a marketing perspective for example in consumer products and brand assortment management (Morales et al., 2005; Chong, et al. 2001) ², less attention has been given to business-to-business markets. George J. Avlonitis has made a substantial contribution to this area. His work in the early 1980s focused on the product deletion decision and strategies. A more recent contribution (Avlonitis, et al. 2000) draws on this work and develops a useful typology of product deletion. They propose a classification scheme based on situational and product specific variables and this has informed our approach.

We adopt a case study methodology to investigate the variables that impact on the product deletion decision. The case company is one of the top three global Orthopaedic Implant companies. Analysis was conducted across six key regional markets using financial data, archived documents, and interview data. In total 36 interviews were conducted with managers across the nine company departments affected by product deletion. A semi-structured interview schedule was used that explored the following areas: product portfolio, markets served, processes used (these depended on the function e.g. forecasting, pricing, cost category methodologies), product rationalisation issues, financial issues, and changes underway. An inductive approach is adopted and similar to Alvonitis and James (1982) and Avlonitis (1982, 1986) this research focused on problem evoking situations that provide the factors and dimensions that in turn informed the design of both of the classification and decision-making frameworks (Harness et al., 1998).

Industry and case company context

Orthopaedic implant product portfolios are complex as they contain an extensive number of legacy products. Each implant requires an instrumentation set³ and this adds further complexity to global supply chain management. This also leads to a lack of goal congruence between marketing & sales and operations. The latter want to lower costs by reducing the number of products in the portfolio and the former mainly focus on gaining incremental business and are less concerned with the need to withdraw end of lifecycle products.

The global market is disproportionately geared towards the Americas; this is due to growth rates and market potential. There are three major global companies that compete across all markets, but each country has their own share of small national players.

European markets are becoming increasingly constrained by financial pressures and there is clear evidence of price reduction. The strains that Europe faces

² For example the *Journal of Retailing* devoted *Volume 75, Issue 3, Autumn 1999* to an "Introduction to the special issue: assortment planning".

³ These are tools that the surgeon uses when performing implant surgery.

from budgetary controls and regulations can be seen in the low revenue growth rates, despite the increased numbers of procedures. Table 1 provides a breakdown of the global orthopaedics implant market. Overall there is a need to remove legacy products that create a cost burden and free up resources for newer technologically advanced products.

Region	Estimated (\$billion) in 2005	Percent of Market (%)	Growth Rate (%)	Constant Currency Growth Rate (%)
United States	16.0	63	15	15
Europe	6.1	24	7	7
Japan	1.6	6	4	5
Pacific	1.0	4	10	7
Canada/Latin America	0.9	3	19	11
Total Market	25.6	100	13	13

Table 1: Breakdown of the Worldwide Orthopaedics Market

Source: Stryker Fact Book 2005-2006

Due to the downward pressure on price, only those who manage to improve their operational efficiencies will survive. Close monitoring and proper management of inventory of both implants and instrumentation sets may improve performance without incurring any extra costs. Sales must be aligned to the overall objectives of the company, therefore a focus on key brands and improved inventory stock turnover should be reflected in their incentive scheme.

Findings

Consolidation at Product Category level: The case study company was found to enjoy good growth rates buoyed by acquisitions and mergers over recent decades. While the company enjoys a dominant position in the marketplace it finds itself in a consolidating industry where growth by acquisition has slowed and competition has increasingly focused on price. This has led to an increased emphasis on product portfolio management that includes many legacy products.

For the purpose of case company analysis we focus on one product category - hip implants. The company currently holds 61 hip implant brands. This creates not only product and technological complexity, but also impacts in terms of the sales, marketing and distribution effort to support such a high number of SKUs and stock. Each brand consists of a family of implants, for example this product range (hip implants) has in the region of 20,000 SKUs. According to the key informants and documentary evidence this translates into a poor forecasting MAPE (mean average percentage error) of approximately 28% for implants and 40% for instrumentation and this in turn leads to escalating inventory and subsequently product write-off costs. In addition higher costs are also evident at production level. The key informants indicated that the production of high volume products was, from time to time, sacrificed to accommodate low volume brands. Analysis of the current product portfolio provided strong evidence to support the argument that a streamlined global portfolio will not only reduce the complexity, but it will increase the value of its brands vis-à-vis increased recognition, market feedback and worldwide standardisation.

Using accounts data, a simple analysis on the cumulative percentage share of total sales (figure 1) revealed that 16% of the brands represent 80% of the total sales and 25% of the brands represent 90% of the total sales. Thus, there is a need to classify brands according to their product lifecycle stage and determine which brands are near or in decline. This will in turn inform the business case for brand withdrawal.

Cumulative Sales Share of Brands

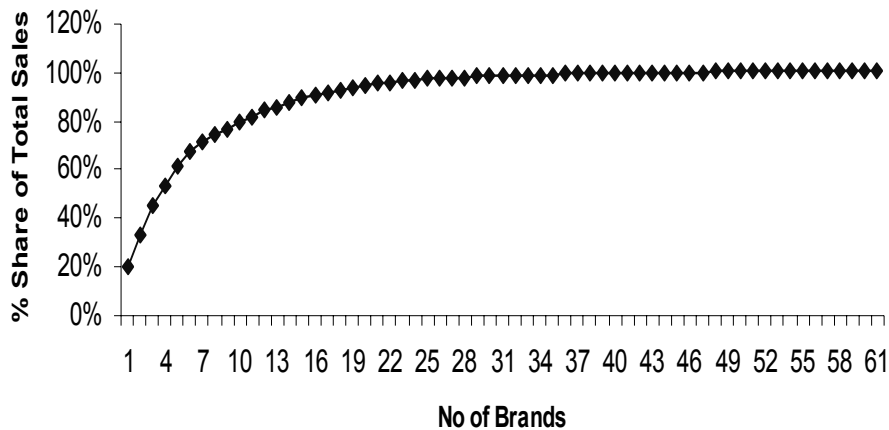


Figure 1 - Cumulative Sales Share of Brands

Product Portfolio Analysis – A Classification System: The evidence presented above provides a compelling argument for the development of a product rationalisation framework. The first stage in establishing this involves the classification of all brands based on a set of relevant criteria. We proposed and used the following criteria:

- 1) Age of the Product;
- 2) Percentage of Total Sales;
- 3) Compound Annual Growth Rate (CAGR) of Unit Sales over the past three years;
- 4) Contribution Margin and;
- 5) Product Strategy/Market Constraints.

These criteria are a mix of both qualitative and quantitative factors and when combined form a tool to view the portfolio from a broader perspective and thus help identify the brands suitable for rationalisation. The combined information from these criteria provided the basis for classifying all brands into 5 categories (table 1 for definitions) Table 2 summarises the quantitative indicators.

Category	Title	Definition
0	New Product	Launched within the last 5 years.
1	Star Product	Low sales level with great sales growth potential.
2	Focus Product	Most important products for the company, high growth in sales.
	Strategic Product	Product that generate cash for the company, high sales growth but might be experiencing a slight decline in sales growth.
3	Maintenance	Product that has stable sales growth but does not represent a significant part of the company turnover.
	Warning	Product with low sales and declining sales growth.
4	Declining	Product that should be withdrawn as has a negative contribution margin and heavy sales decline.

Table 2: Classification definitions

In the current case 75% of the portfolio (46 brands) has less than 1.65% of the sales (average percentage share of sales). This provides further evidence of the need to cull the under performing brands first. Furthermore, substituting declining brands with core products may stem the tide of declining sales and improve their overall profitability.

Category	Title	Age	3 yr volume growth	% share of total sales	Profitability
0	New	<= 5			
1	Star	>5	≥ 20%	< average	
2	Focus	>5	≥ 15%	≥ average	
3	Strategic	>5	-10 to 15%	≥ average	
4	Maintenance (a)	>5	< -10%	≥ average	
	Maintenance (b)	>5	0 to 20%	< average	
5	Warning	>5	0 to -30%	< average	
6	Declining (a)	>5			X < 40%
	Declining (b)	>5	< -30%	< average	

Table 3: Classification Criteria: quantitative indicators

In the current case, the evidence suggests that any brand with less than a 40% contribution margin is classified as poor due to high sales and distribution costs eroding overall profitability. Thus a brand with good sales and stable growth may make a negative contribution to the organisations profits. This emphasises the need for multiple criteria as these brands (loss making) could be stars, maintenance brands or declining brands.

However, deciding product classification solely on financial criteria is undesirable as other market constraints or external forces influence a company's brand portfolio decisions, e.g. relationship with surgeons, opinion leaders and clinical imperatives. To achieve a complete perspective on product performance, market conditions and product strategy have to be taken into consideration. This forms the final basis for product classification.

To test the classification tool, we applied it the 'hips' product category that included 61 brands. The results are reported in table 4.

	New	Star	Focus	Strategic	Maintenance	Warning	Declining	Total
No. of Brands	4	3	3	5	14	17	15	61
% of Sales	15.1	0.4	33.1	28.5	15.7	5.9	1.8	100
% sales/brand	3.8	0.1	11	5.7	1.1	0.3	0.1	1.6

Table 4 - Sales Contribution by Category

New, Focus and Strategic brands make the greatest contribution to sales with the average sales contribution of a brand in the Focus category at 11%. This compares to the average for the star, warning and declining categories at less than half a percent. These with the exception of star brands may be a burden on the company. The key question is if this burden is worth carrying - this will be examined later.

Does classification work? To test this classification framework analysis was conducted to quantify the potential savings from eliminating the low performing brands identified. Based on sales and cost analysis, removing the bottom 15 brands (on the basis of percentage share of total sales) in this product category would result in a loss of less than 1% of total sales while generating operational savings of USD \$13m. The costs associated with this rationalisation centre around instrumentation sets. Thus the classification has exposed brands categories that are a substantial cost burden to the organisation. However, to achieve the savings identified some internal conflicts need to be resolved. In particular, currently the sales staff are motivated to achieve incremental sales through these declining brands. Incentives for sales staff need to be addressed as perceptions about customer behaviour (if certain brands are discontinued) are a major deterrent to rationalisation. The fear of losing key customers in the *swap-out* process (i.e. replacing one brand with another) is thus resulting in a heavy cost burden on the organisation.

Decision-making framework to support rationalisation of product range:

As highlighted above the classification system exposes costly brands. However, further analysis is required to estimate the cost/savings that will arise from *swapping-out* a product. This analysis needs to take a global perspective and account for product and market characteristics to accurately determine the cost/savings. This was emphasised within the case company where global rather than country specific products portfolios are a necessity.

The evaluation takes two scenarios into account i.e. *Do Nothing* and *Swap-Out*. *Do Nothing* scenario is a cost/benefit analysis assuming the product is allowed to 'die naturally' rather than be replaced. *Swap-Out* entails a cost/benefit analysis where the brand is withdrawn within a defined period and is replaced by a newer and better product. *Swap-Out* is arrived at by the sum of cost/savings from withdrawing the old brand and cost/savings from incremental growth of the replacement brand. The analysis covers a 10 year period and Net Present Value (NPV) is used as the final value. The final cost/savings is the difference between *Swap-Out* and *Do Nothing* scenarios.

An explanation of the framework: The decision-making framework and forecasting approach adopted was informed by analysis of interview, financial and operational data. The decision-making framework includes data on sales, COGS (cost of goods sold), contribution margin, SD&A (sales, distribution and administration), implant inventory carrying cost, implant write-off cost, instrumentation cost and production savings. These data are drawn from case company documentation and interviews.

The forecasting approach was based on (i) historical trends in volume growth and price fluctuation and (ii) product and market knowledge gained through primary research in the markets. In the *swap-out* scenario the forecast is not based on actual sales figures but on incremental sales figures where the

replacement product is already on the market. Thus further incremental sales growth can be derived by focusing resources on it and not on the legacy product. To make the forecast a number of assumptions must be made: (i) customer retention rate, (ii) customer conversion rate and (iii) growth of new customers.

The customer retention rate is the number of customers expected to migrate to the replacement product from the legacy product.

Since, the legacy product is already in decline, it is assumed that there will be a year-on-year loss of customers for that product. However, with the *swap-out* scenario the company is offering a better product and should be able to convert some of these customers to the replacement product rather than lose them. This can be achieved by focused marketing efforts due to the availability of additional resources freed up by the discontinuation of the legacy product. This is expressed as the percentage of customer recovered.

Growth rate of new customers is the rate at which the company will be able to attract competitors' customers due to the fact that the replacement is a better product and is supported by a focused marketing and sales programme. The number of customers targeted each year will depend on the target year for product withdrawal. Since this will be a focused marketing approach different customer segments should be targeted at different stages.

Based on these assumption (which are guided by product and market specific knowledge), the sales units are forecasted using the retention and conversion rates along with the growth rate. This is then multiplied by the price forecast to estimate the ten year sales value forecast. This process is repeated for all regions and summed up to get the global ten year sales forecast.

Estimation of each cost category follows a similar methodology – i.e. use of specific operational and financial data supported by market knowledge available from company documentation and interviews.

Application of the decision-making framework: To test the framework we used the replacement of an existing product (labelled X) with an improved product (labelled Y) that was already on the market. Figure 2 reports sales and forecasted sales. Under the *do-nothing* scenario sales of X are forecasted to slowly decline over the 10-year period, while under the *swap-out* scenario they are withdrawn in year 3. While Y receives a sales boost in year 3, overall sales gradually increase.

The costs for Y are initially higher for all cost categories; however these decline in most cases by year 4. *Swap-out* costs are higher in the early years; however the projected decline in profits over the first four years is more than compensated by higher profits in the remaining six years. Of greater importance is the loss-making position that company would find itself in under the *do nothing* scenario in year 5. While it may appear illogical for company to continue to supply a loss-making product this is what happens, since customers must be supplied as part of the total service provided. The NPV over the 10 year period for the *swap-out* scenario is almost twice that of the *do nothing* scenario.

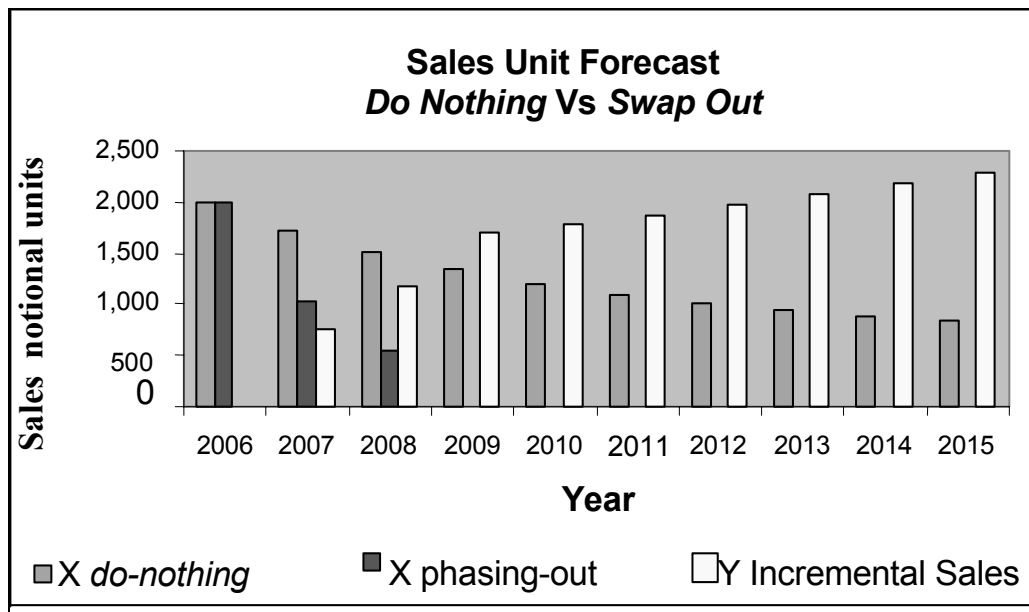


Figure 2: Sales unit growth/decline for both scenarios

The main cost variables were lower inventory and production costs for the replacement product based on incremental sales due to withdrawal of legacy product.

Overall our analysis finds that many brands are of little financial worth and are frequently of no long-term strategic value to the company. Through a series acquisitions and a continuous flowing new products pipeline the case company has developed a portfolio of more than 60 brands in this category of which 15 generate significant sales for the company. In order to maximise profitability it is therefore necessary to drive growth through a focus on the top performing brands and improve operational efficiency.

Conclusion

In recent decades firms have embarked on a core competency development path and aimed to build dominant brand positions in global markets. In addition to heavy investment in research and development this approach has sparked a wave of acquisitions and mergers. This created revenue growth but also burgeoning brand portfolios. The challenge is to rationalise this portfolio to reduce costs while maintaining a dominant global market position. The case company fits this strategic paradigm. Our study identified the need for a classification system and we find simple product portfolio analysis using operational, financial and market data useful in this regard. Its robustness has been tested on one brand portfolio. A number of key issues arise: (i) the level of rationalisation, i.e. at SKU or brand level, (ii) ability of the classification and decision-making frameworks to take account of the impact of brand deletion on other brands and (iii) the multi-dimensional nature of brand rationalisation and impact on performance measures.

The focus on brands rather than individual products within a brand portfolio is of strategic importance for the case company. This company faces product lifecycle challenges in global medical device supply chains. In this industry inventory levels are typically high for two reasons: consignment stock held at hospital level

that covers all size requirements and an instrumentation set for each implant. Thus a high number of brands results in a very high number of SKUs. This emphasises the need for rationalisation at brand level rather than on individual SKUs within a branded product range. This is due to the increase in brands as a result of mergers and acquisitions. In this respect it is interesting to compare this approach to business portfolio management that was popular during the 1970s and 1980s. The latter was primarily in response to the rise of conglomerates while the current product/brand portfolio approach is in response to consolidation.

The classification and decision-making frameworks presented here emerged from case study observations and need to be tested in other cases in this industry and across industries. These frameworks take into account the impact of brand deletion on other brands in the portfolio. In this regard use of both product lifecycle variables (time and growth rate) and portfolio matrices (potential and contribution) make for a robust management approach to brand development. For example, this facilitates the identification of 'focus' and 'strategic' brands as cash generation brands, maintenance brands as cash cows, and 'warning' brands as candidates for swap-out analysis. While this research investigated the replacement of brands with existing, similar brands, further research using new products would contribute to the development of decision-making tools in this field.

The impact of brand rationalisation on the customer's purchase decision is always central to product range and assortment management. The decision-making framework developed and tested in this research identifies key metrics: customer retention rate, percentage of customers recovered and growth rate in customers. The incorporation of product and market knowledge is a key element of the proposed decision-making framework and this requires a shift in focus across a number of functional areas, especially sales and marketing. Increasing product variety has become a key strategic issue and this has initiated a refocus on performance measures. The case company needs to revisit performance measurement as it moves from a growth phase driven by sales to a focus on margins. Thus incentive alignment across functions is a key challenge. This is most evident in the sales & marketing area where there is a need to change from sales based metrics to margin based metrics coupled with a changing role from sales only function to knowledge workers contributing to a product lifecycle management cross-functional team.

While there are specific characteristics of medical device industries that impact on product lifecycle management, there are also similarities with other industries. In particular, many industries have experienced a similar level of globalisation and consolidation with the accompanying wide range of legacy products. The case based findings in this paper may well resonate with many other industries where there is a high level of brand specificity.

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MANAGING SUPPLY CHAIN RISKS: AN INTERDISCIPLINARY PERSPECTIVE

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ABSTRACT

In the 1950's a seminal paper was published by Charles Lindblom 'The Science of Muddling Through' which highlights the theory of decision making through small discrete increments rather than big pre-planned steps. Lindblom identifies two methods of decision-making. One is the rational comprehensive (Root) approach where policy formulation is approached through means end analysis and the other approach is the (Branch) approach where means and ends are not distinct. This paper considers these concepts along with the "Garbage Can Model" and the "Mixed Scanning" concept in the context of decision making and managing in uncertain scenarios. The discussion is focussed around the processes for supply chain risk management. The research is presently in its infancy and this paper discusses a conceptual research model. As the research progresses further, validation of the model will be possible using the case-study technique. Presently, in its current state it can be used to retrospectively validate secondary data.

INTRODUCTION

In today's business environment a supply chain is stretched out across the globe. This situation thus exposes the supply chain to a whole new set of factors (external risks), which can create chaos and disruption. But this does not mean that the supply chain is devoid of any risks internally. Supplier issues, strikes, quality problems, logistics issues, etc. lead to more internal operational risks, which need a different level of mitigation. The academic work on supply chain risks has seen on a steady increase in the past couple of years. The primary aim for this research on supply chain risks is the necessity to avoid or at least reduce the impact of supply chain disruption and create a perpetually working supply chain devoid of any uncertainty. However, this is not always possible and hence there is a need to investigate "proactive" and "reactive" methods to deal with supply chain uncertainties and risks.

UNCERTAINTY AND RISK

In his influential work, Frank Knight (1965) established the distinction between risk and uncertainty. According to Knight a phenomenon which is un-measurable is "Uncertainty" whereas one that is measurable is "Risk". Risk is defined as uncertainty based on a well grounded (quantitative) probability. Formally,

Risk = (the probability that some event will occur) X (the consequences if it does occur)

According to Lovkvist-Andersen, et. al., 2004, genuine uncertainty, cannot be assigned such a (well grounded) probability. Furthermore, genuine uncertainty can often not be reduced significantly by attempting to gain more information about the phenomena in question and their causes. According to the Royal

Society (1992, p4) "risk is the chance, in quantitative terms, of a defined hazard occurring". Deloach (2000) has defined business risk as the level of exposure to uncertainties that the enterprise must understand and effectively manage as it executes its strategies to achieve its business objectives and create value. Also, Norrman and Jansson (2004) also express risk as,

Risk= Probability (of the event) × Business Impact (severity)

They mention that while risks can be calculated, uncertainties are genuinely unknown. Holton (2004) however suggests that it is only a perception that we have of the situation.

RISKS IN THE SUPPLY CHAIN

Supply chains today, are exposed to factors which can create chaos and disruption. Local political turmoil, the ever increasing complexity and uncertainty of weather conditions, terrorism, counterfeiting, and a plethora of other such issues create external risks in the supply chain. The supply chain is also subjected to risks internally. Supplier issues, strikes, quality problems, and logistics issues are more internal operational risks, which need a different level of mitigation. Christopher and Peck (2003) taking inspiration from Mason-Jones and Towill (1998), have categorised supply chain risk into five categories: Internal to the firm: Process, Control, External to the firm but Internal to the Supply network: Demand, Supply, and External to the network: Environmental. Peck (2005, 2006) also suggests that the sources and drivers of supply chain risk operate at several different levels. The four levels suggested are:

Level 1 – value stream/product or process.

Level 2 – assets and infrastructure dependencies.

Level 3 – organisations and inter-organisational networks.

Level 4 – the environment.

Spekman and Davis (2004) have suggested dimensions for understanding supply chain risks incorporating some regular variables viz. movement of goods, information and money. However, they also stress the importance of secure IT systems, Corporate social responsibility and Relationship between supply chain partners. These dimensions were also resonated by Cavinato (2004) when identifying risks and uncertainties in supply chains, adding innovation to the other variables. In LaFond (2007, www.manufacturing.net) one of the respondents has mentioned that "It really is almost impossible to predict when most emergencies will happen.. Many companies think, 'It can't happen here' or 'We would never have that problem in our plant,' but then when something does occur, they are caught off-guard and not prepared".

SUPPLY CHAIN RISK MANAGEMENT

Rice and Caniato (2003) report that many firms have developed various risk assessment programmes that are intended to:

- 1) Identify different types of risks;
- 2) Estimate the likelihood of each type of major disruption occurring;
- 3) Assess potential loss due to a major disruption; and
- 4) Identify strategies to reduce risk.

In considering the risks primarily in the supply chain, Rice and Caniato (2003) and Zsidisin et al. (2000) suggested that a supply chain risk assessment programme motivates a firm to develop contingency plans. Research in this area has primarily focussed on the supplier side. Spekman and Davis (2004) have suggested that interdependency carries risk in the supply chain, but these can be managed. Zsidisin et al., (2000) present suggestions for minimising risk:

- 1) Carrying buffer stock and improving inventory management;
- 2) Using alternative sources of supply;
- 3) Use of contracts to manage price fluctuations; and
- 4) Quality initiatives.

ORGANISATIONAL DECISION MAKING: INTERDISCIPLINARY CONCEPTS

THE GARBAGE CAN MODEL

Cohen, March, and Olsen (1972) proposed the Garbage Can model to explore processes of decision-making in organisations termed as "organized anarchies", which are defined by three characteristics: problematic preferences, unclear technology, and fluid participation. "Problematic preferences" refers to ambiguity regarding problems and goals. Organisational actors may be uncertain as to both the nature of problems they face and what they hope to accomplish. "Unclear technology", refers to an organisational perspective in which organisational members are uncertain of the rules, structures, and processes by which decisions are made. "Fluid participation" refers to a phenomenon when different actors are involved in different decisions, or in the same decision at different times. The basis for the decision making process is that participants interact with problematic preferences and unclear technology to produce distinctive patterns of decision-making. The decision is an outcome or interpretation of several independent streams in the organisation. Four streams were initially identified in the theory: problems, solutions, participants, and choice opportunities. "Problems" are concerns, "Solutions" are answers actively looking for questions, "Participants" are actors involved in the process, "choice opportunities" are the decision making situations.

According to Lipson (2007) in a rational choice theory, solutions are chosen for their optimally efficient resolution of pre-existing problems, whereas in the garbage can theory problems and streams are for the most part, independent. "Solutions," or inherently preferred policies, may exist prior to any problem, and advocates of particular solutions will seek to attach them to any problem and choice opportunity that promises to serve as a vehicle for the policy's adoption. The linking of problems and solutions is determined chronologically, as problems and solutions that arise at the same time become linked in choice opportunities—instead of a rational fitting of solutions to problems. Cohen, et al (1972) suggest that in order to understand processes within organizations, one can view a choice opportunity as a garbage can into which various kinds of problems and solutions are dumped by participants as they are generated.

MIXED SCANNING APPROACH

In his seminal paper Charles Lindblom (1959) highlighted the theory of decision making through small discrete increments rather than big pre-planned steps. He described the incremental mode of decision making as the "science of muddling

through". Lindblom identified two methods of decision-making. One is the rational comprehensive (Root) approach where policy formulation is approached through means end analysis and the other approach is the (Branch) approach where means and ends are not distinct. According to Tarter and Hoy (1998), Lindblom proposed that successive limited comparisons may be the only feasible approach to systematic decision making when the issues are complex, uncertain and conflict-laden. In the rational approach, as suggested by Rosenhead (1980), a decision-maker establishes an agreed set of values, lists all opportunities for action, identifies the consequences which would follow from each action and then selects the action whose set of consequences rates highest on the agreed values. Amitai Etzioni (1967, 1986, 1989) proposed an adaptive strategy which combined the incremental and rational models of decision making. This was named as the "mixed scanning" model. Tarter and Hoy (1998) when considering mixed scanning suggest that organisational drift is unlikely when incremental decisions are consistent with broad policy as it combines rationalism to flexibility. The mixed scanning strategy distinguishes between fundamental and incremental decisions. Fundamental decisions are made by considering the main options with respect to the goal, whereas incremental decisions are made within the context set by fundamental decisions.

THE CONCEPTUAL MODEL

Figure1, depicts the conceptual model which brings together the concepts of "Garbage Can Model" and "Mixed Scanning" in a process map to mitigate and manage supply chain risks. The issues to consider in this case are regarding the:

1. the form of the "Garbage Can Model", and
2. the method used for "mixed scanning"

The Garbage Can as depicted in Fig. 1 could be a symbolic representation of the various choice opportunities (combinations) available to the organization on account of the in interactions between the typical **problems** it faces, the **solutions** it has to these problems (based on resource availability and utilization) and the **human resources** (individual or teams). This however could also be a physical repository of choice opportunities saved in a specific format depending upon the formal knowledge management process that the organization may implement. Another element to all these choice opportunities which may or may not be derived from the three interacting variables is the tacit knowledge stored in individual human beings working in the company on account of experience in a particular task. This tacit knowledge may be utilized by the individuals during the interaction between the three variables to form choice opportunities but may also remain unutilised and hence, is necessary to be tapped into. Cohen et al (1972) in their conclusion did mention that the garbage can process they had simulated does not resolve problems well, however, the process *"does enable choices to be made and problems resolved,, even when the organisation is plagued with goal ambiguity and conflict, with poorly understood problems that wander in and out of the system, with a variable environment, and with decision makers who may have other things on their mind"*.

In the model, when the organisation is faced with a supply chain uncertainty, a mixed scanning approach will used to consider the issue and the possible strategy to tackle the issue. The uncertainty can take two forms: risk (with a

defined probability) and an Uncertain scenario. In the context of this model it is presumed that for a risk scenario, since there is a probability of it happening, a proactive strategy of risk mitigation/ avoidance can be employed as against a completely uncertain scenario where it is required to react quickly to mitigate the risk. In order to derive the appropriate strategy the mixed scanning approach will also take into consideration the choice opportunities available in the organisational garbage can. This will lead to an incremental approach for risk mitigation. In a reactive state solutions are required quickly and hence the garbage can and the incremental approach may prove to be useful. However, sometimes a completely new solution or a breakthrough in innovation is required to mitigate, generally in the proactive state with a rational approach. This may require the organisation to consider externally available choice opportunities. The process map is a closed loop map as the implemented strategy may create a new constraint or uncertainty for the supply chain.

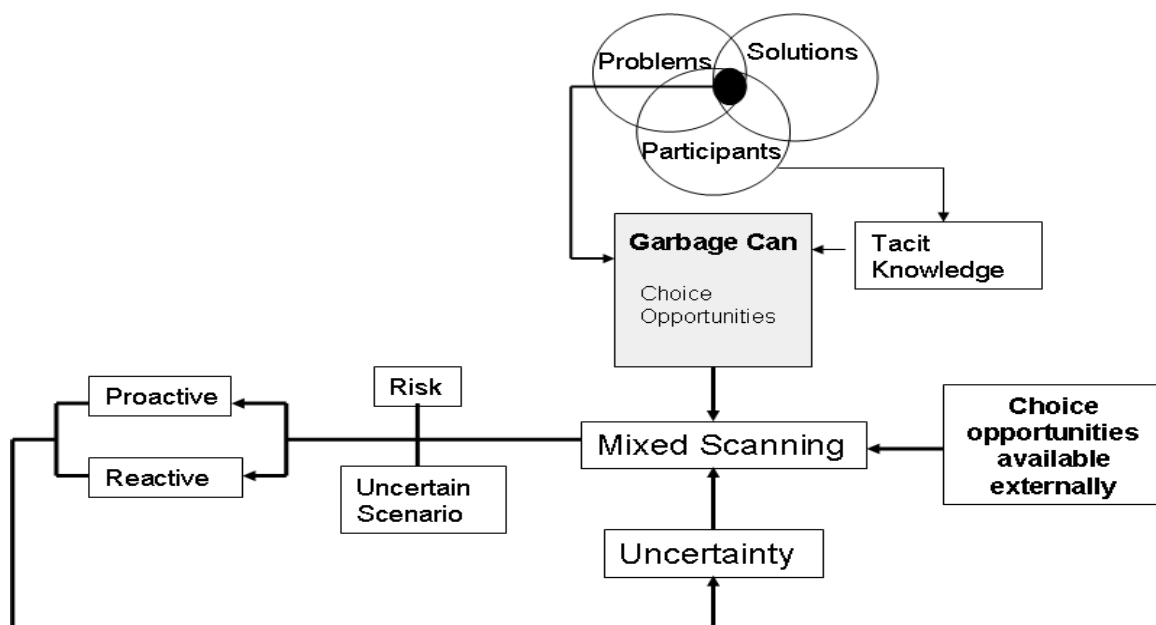


Figure 1: An interdisciplinary perspective towards supply chain risk management

Retrospective validation: The conceptual methodology in its current form (figure 1) needs to be tested empirically. However, the methodology may be used to retrospectively validate secondary data. Following is an analysis of the Nokia- Philips- Ericsson case (Sheffi, 2005; Norrman and Jansson, 2004)

Case: On Friday, March 17, 2000 the Philip's semiconductor plant in New Mexico caught fire when struck by lightning. The fire damaged the fabricator cleanrooms and the contamination ruined wafers in almost every stage of production. The plant's two important customers who accounted for 40 percent of the orders were Nokia and Ericsson. Nokia and Ericsson were informed of the fire and of a one- week delay in the order. Both companies could have handled a delay of a week, but Nokia decided that the situation needed a close scrutiny and initiated a process of collaborating with Philip's on recovery efforts. When Philip's finally declared the scope of the disruption which would have taken months to clear,

Nokia immediately started ascertaining alternative sources of supply. They managed to persuade Philips's to supply chips using spare capacity from their plants in Eindhoven and Shanghai. Nokia also reconfigured the design of their basic phones so that the modified phones could accept slightly different chips from Philips's other plants and other suppliers. Using the management of the risk as a competitive advantage within six months of the fire Nokia's "year-over-year" share of the handset market increased from 27 to 30 percent.

Ericsson however, was slow to respond to the issue partly due to communication issues within the organisation and when they realised the magnitude of the problem, Nokia had already acquired Philips's spare capacity. Ericsson thus failed to obtain the necessary chips for its phones from Nokia and from its other suppliers. It could not deliver the right mix of products in the market and thus lost roughly 400 million dollars. About a year after the fire, Ericsson signed a deal with Sony to create a joint venture to design, manufacture and market handset. The new venture Sony- Ericsson is owned 50-50 by the two companies.

The Model: Applying the model in Figure 1, it is clear that initially both the companies had not thought of a scenario where a supply disruption of one of their most key components would have created a major setback to their production and sales processes. Nokia and Ericsson had different strategies to deal with the uncertainty. Nokia considered the uncertainty to be more of a risk with a high probability of supply disruption. Hence, Nokia used a mixed scanning approach to have a very rational goal (to mitigate the disruption) but an incremental approach towards fulfilling the goal. The incremental approach had two main tasks:

- 1) to have continuity of supply from Philips, and
- 2) to find alternative suppliers to fulfil inventory requirements

To ensure continuity of supply from Philips, Nokia had to negotiate on an incremental basis for diverting Philips's excess capacity from its other plants. For finding alternative suppliers Nokia had to access its "organisational garbage can" to develop a modular design so that it could accommodate chips from alternative suppliers.

Ericsson on the other hand, initially did not consider it necessary to react to the uncertainty nor did the management team consider the probability of supply disruption. Hence, the model is not relevant for the initial stance taken by Ericsson. However, when Ericsson finally started scanning the environment and decided to incrementally negotiate with Philips for continuity of supply, it was too late as the excess capacity was diverted to Nokia.

CONCLUSION

The research presented in this paper in the form of the conceptual model (fig. 1) is still in its infancy. The inter-disciplinary nature of the research in borrowing theories and concepts from the public policy formulation domain provides an opportunity to look at organisational decision making in situations of uncertainty from a different perspective. The research also brings together in this model, "mixed scanning" as an important process for mitigating uncertainty in the organisational supply chain environment. The question regarding the form of the garbage can still lingers on and as the research progresses further, the concepts

of knowledge management will be utilised to form the initial format of the "Garbage Can". In the next phase of this research, semi- structured interviews will be conducted with supply chain personnel in organisations. who have to deal with environmental uncertainty regularly. The decision making systems and information retrieval processes inherent in these organisations based on the "Garbage Can" concept and the mixed scanning process as depicted in fig. 1 will be further explored.

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SECTION 2

INTERNATIONAL SUPPLY CHAIN NETWORKS

STRATEGIC CONTROLLING OF ORGANISATIONAL COMPETENCIES IN INTERNATIONAL SUPPLY NETWORKS (ISN) – CONTRIBUTIONS AND LIMITATIONS FOR GAINING SUSTAINED COMPETITIVE ADVANTAGE IN DYNAMICALLY CHANGING AND COMPLEX ENVIRONMENTS

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ABSTRACT

The main contribution of this paper is to identify the need for a quantitative management-tool to manage organisational competencies in International Supply Chains in order to ensure the long-term survival of an International Supply Networks though complex and dynamic environments. Additionally contributions and limitations of existing tools in strategic controlling in respect to managing organisational competencies in International Supply Networks shall be evaluated.

COMPETITIVE ADVANTAGES IN ISN

International Supply Networks (ISN) can be understood as systems that consist of different companies and supply chains who act interlinked in global markets (Hülsmann and Grapp, 2005). The difficulties and outcomes of the tendency to International Supply Networks can be described by phenomena like hyper-linking which emphasise that companies are not only connected to their direct business partners but as well indirectly to other actors within the business community (Tapscott, 1999). For the management in International Supply Networks these linkages imply that not only changes in the directly linked environment are notable but as well changes in the indirectly linked surrounding which causes complexity and dynamics (Welge and Al-Laham, 2003). This leads to the necessity for companies to generate not only temporary advantages but sustained competitive advantages in order to help the organisation to survive on the long run (Hicks and Gullet, 1975). Even if sustainable competitive advantages are hard to achieve (Williams, 1992), by introducing concepts and routines that enable the organisation to handle environmental complexity and dynamics in a flexible way and therefore to decouple from market developments a sustained competitive advantage might be achieved (Hülsmann et. al., 2008). Therefore, having the ability to react flexibly to changes in the interlinked environment could improve the competitive position of organisations because strategic flexibility enables an organisation to adapt to changes that have a substantial impact (Aaker and Mascarenhas, 1984). For International Supply Networks this could imply, that they would have the ability to react to changes in their hyper-linked environment adequately and in a long-term perspective (Hülsmann et. al, 2008). Referring to Wycisk et. al., who state that Supply Networks can be seen as complex adaptive logistics systems (CALs), autonomous logistics objects like RFID-chips or sensor networks and the organisational structure they are embedded into like an intelligent container (Jedermann and Lang, 2007) could be a source for flexibility, adaptivity and emergence (Wycisk et. al. 2008). For that reason, logistical actors might develop a sustained competitive advantage by developing and managing technologies and the organizational structures

they are embedded into in order to generate a sustained competitive advantage due to their ability to use technologies like RFID to react flexibly to complexity and dynamics in the environment and therefore develop business models that gain company value due to unique services.

ORGANISATIONAL COMPETENCIES AS SOURCES FOR SUSTAINED COMPETITIVE ADVANTAGE

One approach to generate sustained competitive advantages is the competence-based view (CBV) who states that organisational competencies can be an explanation for a sustainable superior performance (Freiling 2004, p. 28). Freiling defines, that a competence is an "organizational, repeatable, learning-based and therefore non-random ability to sustain the coordinated deployment of assets and resources enabling the firm to reach and defend the state of competitiveness and achieve the goals." (Freiling 2004). According to that, having organisational competencies might enable an organisation to sustain competitive success and therefore increase the probability for the survival of the organisation in a long-term perspective (Sanchez 2004). According to Freiling, the competence-based view states, that an organisation can be more successful, if it is able to use available resources more effectively and efficiently than its competitors (Freiling 2004).. Other characteristics of competencies are that they cannot be imitated or substituted easily (Teece et. al. 1997). In the case of International Supply Networks, organisational competencies could emerge e.g. due to the use of autonomous logistical objects like the intelligent container and business models they are embedded in, because unique business processes and services might be developed. For example an intelligent container that is able to report, that transported food is starting to go to seed, could be redirected to a destination that is reached earlier. As a consequence the food could still be sold before being unworthy. This could enable an International Supply Network or a single logistical actor to distinguish from its competitors by offering unique services or by offering popular services with unique characteristics (e.g. traceability or higher flexibility). Therefore, developing and managing organisational competencies oriented by long-term and strategic goals of the organisation might be a way to ensure the long-term survival of International Supply Networks and its logistical actors (Hülsmann and Austerschulte 2008). On the one hand the emergence of organisational competencies might be coincidental on the other hand multiple concepts that aim at developing and using organisational concepts on purpose have been developed (Krüger and Homp 1997; Teece et. al. 1997; Sanchez 2004). But even if there are some concepts that aim at developing and managing organisational competencies, it is noticeable that these are all conceptual and not integrated into the organisational and managerial structures. Referring to Hubbard, one fundamental function to facilitate management of intangible assets and therefore organisational competencies is to operationalize these in order to make them measurable and hence controllable (Hubbard 2007). Therefore, if an organisation is aiming at generating positive effects by using organisational competencies, the question is what kind of management tool is needed in order to analyze, develop and manage an intangible asset like an organisational competence, which requirements have to be fulfilled and how can such a management tool be integrated in the organisational structure of the organisation?

STRATEGIC CONTROLLING OF ORGANISATIONAL COMPETENCIES

Strategic controlling is a part of the organisational function of strategic management. It comprises all controlling tasks that support the strategic leadership of an organisation like coordination of the supply with relevant information for strategic planning and control (Horváth 1996). Aim of strategic controlling is to imply processes for the controlling of strategies into the cybernetic controlling process in order to ensure the long-term survival of an organisation (Günther and Breiter 2007; Baum et. al. 2007). Therefore, strategic controlling would be the organisational function to enlarge, in order to make organisational competencies usable for strategic management and developing a competitive advantage in International Supply Networks in order to evaluate potentials of new technologies and their ability to enable flexible reactions to changes in the environment. Existing tools within strategic controlling to survey relevant information are for example SWOT-Analysis, strategic records, GAP-Analysis, portfolios or analysis of value chains which are mostly qualitative (Horváth 1996). Especially for knowledge-based strategic assets like organisational competencies different kinds of mapping approaches have been developed. These tools supply a visual landscape of objects and place them into relationships (Huff and Jenkins 2002). Up to know a qualitative approach for strategic competence mapping exists (Johnson and Johnson 2002), but this has not been adapted to the complex and dynamic conditions in International Supply Networks like different logistics actors and heterogeneous organisational structures. In contradiction to this, a need for a qualitative approach for managing organisational competencies in International Supply Networks has been identified earlier, what includes that competencies have to be identified, measured and compared to the intended strategy of the International Supply Network in order to adapt the competencies to future changes in the environment. According to this strategic controlling is still limited in view of facilitating a management-tool that might enable an International Supply Network to gain a sustained competitive advantage based on competencies, because relevant data can not be provided and heterogeneous structures are not taken into account. For this reason existing approaches need to be developed further to include quantitative data on the one hand and to cover special needs of structures in Supply Networks in order to use opportunities within strategic controlling and organisational competencies. Concerning to Hubbard, every intangible asset is measurable and needs to be measured in order to increase the informational bases for managing and to decrease uncertainty (Hubbard 2007). One approach that might overcome existing limitations in strategic controlling of International Supply Networks could be for example a mapping approach that is based on cause-effect structures of the evolution of competencies based on data concerning characteristics of competencies showing past, actual and possible future competence-bases. In addition, organisational structures of the International Supply Network and its actors in relation to aimed strategies, technological options and possible future developments could be linked to the competence-map in order to detect missing, underdeveloped or outdated competencies. This might provide strategic management with necessary information to manage the competence-base in order to ensure the long-term survival of International Supply Networks due to competitive advantages that place the International Supply Network into position to react flexible to complexity and dynamics in the interlinked environment by embedding new technologies like RFID in unique organisational structures and business models and create unique services.

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ECONOMIC SUCCESS OF AUTONOMOUS COOPERATION IN INTERNATIONAL SUPPLY NETWORKS? – DESIGNING AN INTEGRATED CONCEPT OF BUSINESS MODELLING AND SERVICE ENGINEERING FOR STRATEGIC USAGE OF TRANSPONDER-TECHNOLOGIES

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ABSTRACT

The main contribution of this paper is to design an integrated concept for the goal-oriented, customer-focused design of logistic services. Increasing and changing requirements of industrial as well of trading firms as customers on the logistics service market induces the need for developing and using a methodology to evaluate potentials for the differentiation of logistic service providers by special logistic service offers. Therefore, the intelligent container will be examined as one AC-based technology for the Management of ISN.

ECONOMIC SUCCESS THROUGH AUTONOMOUS COOPERATION IN LOGISTIC SERVICE PROCESSES

In International Supply Networks (=ISN) as modern logistic structures "companies are involved in different supply chain networks which again compete among each other on the world market (Seebauer 2003; Lambert et al. 1998). These networks of supply chains shall be characterized as ISN." (Hülsmann and Grapp 2005) Today's logistics management has to face conflicting changes (Haller 2002). On the one hand, there is a need for concentration of logistics service providers on their core competencies. On the other hand, a proceeding differentiation of industry structures and increasing demand for logistics services take place (Klaus et al. 2006). This means, such a globalized logistics context of networks (Sydow and Windeler 1999; Sydow 2002) can be described by typical drivers of change and diversity like hyper-linking, hyper-competition, hyper-turbulence (Tapscott 1999; Siegele 2002). In turn, these phenomena cause complexity and dynamics in logistic processes (Hülsmann and Windt 2007). The initial perception has been, that logistic systems with a higher degree of autonomous cooperation (=AC) – based on the intelligent usage of transponder-technologies (e.g. RFID) – could cope in a better and more efficient way with an increasing complexity and dynamics in ISN. Therefore, AC is expected to result in positive emergence (higher effectivity and efficiency of logistic processes) and a higher system robustness (better process quality, less errors and frictions) (Hülsmann and Windt 2007). Constantly, new technologies (e.g. RFID) of AC are developed. However, technological progress also has to contribute to economic success to be relevant for the management of ISN. As to Remer in a general sense economic success describes the financial profitability and earning power of a company (Remer 2004). Here, companies are understood as logistic service providers involved in ISN structures. But to achieve economic success logistic service providers have to build up competitive advantage. This is necessary to react on fast changes in the environment (e.g. development in technology of competitors), which force logistic service providers to move rapidly. They have to differentiate themselves by offering customer-oriented, specialised logistic

services (Müller-Stewens and Lechner 2005). Thereby it is intended to build up new advantages while undermining the advantage of competitors (D'Aveni 1995) to achieve relatively higher performance than that of their competitors (Wiggins and Ruefli 2002).

Technologies, methods and approaches as service offers of logistics service providers in ISN have to be systematically serviceable for the design of the portfolios of products as well as of processes. Competitive advantage by technological progress could be build up (Müller-Stewens 2005) – based on the organisational competencies resulting from the implementation of transponder technologies and AC as the major principle for the design of logistic processes. Consequently, the overarching question of this paper then is to examine how technological solutions like transponder technologies can be strategically used for establishing competitive advantages, for the positioning and differentiation of logistics service providers, and for the building and leveraging of organisational competencies (Barney 1996; Thiele 1997, Hamel and Prahalad 1997).

Following this argumentation line, the main objective of this paper is to develop an integrated concept for the strategic utilization of AC-technologies in ISN. It is not intended to examine contributions for success, but to realize economic success by building up competitive advantages (Hülsmann et al. 2008). The corresponding management tool which has to be developed shall consist of two parts. On the one hand, it has to consider the dimensions of business model design (Freiling 2004), on the other hand the design steps of service engineering (Burr 2002). Each element of this tool shall be used for designing systematically logistic services based on AC-technologies. Consequently, the paper will be structured as follows: **(1)** Introducing briefly AC as a management approach; **(2)** sketching the two components of business model design and service engineering and finally integrating them into one management tool for ISN; **(3)** applying the developed tool by illustrating its functions for the intelligent container as AC-technology in logistic processes of ISN.

AUTONOMOUS COOPERATION AS A MANAGEMENT APPROACH FOR ISN

As to Hülsmann and Windt AC describes processes of decentralised decision-making in heterarchical structures. It presumes interacting elements in non-deterministic systems, which possess the capability and possibility to render decisions. The objective of AC is the achievement of increased robustness and positive emergence of the total system due to distributed and flexible coping with dynamics and complexity (Hülsmann and Windt 2007).

In a general, social system view-oriented comprehension AC as a management approach means leaving operative decision-making in its sub-systems, -units, and -elements while the individual system components operate independently from centralized decision-making structures (Hülsmann and Grapp 2005; Hülsmann et al. 2008). In consideration of an increased relevance of ISN management the need for intelligent systems with adaptive capabilities on a local level can be assumed (Wycisk et al. 2008). On a local level systems however follow central goals such as service levels. It may happen that local reactions in response to changes and deviations (i.e. incidents, delays, new orders etc.) occur (Herzog et al. 2003). In the practical management context AC is enabled in different ways to cope with logistical requirements. There are technologies (e.g. intelligent sensor networks of reefer containers in fruit supply chains), methods (e.g. autonomous routing) and approaches (e.g. collaborative vehicle routing and scheduling) of AC, which contribute to decentralize intelligence (i.e. local

intelligence) and enable adaptive decision routines even on the level of single goods (Smart Parts).

BUSINESS MODEL DESIGN & SERVICE ENGINEERING AS INTEGRATED MANAGEMENT TOOLS

This paper intends to consider the systematic strategic differentiation and positioning of logistic service providers by AC-technologies. Therefore on the one hand the concept of business model design (Freiling 2004) for an economic-based structuring as well as on the other hand the service engineering approach for a systematic development of services (Burr 2002) is needed. Consequently, business model design and service engineering shall be described as two dimensions of one integrated tool. It is intended to use these concepts in an AC-based toolbox for the business model design of logistic service providers (see figure 1).

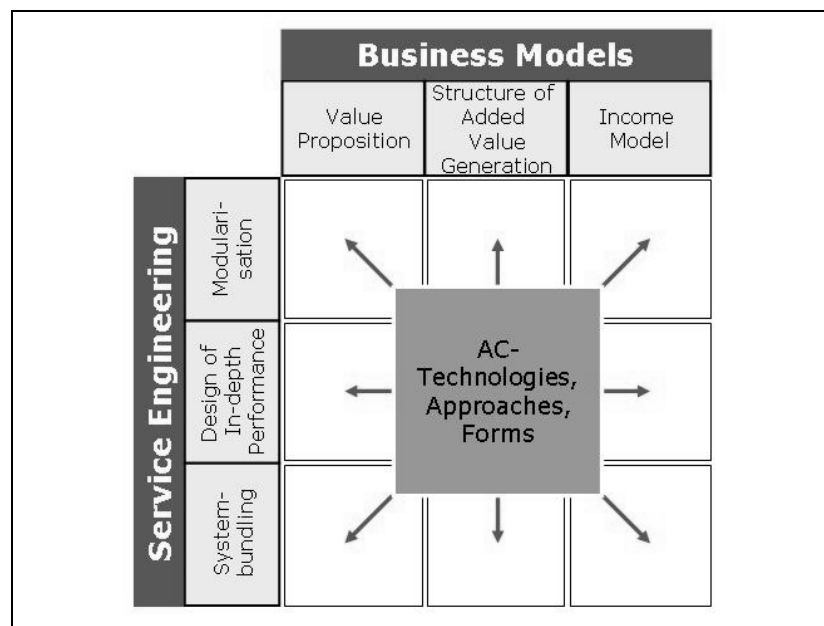


Figure 1. AC-based toolbox for logistic service providers

The concept of **Business Model Design** consists of the following dimensions: value proposition, structure of added value generation and model of income (Freiling 2004). The **1st dimension "value proposition"** refers to the market opportunity. This means the specific business activity to achieve competitive advantage (i.e. potentials for positioning and differentiation on the market of logistic services). The **2nd dimension "structure of added value"** generation refers to the technical-organisational realisation of the identified business activity (i.e. elements and processes for structuring a certain business activity in detail). The **3rd dimension "model of income"** means the concrete description and quantification of the revenue by the value proposition as well as the determination of charging of costs by referring on the model of income of the respective service offer (i.e. marketing and financial controlling for logistic processes).

From a more detailed perspective logistic service providers have to check the following questions for their business model design (Müller-Stewens and Lecher 2005) allowing them a goal-oriented proceeding: which services (e.g. AC-based logistic services) will be offered to which customers (e.g. trading or industrial firm)? (service offering model); How and in which structure this service has to be

designed (i.e. focusing on resources or competencies of a logistic service provider, that offers a specific, customer-oriented AC-based logistic service in its portfolio)? (service design model); How can the target customer group (i.e. trading or industrial firms as customers of AC-based logistic services) be attracted, maintained and sustained (marketing model)? How shall the revenue mechanism be concretely designed (i.e. which customers prefer a logistic service at which price) (revenue model)?

The design steps of **Service Engineering** as a popular approach from service management (Keith 2004) are: modularisation, design of in-depth performance, and system-bundling) (Burr 2002). **1st step:** "Modularisation" means to define differentiated modules for one service that will be offered by a company (e.g. alternative logistic processes in which a specific AC-technology could be applied). **2nd step:** "Design of in-depth performance" describes the degree of detailing a specific service (e.g. extent of the degree of logistic service's activities that are executed by the logistics service provider itself). **3rd step:** "System-bundling" finally allows the combination of different modules which are, from an overarching perspective, each detailed to a certain degree (e.g. configuration and specification of a logistic service according to customer needs). This proceeding meets the need of adapting to currently changing markets (Haller 2002). Because of the tendency to increasingly individualised customer needs (Baumgarten and Thoms 2002) it is getting more and more ambitious for logistic service providers to create customer-oriented services with an adequate design. Thereby logistic service provider's competence profiles are challenged. Consequently, the approach of a modular service architecture shall be used for an efficient exploitation and exploration of resource potentials (e.g. technologies), meaning options resulting from AC (Burr 2005).

Each element of this tool shall be used to systematically design logistic services based on AC-technologies. Both approaches have to be considered in an integrated way allowing either to increase logistics service quality by service engineering as well as explicitly formulating AC as part of every company's business design and thus providing a basis for its evaluation.

ECONOMIC SUCCESS BASED ON COMPETITIVE ADVANTAGES BUILD ON AC IN ISN

In the following paragraph, the developed toolbox (see Figure 1) will be illustrated regarding its functions for evaluating services in the context of a practical logistic service example. As stated above, especially technologies of AC seem to have an increasing relevance for the design of logistic service processes. Now, it will be examined, if and how far the intelligent container as an exemplifying AC-technology (see Figure 2: Intelligent Container, WWW, 14.04.08) could be used as a logistic service to build up competitive advantages and thereby lead to economic success for the management of ISN.

The intelligent container is "an autonomous transport monitoring system for perishable and sensitive goods. The system links technologies from the fields of RFID, sensor networks and software agents to provide a permanent and freight-specific supervision of each transport package" (quod vide Jedermann et al. 2007; Intelligent Container, WWW, 14.04.08). If this concept is envisioned for the management of ISN, compared to a usual container the intelligent one seems to bear potentials for a strategic differentiation of logistic service providers because of its "new" capabilities (Hülsmann et al. 2007). This will be evaluated by using the toolbox (see Figure 1) containing the business model design and service engineering proceeding.

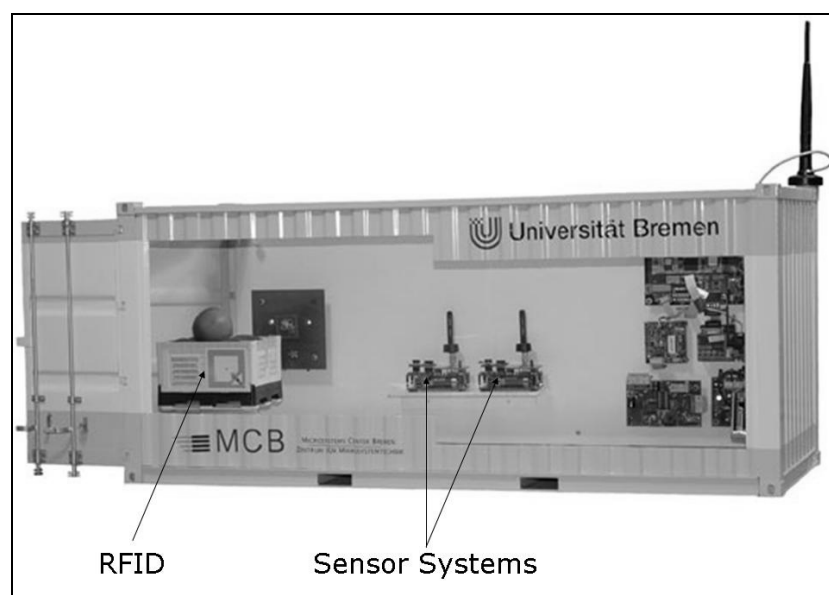


Figure 2. Intelligent Container: Intelligent Container, WWW, 14.04.08

A practical logistic context of ISN for which the concept of the intelligent container could be used would be the case of a logistic service provider that manages transportation processes for fruits as sensitive goods. In this example, containers are shipped with different types of fruits. The containers are equipped with AC-technologies such as RFID tags and micro chips inheriting all information needed to schedule their way all over the globe on their own. In these logistic processes of ISN containers represent smart parts that coordinate their way according to their individual logistic objectives (e.g. time, costs, quality and/or quantity) to their destination. They are capable to collect environmental information (e.g. traffic news, weather prediction, temperature, humidity and other relevant parameters) and additionally to exchange information among each other (Hülsmann et al. 2007).

In the following, the contributions of the nine toolbox fields (see below no. 1 to 9 in Figure 3) and their functions to evaluate will be considered for the example of the intelligent container as AC-enabling technology in ISN:

Modularisation & Value Proposition (no. 1) means in the chosen example, that the intelligent container is used as a part of logistic services equipped for the transportation of different goods (e.g. temperature sensors can be recalled to control the present status of the delivered bananas and their ripe degree).

Modularisation & Structure of Added Value Generation (no. 2) describes, how and for which specific logistic processes the intelligent container could be used as AC-enabling service-technology (e.g. transportation of sensitive goods such as fruits).

Modularisation & Income Model (no. 3) refers to the single cost positions for equipping a single container with a certain AC-technology and examines potentials for future revenues through the intelligent container (e.g. costs for temperature sensors and revenues from guaranteeing a specific ripe degree).

Design of In-depth Performance & Value Proposition (no. 4) is about the degree of activity to which a logistics service provider is involved in the execution of its offer of the intelligent container as part of transportation services (e.g. consulting and acting as agent for the realisation of an optimal cold chain).

Design of In-depth Performance & Structure of Added Value Generation (no. 5) specifies details for the application of the intelligent container as a specific service for logistic service processes (e.g. choosing transportation means

and routes according to the actual ripe degree of bananas). **Design of In-depth Performance & Income Model (no. 6)** means detailing costs and revenues for the intelligent container as a specific service for logistic processes (e.g. transparent transportation process allows an early return-risk estimation for fruit wholesaler). **System-bundling & Value Proposition (no. 7)** describes the aggregation of different logistic service activities to one logistic service (e.g. lower guaranteed failure rate, flexible route adaptation, transparent transportation of fruits). **System-bundling & Structure of Added Value Generation (no. 8)** aims at the generation of an overarching definition of connected activities for usage of IC in logistic processes (e.g. timely optimal coordination of transitions between shipping and truck transportation and parallel consideration of ripening data of transported fruits). **System-bundling & Income Model (no. 9)** means giving an overview of all costs and prospective revenues from the intelligent container as a logistic service (e.g. all costs for acquiring, equipping the intelligent container and revenues from realising strategic options such as learning options for a flexible reaction depending on the ripe degree as well as the requirements of the fruit retailer).

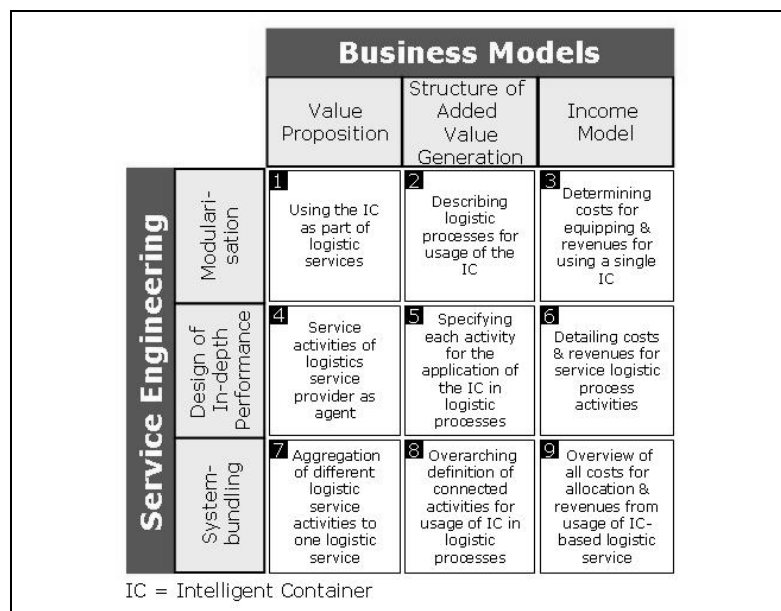


Figure 3. Intelligent container as AC-based logistic service

In how far does the intelligent container as AC-enabling technology lead to build up a **unique selling proposition (USP)**? Durability and profitability are two decisive characteristics to evaluate this question (Schmalen and Pechtl 2006). **Durability:** the intelligent container could represent a USP if it is adapted (e.g. by temperature sensors etc.) to the specific requirements of goods (e.g. fruits). This means only a USP if it is part of a sophisticated, unimitable logistics service concept so that it cannot be copied and substituted easily by competitors. **Profitability:** because there is an increasing demand that goods need to be transported worldwide the intelligent container with its specific functions represents a valuable offer to customers. They will be increasingly willing to pay a lot to ensure delivery reliability and high quality of their goods. To conclude, the modularity of the above illustrated integrated framing model (Figure 1 and 3) allows a flexible combination of logistic service activities and value chain structures for ISN-Management. The shown methodology contributes to generating competitive advantages, which finally leads to economic success of

logistics service providers in ISN, under the precondition and decisive limitation that the intelligent container as AC-enabling technology in logistic processes is not imitable.

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INCREASING THE RESILIENCY OF GLOBAL SUPPLY NETWORKS BY USING GAMES

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ABSTRACT

The use of serious games can raise the awareness and understanding for the cooperation-specific risks, and the necessary tools and methods to overcome potential dangers. Through the careful design of a concept, gaming can prepare managers and employees for identifying, analysing, and evaluating risks that can occur within a global supply network.

This paper presents a concept and the first results of two computer games applied as training aid for companies involved in supply networks covering the issues of innovation and risk management. The work is based on experience and results of three gaming projects carried out at BIBA in Bremen, Germany as well as on the results of a questionnaire carried out on the conferences ISL 2006, PRO-VE 2006 and ICE 2006.

INTRODUCTION

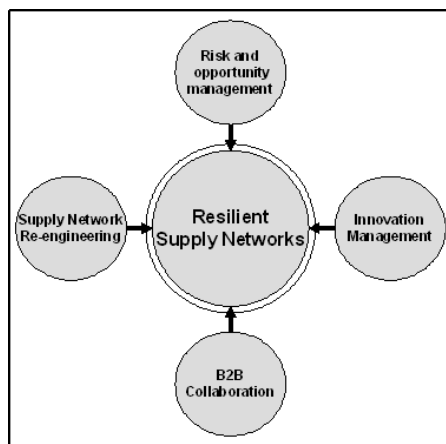
Globalisation of manufacturing has caused an increase of locations with common markets and customers resulting in a harder competition for each of the involved players. Furthermore each company has to operate in an increasingly dynamic market and sourcing situation. Combining this observation with the trends toward more complex products, decreasing product life cycle times, higher customisation of products and higher demand of knowledge, leads to the necessity for companies to produce products in co-operation with other enterprises, leading to the evolvement of global supply networks. The goal of these networks is the optimisation of logistical and production processes. An important negative side-effect in the operation of global supply network is that they are more vulnerable and inflexible due to the large number of different entities and their complex interrelations also increases the number of risks possible occurring, which might lead not only to higher costs but also decreasing the quality of on-time deliveries. Furthermore, looking at the European manufacturing companies, they face strong competition from Asia and cannot compete against the low wages and price advantages from Asian competitors. Thus innovation will be a key advantage of western economies against future and today's competitors.

The ability of efficient delivery, the capability to adapt the global supply network to fit the customers need is a must, both for products that are produced by the manufacturer, but also for the complementary products that are part of their product lines. Manufacturers are therefore seeking first-tier suppliers that are able to collaborate in global networks that are continuously adjusted to a dynamic market and sourcing situation. Such networks are termed resilient supply networks in this article.

RESILIENCY IN GLOBAL SUPPLY CHAIN NETWORKS

Resilience is both an applicable and important concept for manufacturers in turbulent times. In strategic management, resilience has been defined as a process capability. In order to reinvent themselves companies need to overcome barriers to change and develop multiple sources of competitive advantage. Resilience can be defined as “the capability to self-renew over time through innovation” (Reinmoeller and van Baardwijk, 2005). Another definition is provided by Christopher and Peck (2004) which distinguish between robust and resilience. Robustness may be desirable, but does not itself equate to a resilient supply network. They define resiliency as “the ability of a system to return to its original state or move to a new more desirable state after being disturbed”. Our understanding of the term is therefore that resilient supply networks are robust to disturbances, but also has the ability to innovate and rapidly adapt to a turbulent competitive situation. A brief review shows that there are several ways of conceptualising and adapting the basic idea of resiliency to supply networks. A deeper introduction can be found in Coutu (2002), Christopher and Peck, (2004), Hamel and Välikangas (2003), Reinmoeller and van Baardwijk (2005). Even though these authors focus on different aspect, they seem to agree upon that resilient organisations are sensing, innovative, networked and prepared. Thus resilient manufacturers must have the capability to:

- Identify **risks** and **opportunities** in the network and manage them early
- **Collaborate** efficiently with a large number of actors in loosely coupled supply networks than can easily be altered
- **Reengineer** supply chains repeatedly in order to optimise material flows and profit
- Continuously **innovate** products and processes in order to adapt to a turbulent competitive situation



No business has been reported to possess all the required specifications for resiliency. Leading proponents of resilience can give examples of resilient behaviour, but they are still developing the core principles for how to implement it. Recent research (see e.g. Christopher and Peck, 2004; Hamel and Välikangas, 2003) indicates that some general building blocks (Figure 1) might underpin resilience in supply networks. These general blocks are shortly described below.

Figure 1: The Four main areas of resiliency

RISK MANAGEMENT IN SUPPLY NETWORKS

“Business has always faced risks, but recent events have provided dramatic evidence that, in today’s economy, risk is reality” (Starr et. al., 2003, Bovet, 2005). This risk reality is forced by trends like rapid growth in global sourcing and offshore manufacturing due to cost and efficiency focus, the continued move to reduce the supplier base; industry consolidation and the centralisation of distribution facilities (Peck, 2003). Supply chain risk is therefore an evolving area

(Peck, 2004). Reviewed literature presents several guides, tools and measurement techniques developed to help companies assess their risks, and foresee possible disruption to their processes (Slywotzky and Drizik, 2005, Rice and Caniato, 2003, Kajüter, 2003, Peck, 2003). However, these tools are more aimed at corporate risk assessment tending to focus on risk management from a single firm rather than a network perspective, and have therefore to a large extent failed to keep pace with the reality of networked global supply chains (Peck, 2004). The existing risk monitoring is aimed at the systematic control of a supply chain, but there is a severe lack of useful instruments e.g. to control and compare actual state with target state of the risk situation. Furthermore, metrics to help compare and choose between various options are missing, and there is a need for tools containing more managerial guidance (Harland, Brenchley and Walker, 2003). Also, the industry needs tools that will enable companies to take advantage of opportunities concealed in unexpected events (Slywotzky and Drizik, 2005). In sum, there is a need for further development of methods for global risk and opportunity management as well as to increase the awareness of risks.

However, this awareness of risks can not only be with certain entities in a company, but need to penetrate the whole network. The risks are of complex nature, many of them originate from organisation entities and humans collaborating with each other. Many managers and employees are unaware of the cooperation-specific risks within the "lean" global supply networks. Furthermore, many enterprises see cooperation-specific risks as unavoidable, since they lack appropriate tools. Raising the awareness of risks in involved enterprises and employees is not question of finding suitable technical solutions for a whole network, but also about preparing employees and the whole organisational structure by giving them the methods and the possibility to know how to react on or prevent events with negative impacts.

INNOVATION MANAGEMENT

A study from Deloitte (2005) estimates in six years products representing more than 70% of manufacturer's sales today will be obsolete. For companies in fast moving technology-intensive industries (e.g. the electronics industry) this may only take a year or two. Only companies that can consistently bring innovative new products to market and redesign their business processes will continue to grow (Tucker, 2002). In times of turbulent business environments, the only dependable advantage is the capacity to anticipate events and trends, and adjust accordingly. Hamel and Välikangas (2003) call this "*strategic resilience*" – the ability to reinvent business models and strategies before forced to do so by external circumstances. History has shown that profitable innovation is very difficult to achieve. Very few product ideas make it to market, and those that do, have a failure rate of 50-70% (Tucker, 2002). The process of transforming an idea into a successful product on the market, or implementing new business processes that affect the entire supply network, is enormously complex. The generation of ideas (ideation) is the most crucial step in the early stage of innovation projects. Before entering the stage-gate-process of development, prototyping, manufacturing, and marketing and sales the ideation is beforehand. A study from Deloitte (2005) found that a clear majority of manufacturers' supply networks lack the capabilities of effective innovation management, mainly due to the rapidly increasing complexity of global markets and supply.

SUPPLY NETWORK ENGINEERING

Supply network reengineering has been a management issue for some time. Supply networks are usually optimised and engineered to improve efficiency and customer service (Christopher and Peck, 2004). Today, most of these efforts are carried out with manual methods such as value stream mapping, SCORE, or internally developed decisions-support systems. In resilient supply networks, where supply chains should be loosely coupled and repeatedly rearranged, better tools are required. A literature review has shown that several different applications have been developed in different areas. Even though these might be used, they do not deliver optimal solutions which enable manufacturers to rapidly adapt their supply network to the changing global environment.

The trend in network collaboration is towards "distant collaboration", where B2B technologies reduce the need for tight vertical integration. The result is decoupled and loosely integrated networks able to form new supply chains immediately; a main characteristic of resilient supply networks. Collaboration means, above all, the integration of systems, services and people in order to deliver results. It is therefore imperative to form sustainable collaborative networks.

RESEARCH APPROACH

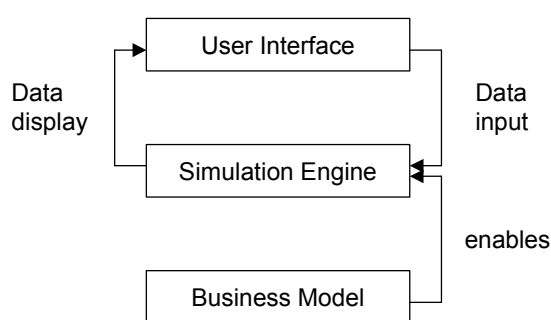
Increasing the resiliency of global supply network is actually therefore a question of offering both suitable tools as well as to prepare each organisation as well as the global supply chain. Preparing an organisation and the involved employees on the new requirements is hardly a question of finding suitable technical solutions but more about preparing the employees and the organisational structure, because a successful co-operation does not only rely on a seamless information flow between all partners, but also on the ability of the participating organisations to act in a dynamical environment. In this article however, we focus on the organisational aspects, and mainly on how it is possible to support the employees involved in global supply networks by mediating and fostering two different set of competencies. This stresses the need of continuous learning, which constitutes the true competitive advantage for organizations. Moreover, the learning rate of the organization must be higher than that of competitors so that the former can survive. An individual does only learn what he can perform and convert/implement. This implies, that in order to offer vocational training for training employees to face new situations and carry out new collaborations in a dynamical environment, curricula need to be developed, which allow active participation of the employee: An effective tool for mediating learning is serious computer games (Windhoff, 2001).

BMOG

After analysing different gaming approaches and different available games and compared these with the user requirements, it was decided upon, that we need some sort of game engine, so that the player can get an individual adapted end user scenario. A gaming engine allows for the generation of different games and levels of games without having the need of re-programming. This is the reason for separating the engine from the underlying model. The engine reads and executes game models providing an advanced user interface for the players.

The architecture of the simulation game consists of an underlying business model, a simulation engine and a user interface, which allows to examine the model elements and to apply game specific actions. These parts are described below:

Business Model: The underlying business model provides all modelled entities as a formal basis for the implementation of the simulation game. It enables the definition of the simulation engine.



Simulation Engine: The engine works on the underlying model and simulates time and costs, which are the main variables influenced by the players in taking specific actions. The simulation engine can be seen as the central control unit of the game.

Figure 2: User Interface, Simulation Engine and Business Model

User Interface: The user interface allows to browse the overall and personal information in the game and to apply game specific actions. The user interface allows data input from players as well as displaying game relevant information. Structure of the game is process driven i.e. it simulates the processes mainly running in a working environment of engineers. It is a game engine for collaborative games, since this is the main working situation.

SPECIFIC GAMING SCENARIOS

Beware. Beware is a multi-player online game implemented in a workshop setting. The application is used as a training medium for companies involved in supply networks covering the issue of risk management. Currently, Beware is designed with two disparate and independent levels, but their numbers can be increased if necessary. In the first level, the participant experiences risks within the organization. The main task is the identification of various risks as well as the application of suitable methods to assess and reduce these risks. In the second level, the task is the same although the participant deals with collaboration risks and hence, needs to handle complex situations. If the game is played by users familiar with risk management and only interested in experiencing the impact of cooperation risks, the first level may be skipped. Each scenario lasts about three hours. Some indicators, such as time, quality and costs, are supplied to the user as feedback during and after the game. Due to our experience with previous games, the time between playing the two levels of the game was increased from one day to one week, so that the participants had more time to reflect on what they had experienced and how to apply the methods.

refQuest: The main objective of *refQuest* is the support of idea-generation in a structured way. The game shall stimulate this goal by looking at a given problem from many perspectives. The perspective of the game changes in each round. The team may also change.

The *refQuest* game encourages thinking in new ways and motivates the participant to overcome frustration when an idea does not emerge fast enough. *refQuest* is based on a concept called Reframing the Question, which focuses on structuring the ideation process by stipulating specific perspectives for the innovation workers. The current version of the game supports the application of actions, collaborative work on documents and the occurrence of disruptive events.

RESULTS

Beware: Originally, the processes in Beware were executed linearly. However, the initial results, did not show any good result for the players abilities to develop strategies on reducing risks, only on identifying. The analysis showed that this was caused in the degree of complexity of each single process step. This was reduced in the first level, but then the number of processes increased. Due to the large increase, it was necessary to change from a sequential model to a model allowing for parallel processing. There are two reasons for this, first of all, it simulates how a risk management process should be carried out- i.e. identify potential risks before they occur, and secondly, it is also a question of motivation- players who do not have anything to do loose the motivation and attention to what is happening in the game.

The first four workshops after adding the new processes and changing the model were carried out in January and February 2008 with 36 participants. Even though the software still had several bugs and did not execute the game optimal, the results shows a significant improvement in the students ability to identify risks and problems within the communication in the network as well as in their ability to develop suitable strategies.

The figure below shows the students ability to identify communication problems (figure left) and their ability to find strategies to cope with them.

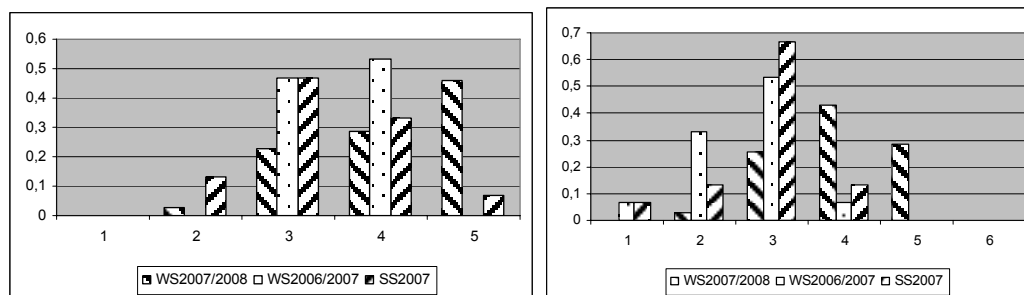


Figure 3: Students' assessment on their ability to identify communication problems (figure left) and their ability to find strategies to cope with them (1= not improved, 5= very much improved)

Further more a comparison of the results of the pre-test and the post-tests showed the student had increased their knowledge on different risk management methods and also that the understanding and awareness of risks in manufacturing networks were improved.

refQuest: A main difference of using games in the support of ideation instead of more traditional methods like brainstorming etc. is that games in themselves

should be motivating and to some extent make fun. Another difference is that games always have a competing element, which mostly makes it interesting to play.

The table below shows that the first impression of the game is quite good and that the players do think it will support the ideation. However, after analysing the comments on the questionnaire as well as combining these with the oral feedback and the observation done during the game, it becomes clear that even though the first evaluation of the game shows that the game supports the idea generation, there are several minor elements which need to be improved. The use of events, momentarily set by the facilitator had a positive and motivating aspect at the game, since it could be applied if the motivation seemed to decrease as well as in order to help to find a solution. But in this first version it was only possible to set predefined events. The comments showed that it probably would be better if the events could be set on a fly. It was also shown that the competing element was too low for the tester. This could be solved by playing the game with several groups in parallel so that they can compete against each other. The *refQuest* game is implemented as a browser game.

<i>The game is ...</i>	---	--	-	0	+	++	++ +	<i>The game is ...</i>
Too short				80	20			Too long
Unrealistic				20	40	40		Realistic
Not useful for my profession					40	60		Useful for my profession
Can not be integrated in my daily working routines					60	40		Is surely possible to integrate in my daily working routines
Will not support my daily work				20	40	20	20	Supports my daily work

Table 1: Results from the early evaluation of the *refQuest* game

CONCLUSION

The evaluation of the new versions of the games has shown that the use of games in increasing the resiliency of global supply networks work to a certain extent. However, in the case of risk management, the good results can only be achieved when the game is in a workshop setting also mediating the basic risk management skills, or , if not, the player need to know them on before hand. In the case of ideation, the evaluation showed that the game need to be better integrated in the working environment.

The evaluation of the games also shows that the documentation of generic game scenarios needs to be detailed. This is especially necessary as long as the player play the generic game, in which they do not recognise the processes and the working environment from their daily work. An implementation in different business environment requires an adaptable game framework so that the game reflects the running processes in each company. This will improve the "productivity" of the game as well as improve the efficiency because the players will know the environment. At the moment the game may only be changed by first carrying out a business process analysis and then change the scripts. This is very time consuming both for the potential company as well as for the game

designer and the programmers. For the future it is intended to build an authoring tool which allows an author to manage the game objects.

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CHALLENGES IN COORDINATING NETWORKED ENTERPRISES

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ABSTRACT

Nowadays companies are engaged in global supply chains. In many cases these companies are not only part of one supply chain, they are participating in different probably competing supply chains. From this perspective a company is part of a supply web with multiple suppliers and multiple customers, formed by a number of supply chains. Within each supply chain the participating companies have to coordinate their activities to work efficiently. That means its decision taking is guided only by its own interests following local objectives. This coordination has to be done regarding different requirements that arise from the autonomy of the involved decision taking entities. These coordination requirements are presented in this article. In fact, the coordination of activities of different companies organized in a supply chain was focused by other researches as well, e.g., (Dudek and Stadtler, 2005). Among others these approaches are going to be evaluated thoroughly using the presented coordination requirements. It turns out that none existing approach is capable to satisfy all requirements. It is detailed for each approach which coordination requirements cannot be fulfilled. To point out how a coordination mechanism could look like satisfying these coordination constraints a coordination approach on the base of negotiations among agents is presented. Each company is represented by an agent. This agent wraps the existing planning system. Using software agents allows modelling the supply chains in an adequate way (Swaminathan et al., 1997). These agents use negotiation protocols for coordinating the local plans in an automated way.

INTRODUCTION

Nowadays companies are engaged in global supply chains. In many cases these companies are not only part of one supply chain, they are participating in different probably competing supply chains, e.g. a supplier in the automotive industry. This is sketched in Figure 1. First management approaches for supply chains can be summarized as 'integrated supply chain management', see e.g., (Ellram and Cooper, 1993). Software that can support those management approaches was designed and is called Advanced Planning Systems (APS) (Stadtler and Kilger, 2002).

From this perspective a company is part of a supply web with multiple suppliers and multiple customers, formed by a number of supply chains¹. Different autonomous companies cooperate to produce together a product or service. Within each supply chain the participating companies have to coordinate their activities to work efficiently. Without loss of generality it can be assumed that each company is autonomous in economic and legal sense. That means its decision taking is guided only by its own interests following local objectives. In

¹ Note that the concept of virtual enterprises leads to similar enterprise networks.

the following the focus lies on such companies and the challenges resulting of being an autonomous entity in a supply web.

The resulting problem arises from the fact that an autonomous planning entity has to coordinate its activities while

- each company plans its activities according to its local objective and
- each company has to satisfy requirements of different other companies in terms of requirements on the company plan.

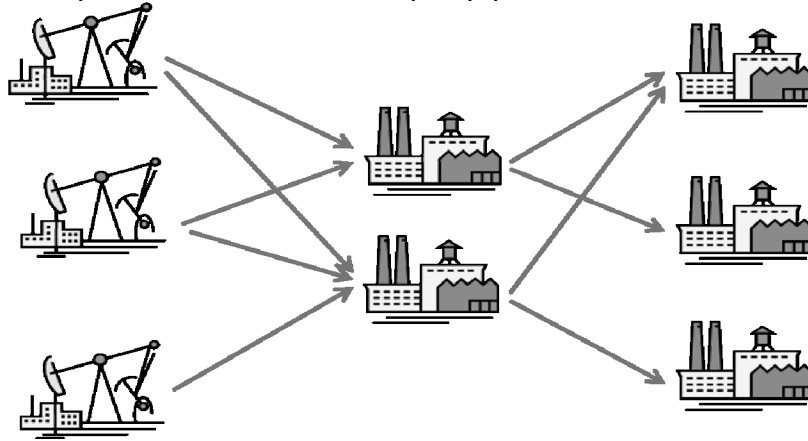


Figure 1: simplified overlapping supply chains

The required coordination mechanism has to meet functional and non-functional requirements. The compliance of these coordination requirements is essential if those mechanisms have to be applied to real world like scenarios.

In fact, the coordination of activities of different companies organized in a supply chain was focused by other researches as well e.g., (Dudek and Stadtler, 2005; Frey et al., 2003; Wagner et al., 2003; Walsh et al., 2000). Different approaches are discussed and evaluated using the coordination requirements to see which of these approaches can fulfil the requirements. As it turned out that none of the presented approaches can fulfil all coordination requirements.

To point out how a coordination mechanism could look like satisfying these coordination constraints a coordination approach on the base of negotiations among agents is presented. Using software agents allows to model the supply web in an adequate way (Swaminathan et al., 1997).

In consequence, the rest of this paper is organised as follows. In section 2 the coordination requirements are presented. Based upon these requirements existing coordination approaches are discussed in section 3. As it turned out that none of these approaches fulfils all requirements, in section 4 a new coordination approaches is sketched. In the last section the results are summarised and further research is outlined.

COORDINATION REQUIREMENTS

In the following we term the entities forming a supply chain planning authorities. This allows a more general approach, e.g., if different sites of a company are involved, they can be treated as two different planning authorities. Characteristics for a planning authority (PA) are that it is responsible for its activities, schedules its activities on its own, and has exclusive resources.

As mentioned before, it is assumed that all planning authorities are autonomous in economic and legal sense.

Of course it can be debateable if a company is autonomous in economic sense towards its network partners in the supply chain, but this economic discussion is not addressed in this paper.

By autonomy we state here that each entity has the exclusive knowledge about its abilities and the exclusive control of its resources. This notion allows, of course, modelling a hierarchy of entities if needed, if an entity obeys to another. For a detailed discussion of the term autonomy and its possible different notions we refer to (Bradshaw et al., 2004; Kirn, 1995).

Beneath the autonomy, a second aspect has to be regarded that increase the complexity of the coordination of network activities. Planning authorities act in a dynamic environment; this has to be regarded defining the coordination requirements.

The coordination requirements are presented here in an informal way; they were constructed by a hermeneutic research. A more formal representation has to base on a formal definition of enterprise networks that is actually not available.

Coordination Requirement 1: Networks are part of a dynamic world (CR1) This implies that the network configuration itself can change over time, as the goals of network members may change. So network members can leave or enter the network.

Changes in the environment can lead to invalid schedules of the network as well. To achieve a useful system for practical purposes, it is necessary that the coordination method offers the possibility of reactive scheduling. Thus it is possible to change an existing global schedule according to requirement changes. The need for reactive scheduling was already recognised in (Smith, 1994). Due to permanent reactive scheduling, the quality of the existing schedule may decrease over time. As a consequence, it is desirable that a schedule improvement mechanism tries to improve the schedule and absorb the effects of reactive scheduling permanently.

Coordination Requirement 2: Autonomy has to be preserved (CR2) A PA uses a local scheduling system with a private local objective function and is assumed to be autonomous. The coordination method has to respect and preserve this autonomy. Network optimisation has to respect the autonomy of the network members. In general, a PA would not accept a degradation of its local plan in favour of a global plan improvement of one network. This may even be true if the global improvement mechanism offers a compensation for the degradation because an external entity cannot compute an appropriate compensation. There are two reasons for this:

- An external entity cannot compute the compensation because each PA has a private local objective function.
- The global improvement works within one network. If a PA participates in more than one network, the change request by one network can affect activities of another network. These effects are unknown to any external entity.

Coordination Requirement 3: Information hiding (CR3) The coordination within a enterprise network is in between cooperation and competition. The planning authorities participate with their core competencies. This implies the danger of losing these competencies to other network members (Corsten and Gössinger, 2001). In an enterprise network, especially when some entities have similar skills or are in the same line of business, a company would not give any information concerning their manufacturing abilities to another competing company. Each planning authority has to secure its core competencies.

In consequence, the information available for coordination can be very limited. A coordination method should only require the absolutely necessary information for each activity, like the earliest start and latest due dates of each activity. This

privacy aspect is emphasised by other authors as well (for example (Frey et al., 2003; Caillou et al., 2002; Kawamura et al., 2000)).

Coordination Requirement 4: Coordination has to be done in parallel (CR4) A PA has to coordinate its activities in more than one network at the same time. Of course, the coordination becomes more complex when different, possibly dependent, issues are discussed with different agents in different agent societies. Additionally, there exists an overlap with the previous constraint. That is because the fact that a PA participates in different networks might be sensitive information for that authority. For example, if a PA A participates in more than one network, the coordination method has to ensure that no PA (except A itself) discovers the engagement of A in different networks. This becomes especially true when the different networks are competing.

Coordination Requirement 5: Scheduling systems are black boxes (CR5) The local scheduling systems should be considered as black boxes, i.e., the scheduling method is not transparent to the coordination mechanism. Scheduling could be done by hand or by a sophisticated scheduling system. The scheduling method is private property of the PA. To support information hiding, the coordination method should see the scheduler as a black box with a given interface. Assuming the local scheduling system as a black box offers some additional advantages, like

- existing systems can stay in use,
- no adaption costs occur, and
- a modular approach allows to exchange the used scheduling system easily.

As a consequence, the coordination method knows only an interface to the scheduling system. This interface offers the functionality that the coordination method can specify the input data for the scheduler and can interpret the resulting schedule.

Very similar requirements are stated by (Hegmanns and Hellingrath, 2008) in the supply chain domain. In the domain of project scheduling similar constraints are assumed by (Kim et al., 2000). An approach in the domain of patient scheduling which addresses autonomous planning entities with comparable coordination constraints, is presented by (Paulussen et al., 2003).

EXISTING COORDINATION METHODS

The coordination of planning authorities like companies forming a supply chain has been addressed by several researchers. The previously developed coordination methods have in common that they are originated in the field of distributed artificial intelligence. This research field is typically divided into two sub-fields. The distributed problem solving where a distributed system is centrally designed and the multiagent system research where the assumption that the agents have a common sense of utility does not hold. The only way in multiagent research to direct the behaviour of the agents is to design an interaction environment that constrains the behaviour of the agents and forces the agents to behave in an intended way.

In this section, an overview of coordination methods for the domain of distributed manufacturing, typically for supply chains, is presented and it is discussed which coordination requirements are not respected by each method. Coordination requirements are referred by their abbreviation. A requirement that no method deals explicitly with is that planning authorities can participate in different networks at the same time and thus have to coordinate their activities in different networks at parallel (CR4).

Coordination in distributed problem solving

In (Kawamura et al., 2000), negotiations among agents that represent a local scheduling system are used. These agents have to ensure that local constraints (e.g. capacity constraints) and global constraints (e.g. sequence of activities) are satisfied. This approach seems quite promising but only simple constraints are allowed and the agents have to be strictly cooperative, so that strategic behaviour is forbidden. But this approach assumes that for each job within an order the needed resources and times are globally known. This violates the information hiding requirement (CR3). The fact that a PA can participate in many networks (CR4) is not discussed but it seems realisable, even though it has not been investigated in detail.

The second widely used approach is to arrange the planning systems in a hierarchical structure. The general idea of this approach is the following. There exists a global or master scheduling system generating a global plan for the entire network based on summarised data. Then each local planning system has to compute a detailed production plan according to restrictions resulting from the global plan. Aforementioned APS systems work in this way (Stadtler and Kilger, 2002). There exist a number of systems also based on hierarchical structures among the planning systems which are not discussed here in more depth because all these approaches fail to satisfy the coordination requirements CR2, CR3 and CR4 for the same reasons.

Coordination in multiagent systems

Probably the most prominent coordination methods in the multiagent system research are auctions. The advantages of auctions are that they can preserve the autonomy of the planning authorities and the computed solutions can be proven being pareto efficient. A disadvantage of auctions is that those methods based on game theory often do not consider the needed computation time. For example, for the allocation problem arising in supply chain scenarios with multiple suppliers the matrix auction found to be an appropriate method (Walsh et al., 2000). But from a computational point of view each computation of a bid and the winner determination of the auction are NP-hard problems (Ruß and Vierke, 1999).

There exists a variety of methods based on the idea of bargaining. A prominent member of this class is the contract net protocol (Davis and Smith, 1983). Because this method is quite simple and described only in general terms it has become a kind of primitive in more complex coordination protocols. (Sandholm and Lesser, 1995) extend the protocol towards bounded rational agents and introduce the concept of decommitments and thus reallocation of activities. The introduction of decommitments increases the uncertainty for an agent depending on the activities of other agents. To reduce the resulting uncertainty decommitment penalties were introduced. The idea of decommitting allocations was used by (Wagner et al., 2003). They describe a coordination method within a supply chain. In that approach, another problem of decommitment penalties becomes clear. The penalty is computed using internal costs of the planning authorities. But this internal information is often sensitive for their owners. Thus, it can be not guaranteed that the information hiding requirement (CR3) is respected.

(Frey et al., 2003) introduce a coordination method that extends market mechanisms towards a more flexible solution in terms of reactive scheduling. To do so, they use information from the local scheduling systems. A special kind of

agent collects internal information from the scheduling system. This information is used within the negotiation protocol to specify the pricing. As the scheduling system is known and internal information is extracted, the coordination requirement CR5 is not satisfied.

In (Dudek and Stadtler, 2005), a coordination method is presented for entities generating local plans forming a supply chain. It is assumed that all planning entities use mathematical modelling for their local plan generation, this violated CR5. The rest of the negotiation model is presented for agents with team behaviour, but extensions for egoistic agents are discussed.

Coordination method	Failed coordination constraints
(Kawamura et al., 2000)	CR3
(Stadtler and Kilger, 2002)	CR2, CR3, CR4
(Walsh et al., 2000)	CR1
(Wagner et al., 2003)	CR3 (CR1, CR4)
(Frey et al., 2003)	CR5
(Dudek and Stadtler, 2005)	CR5
(Paulussen et al., 2003)	Open shop scheduling as global problem
(Kim et al., 2000)	CR2

Table 1: Coordination methods and the coordination constraints they do not fulfil

Coordination methods in related domains

A coordination method using some similar negotiations to the coordination method presented in the next section was presented by (Paulussen et al., 2003). Especially the techniques improving an existing schedule are similar. However, the focus of this research is the scheduling of patients in a hospital. Thus, the global scheduling problem is an open shop scheduling problem. This problem allows some simplifications that are not possible addressing a job shop scheduling problem, which is the underlying model of a supply chain.

In (Kim et al., 2000), a coordination scenario in the project scheduling domain is presented. In that work the aspect of compensations for reschedulings are discussed. A single utility function is assumed to be shared by all agents, which contradicts the preservation of autonomy (CR2), because the autonomy of all agents is defined by their private individual utility function.

To summarise this section the different coordination methods and the coordination constraints they fail are shown in table 1.

THE ABACO APPROACH

The result of the evaluation is that existing coordination methods can not satisfy all coordination constraints. Therefore, a new coordination method has to be designed. This method called ABACO (Agent-BASED COordination), preliminary results were presented in (Schumann and Sauer, 2005).

A multiagent system is used to model the enterprise network which has been done by different authors previously mentioned as well. Intelligent agents seem

an adequate method to represent the planning authorities because they have the following capabilities (Wooldridge, 2000):

- autonomy (this ability is implied by the term agent itself),
- reactivity,
- pro-activeness, and
- social ability.

Each planning authority is represented by an agent that can be customized to its strategy. Additionally, there exists a coordination agent (CA) that represents a network that has to coordinate its activities, here a supply chain. This is sketched in Figure 2.

ABACO grounds on negotiations among autonomous agents. This offers the possibility to design coordination protocols that can ensure CR2 and CR3. Existing scheduling systems are wrapped by agents to ensure CR5. The ABACO method offers protocols for predictive and reactive scheduling and schedule improvements to ensure that CR1 is satisfied. These protocols must be applicable even if there are multiple negotiations in parallel in different networks CR4. So ABACO is capable of coordinating such a production network respecting all constraints. Here, a brief overview is given, since the method itself is not focused in this article.

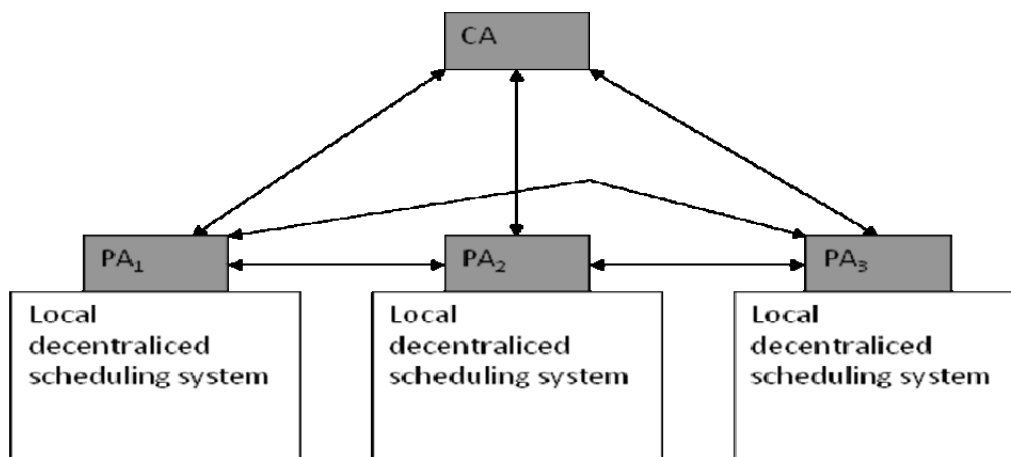


Figure 2: Sketched architecture of the ABACO approach

Predictive scheduling

An order can be scheduled if for at least one sequence of activities, each activity can be accomplished by at least one agent. The network orders are scheduled sequentially. All feasible sequences have to be evaluated. This can be done by a method similar to the contract net protocol (Davis and Smith, 1983). So the best available sequence can be identified. Each designated PA has to confirm its bid, since the situation of a PA might have changed during the contracting process.

Reactive scheduling

Due to the changing environment, the schedule of the network can become partially invalid. Depending on the occurred event, different repair strategies lead to a new schedule. For example, if a new order is introduced it has to be scheduled using the predictive scheduling scheme. If a PA cannot fulfil its commitments, a different one has to be found. If this is not possible, all activities of that order are cancelled and the order is scheduled again, using the predictive scheduling scheme. Similar reactive scheduling strategies can be found in (Frey et al., 2003).

Schedule improvement

If an agent wants to change one of its commitments, it has to act in concert with other agents. Therefore, these agents have to agree to the change. This agreement is reached by a negotiation among these agents. To start a negotiation an agent has to find an improvement in its local schedule. Because the given commitments constrain the local schedule quality, the change of a commitment might offer the potential to improve the local schedule. The agent should compute an alternate commitment concerning one activity which allows it to improve its schedule. This alternate commitment is called change proposal. If an agent can generate a change proposal, it may improve its schedule if the affected agents agree on that change the commitment.

SUMMARY

In this paper, the coordination of autonomous entities is presented as an important problem in the domain of supply chain management. To find an appropriate coordination method, it is important to respect the domain information. This was done by defining coordination requirements. To design a coordination mechanism for practical purposes, it is important to respect these requirements. The explicit description of coordination requirements for a certain domain like supply chains or other dynamic production networks is novel. In earlier publications, these constraints were only implicit or in the best case some requirements were made explicit. Making these requirements explicit offers the advantage to study existing coordination methods. For the context addressed here, this evaluation was done. And even if there exists a variety of coordination methods, all evaluated coordination methods fail to satisfy all coordination requirements. As a consequence the ABACO coordination method was presented as a first approach to close the gap and offer an appropriate coordination method. Although it is yet not specified in all detail, it has the capabilities to satisfy all coordination requirements. The method is so far implemented as a set of conventions in an agent society of truthful agents.

As of now the ABACO method only works in a quit simple way. There are some aspects for which the existing method could be extended. For example, the allocation of activities in the predictive scheduling phase could use more sophisticated contracting mechanisms.

Using the general concept of enterprise networks and the aforementioned coordination requirements, it is expected that the coordination method can be applied in a number of real world problems.

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IMPROVING ADAPTABILITY AND INTEGRATION IN GLOBAL SUPPLY CHAINS THROUGH CROSS COMPANY PROCESS ORIENTATION

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ABSTRACT

To facilitate understanding the paper begins with some points of view regarding origin and development of important terms and concepts. State of the art is shortly described and so are some of the similarities and differences between SCM (Supply Chain Management) and BPM (Business Process Management). Based on earlier research and experiences a new concept XCPO (Cross Company Process Orientation) is launched. Interesting research issues together with potential barriers and drivers for implementation are discussed. Some empirical findings and conclusions finalize the paper.

INTRODUCTION

The design and performance of *supply chains* are of decisive importance for what we might call "sustainable competitiveness", that is long-term competitiveness that hardly can disappear in the short term by changes in the business environment or by somebody copying. Apart from affecting competitiveness supply chains show essential potentials for improvement. In an interview in connection with the publication of the book "The Agenda" the author M. Hammer said a. o. "... *there's a lot more gold in those supply chain hills. The other hills have been pretty much mined out. The supply chain is a major remaining opportunity area.*" (Quinn, 2001).

The design of a supply chain – including a o written or unwritten rules, regulations, contracts etc – can not be especially clear to an external observer, and operational excellence is probably even more difficult to copy. An exemption from this is of course if the supply chain has a high level of standardization and is built up by standardized components. An important factor making supply chains difficult to copy is that they are to a large extent characterized by people (Gattorna, 2006). Thus, take care of your supply chain!

Supply chains are becoming more and more complex. There are different reasons for this, like increasing globalization, heightened uncertainty, increasing product complexity and ever-increasing customer demands for higher services at lower costs (ELA and A T Kearney, 2004). The report mentioned – based on extensive studies of different types of companies in 15 European countries – also call attention to that "*Leading-edge supply chains employ a new set of capabilities to proactively manage complexity, drive performance, and improve competitiveness. They exploit a set of three distinct levers and apply them appropriately.*" The three levers described are collaboration, value chain management, and differentiation.

We can look forward to an exciting development. In single firms Process Orientation and the Business Process Management concept and techniques have

been successful in company development. Could the corresponding also be the case for supply chains?

DEVELOPMENT ASPECTS

In 1993 M. Hammer and J. Champy published a book titled "Reengineering the corporation". Their thoughts contributed to what is known as BPR (Business Process Reengineering). The book became a US best seller and very popular among academics and practitioners – not to mention consultants. A lot of BPR-projects were carried through. However all of them were not successful. As a matter of fact as much as 50-70% were failures (Caron et al (1994), Murphy (1994)). It was also presented in a book by M. Hammer 1996 with the title "Beyond Reengineering" where he said: *"I have now come to realize that I was wrong, that the radical character of reengineering, however important and exciting, is not its most significant aspect. The key word in the definition of reengineering is "process": a complete end-to-end set of activities that together create value for a customer"*. Based on books, articles and interviews this has been his standpoint ever since.

The initial very strong belief – not to say excitement - in BPR in a single company context inspired authors to expand the ideas to SCM. In an article from 1995 "Business process re-engineering the supply chain" G. N. Evans et.al. say a. o. *"those who have already implemented the SCM philosophy will have already travelled the same path as BPR and indeed re-engineered their own processes"*. The authors also say *"...the ideas into the concept of 'business re-engineering' which will subsequently be called 'business process re-engineering' (BPR) in this paper..."*. We find it rather irrational that by adding an important word to a different concept you can draw conclusions about the new.

The main conclusion referred to above is also inconsistent with later research like McAdam, R. and McCormack, D. (2001) "Integrating business processes for global alignment and supply chain management", saying a. o. *"It has been found that there is little evidence of organisations actually exploiting the integration of business processes in their supply chains. In the research literature, the two fields are generally treated separately. Business process management techniques are applied to a single firm, although the concept is not bound by company limits, while supply chain research tends to focus on the relationships between organisations"....."Further research is needed to understand the extent of integration between supply chain management and business process management"*

CURRENT STATE OF BPM

The community Business Process Trends is performing an annual survey regarding the state of BPM. In their latest report they argue that the history of BPM is rather short and even new if we are referring to managing the integrated system of business processes that constitute an enterprise: *"... companies have been working on process level projects for 15-20 years, while enterprise level process work is relatively new for most companies"*, (Harmon, 2008). But the interest for enterprise process modelling, and not only focusing the processes within a legal unit, seem to increase according to the above mentioned report:

- *13% always or most of the time include activities performed by outside vendors/partners in major process models*
- *47% claim that development of an Enterprise Process Architecture is a business process initiative that is underway this year (2007)*
- *57% expect to be more active with development of an Enterprise Process Architecture in 2008 (only 3% expect to be less active)*

There is a growing movement toward what could be called "Enterprise BPM". Included in this movement is a clear interest in the unique combination of processes that secures the competitiveness of the enterprise. Thus, organizations need to develop strategically aligned capabilities not only within the company itself, but also among the organizations that are part of its value-adding networks. Owing to this new business approach, many firms are now viewing processes as strategic assets. Under the new approach, organizations are no longer viewed as a collection of functional areas, but as a combination of highly integrated processes. (Lockamy and McCormack, 2004)

RESEARCH QUESTION AND APPROACH

The purpose of this paper is to explore and discuss possibilities, benefits, driving forces and barriers for increasing adaptability and integration in supply chains by the use of concepts and methods from Business Process Management (BPM).

The research is based on literature studies – both actual and extended over a long time, thus giving us a good idea about different phases of development – , publishing, experiences from past and present research projects, teaching, long term SCM experience, and a decade of practical work as process consultants. The paper is also intended to be part of the documentation of a recently started interdisciplinary research project named XCPO (Cross Company Process Orientation) with funding from the organisation NGIL (Next Generation Innovative Logistics). Case studies of two different supply chains, with well known companies, are currently in an initial phase.

SCM – FROM A PROCESS PERSPECTIVE

Most definitions of the concept SCM includes the word process, see e. g. Lambert (2006). The scope of SCM addresses a wide range of issues. In order to cover all dimensions and aspects of SCM the definitions suggested are often followed by explanations of single keywords as well as their combinations. However, very seldom is the word process explained, despite it is almost always included. A corresponding observation is that despite extensive indexes in the SCM literature the word process is scarcely included (see e. g. Mentzer (2001)).

The situation becomes even more remarkable as there often is a number of "unitized words" included in the literature, unitized words that are needed for creating a deeper understanding for SCM. Examples of this could be process assessment, integration of processes, replenishment process, supply chain processes, key processes (Mentzer). Another typical example is D. Lamberts book "Supply Chain Management: Processes, Partnerships, Performance" (2006). Whereas the two latter words are explained and found in the subject index, the word process is not. Could it be that the word process often is seen as too simple for being worth a definition or could the reason on the other hand be that it is too complex and thus too difficult to define?

The literature offers a number of modernised yet very traditional definitions for SCM. Mentzer describes SCM as *"the systemic, strategic coordination of the traditional business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."*

In 1998, the Global Supply Chain Forum (GSCF) defined supply chain management as *"the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders"* Lambert et al (1998).

Obviously SCM is mostly seen as an integrative philosophy but it is not a matter of course *what* is to be integrated. From a process perspective there is an abysmal difference between *coordinating functions* and *integrating processes*.

The relation between processes and SCM is obvious but not unfussy. SCM is based on a will to give attention to and manage material flows. As a consequence process maps tend to take its starting point from the material flow from origin to destination (from ear to loaf of bread). This is not in harmony with a sound process view. A process is all about satisfying a need. The need of an external or internal customer starts a number of activities that all together contribute to satisfy this need. A useful definition of process is: *a repetitively used network of activities linked in an orderly manner using information and resources for transforming "object in" into "object out," extending from the point of identification to that of the satisfaction of a customer's needs*, Larsson & Ljungberg (2007). Most of all a business process is a value adding structure, a process map must therefore be something more than a graphical to-do-list.

BPM – FROM A SUPPLY CHAIN PERSPECTIVE

The origin of BPM can be found in different other concepts like Just-in-time (JIT), Total Quality Management (TQM) and Time Based Competition (TBC). In connection to BPM the term Process Orientation (PO) is often mentioned. In their book *"Business Process Orientation"* (2001), McCormack and Johnson define this term as follows: *"An organisation that in all its thinking emphasizes process as opposed to hierarchies with special emphasis on outcomes and customer satisfaction"*.

What are the reasons for bothering on the relationships between SCM and BPM? An enterprise cannot afford to have different improvement and management activities going on in parallel without coordination and harmonisation. Initiatives might be addressing the same units of interest but with different ambitions and with different results. The impact of the function oriented organisation is significant not just for operative matters but also for the development. In the very same organisation the sum of these efforts may not only be awkwardly small but also even harmful. The results might obstruct each other. A better coordination of SCM and BPM will not harmonise a diversified portfolio of improvement projects that exist in most organisations but it could be an important first step.

BPM is based on a will to reveal and manage the value creation. A process map subordinated to a proper process view will illustrate a process that takes its point of departure in the value adding sequence from customer need to customer satisfaction (“from hungry to full”).

THE AMBITION TO INTEGRATE

It could be argued that there are major similarities in the ambitions for SCM respectively BPM. The ambition to manage and integrate functions, companies or processes unites the concepts.

From a process integration point of view SCM is much more difficult to implement successfully as its ambition involves different legal units and complex relations. It is not especially bold to argue that the SCM ambition, from a process point of view, is far more demanding and complex than BPM as it is normally used. On the other hand there is a lot to learn from BPM implementations when working with supply chain integration.

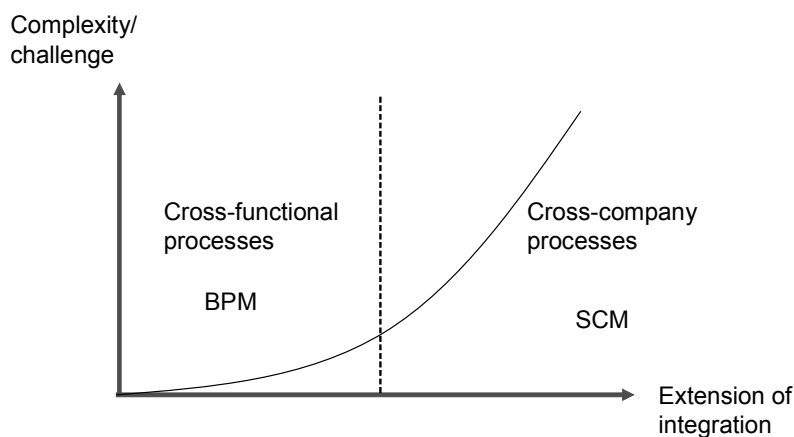


Figure 1 – Similar ambitions of SCM and BPM but with different complexity

Dyadic relations have been studied and successful results have been reported (see e. g. Peter Trkman et al (2007) “Process approach to supply chain integration” which describes “*how business process modelling (specifically process maps) can be used in order to achieve improvements in sharing information and the integration of processes*”....“*All the theoretical findings are illustrated in a case study of a two-tier supply chain in the oil/retail petrol industry, which encompasses a company with several petrol stations and a transporter which transports petrol from warehouses to petrol stations*”). The study also shows how the creation of a common process map essentially simplifies the flow and improves the business. A focal company could potentially find dyads on the supplier as well as on the customer side as a first step in an integration effort.

CROSS COMPANY PROCESS ORIENTATION (XCPO)

As is apparent from discussions above there are similarities but also essential differences between the concepts SCM and BPM. It also means that there are

important differences regarding drivers and barriers for successful implementation of the concepts.

The SCM view – focus on material flow – or from origin to destination does not answer questions of the type “*why, where or how value is created*”, while BPM with its focus on “*value creation for the customer*” must do this. It also means that it is natural that BPM must be adjusted to the strategy(-ies) of the company(-ies) while the flow focus of SCM tend to be more on an operational level. Correspondingly – based on the definitions and using a popular metafor – SCM is focused on “*journeys*” while the BPM concept (“*how?*”) naturally focus on development of the “*road*”. In other words you might say that SCM is about flow while BPM is about structure.

Continuing the discussion of what is natural or not SCM should be cost focused while BPM should be income or benefit focused. The SCM concept “*from origin to destination*” does not necessarily include issues about how value is created while the BPM focus “*from hungry to full*” is likely to also include flow issues.

An important driver for development is to identify gaps in different aspects. In the current case an obvious gap can be found in the fact that SCM includes different links in a supply chain while BPM – with few exceptions – is used for single companies. That leaves BPM used in cross company situations as an interesting, and more or less new research area. A number of *interesting research issues* arise if we extend BPM to be used in connection to supply chains. As examples might be mentioned:

- Which characteristics should characterize the Business Process Owner (BPO) in a supply chain perspective? We assume that just as in the single company case somebody should be appointed to be responsible.
- Which relations should be encouraged respectively avoided between the BPO and the different links in the supply chain?
- How can the areas of authority and responsibility for the BPO be described?
- Which are the potential costs and benefits? How should they be allocated?
- A supply chain can actually be better described as a demand network. How might this affect the BPM concept?
- Companies are normally involved in different supply chains with different business ideas, strategies and objectives. How can this be taken care of?

There is also a number of barriers when it comes to process orientation of a supply chain. Already in a single company there are barriers in the form of so called “*functional silos*”. Extending the processes to a whole supply chain the functional silos still exist as potential barriers. A number of new or more explicit *barriers* will however arise. As examples might be mentioned:

- The links in the chain are different entities from a juridical point of view
- The cultural differences between links are probably larger and must be overcome
- Collaboration between links is voluntary
- Information dissemination is different
- Different links in the chain might have different overall strategies. One may e.g. have a low cost strategy and another a high service and quality

strategy. Are they possible to combine in an efficient manner? Which will be the overall strategy?

- Measurement systems might differ essentially. How to develop a common measurement system?
- Even in a single company there are often several different IT-systems. What about coupling together IT-systems in a whole chain?

Then, what are the *drivers* of improved integration, or if you like, cross company process orientation? We might pick a couple of arguments, there are several, from the interview with M. Hammer, which is mentioned earlier. On the question that he has stressed the importance of knocking down the walls between trading partners and why this is so important and so difficult to do the answer was a.o. *"It's important because walls equal costs. And the higher the wall, the higher the costs. The walls between companies are much higher than the walls inside companies. For the past 10 years, most companies have been focusing on the internal walls" ... "But despite the progress internally, the outer walls remained intact. When activities go over those walls, there is a lot of overhead involved, a lot of duplication" ... "Perhaps the toughest part of knocking down the walls is that you are going against some very deeply ingrained attitudes and patterns."*

Hammer also got the question what he meant when saying that companies need to be process enterprises. The following is a short excerpt from the answer: *"A process view – that is, looking at work in end-to-end terms – is important because costs, delays, errors, and inflexibility come more from the connections between pieces of work than from individual work pieces themselves. When we manage work only in terms of the discrete components, the outcome suffers. To achieve the levels of cost, productivity, quality, service, and cycle-time reduction required today, you need to look at work holistically."*

SOME EMPIRICAL FINDINGS

The very first day we started a case study for the research project underlying this article, we were confronted with four completely different types of process maps in different parts of the very same organisation, just by talking to the people involved in SCM and logistics. Even within the same branch of learning there are tendencies for applying quite different and partly conflicting approaches to processes. Logistical analysis sometimes includes a not beneficial description or division where it is differed between material flow, information flow and financial flow. Considering this division it is not surprising that there still is a belief that IT-systems can be developed in isolation from the value creating processes that are to be supported. One can for instance not develop a common IT-system for different company units if the underlying processes are not harmonised.

Something that often strikes us is the predominance of function-oriented measurements in a company. You cannot even talk about a measurement *system* because the different measures are not related to each other, there are no specific rules and procedures for data capture, compilation, presentation, communication etc and they are hardly possible to use in an efficient way for analysis and possibly leading to action.

CONCLUSIONS

A common characteristic is the need of knowledge, skills and understanding and thus education.

To improve adaptability and integration in global supply chains is a difficult task unless you are not focusing on minor changes, or working with a simple chain. If you realize that supply chains are merely complex networks and take into consideration all the "interesting research issues" and barriers mentioned in this paper (both are by the way only a selection) it is not that easy. On the other hand the potential benefits are great.

Then why not put one's money on and further develop a concept (BPM), methods and tools which have appeared successful for other more limited task like in single companies. In other words a research project like XCPO. Just imagine for example what a change in concept from "origin to destination" to "from hungry to full" will mean when developing a value adding process in a supply chain!

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PROCESS CONTROL IN AGILE SUPPLY CHAIN NETWORKS

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ABSTRACT

The work comprises a new theoretical development applied to aid decision making in a new and increasingly important commercial sector. Agile supply, where small volumes of high margin, short life cycle innovative products are offered, is increasingly carried out through a complex global supply chain network. We outline an equilibrium solution in such a supply chain network, which works through limited cooperation and coordination along edges (links) in the network. The links constitute the stochastic modelling entities rather than the nodes of the network. We utilise newly developed phase plane analysis to identify, model and predict characteristic behaviour in supply chain networks. The phase plane charts profile the flow of inventory and identify out of control conditions. They maintain quality within the network, as well as intelligently track the way the network evolves in conditions of changing variability. The methodology is essentially distribution free, relying as it does on the study of forecasting errors, and can be used to examine contractual details as well as strategic and game theoretical concepts between decision-making components (agents) of a network. We illustrate with typical data drawn from supply chain agile fashion products.

Keywords: Agile Supply Chain, Inventory, Process Control, Push and Pull Strategies, Bullwhip Effect.

Topic: Supply Chain Management, Design and Organization of Supply Chains, Supply Chain Performance Assessment.

INTRODUCTION

For businesses to compete in the commercial sector where markets are increasingly more volatile, and unpredictable demands create uncertainty, their supply chains have needed to adapt to respond to such unpredictability. This capability a supply chain has of becoming flexible is referred to as *agility* ([1]; [2]) and some of the conditions in which an agile approach is best suited can be described by the following characteristics: (i) short life cycle products; (ii) high product variety in the face of unpredictable demand; (iii) small volumes and higher profit margins; (iv) competition based on product specification. With this agility the supply chain more frequently operates in a global context and there is an increasing trend to outsource the supply and manufacturing overseas, through a complex supply network ([2]; [3]; [4]), to reduce costs.

The global fashion industry is a prime example, particularly in the high end of the fashion market, in which businesses are competing in a fickle, volatile and unpredictable market where high-variety, high margin, short-life products are being sourced globally ([3]; [4]). Fashion retailers exploit this unpredictable market by introducing new products to their stores as frequently as possible, where product life cycles, from first offering in a store to discounting, average 6 weeks. There can be few industries where there is a greater need for a more

responsive and rapid design/manufacturing/delivery lead-time throughout a complex global supply chain ([3]).

Using the fashion industry as a case study, this paper aims to introduce a new theoretical development ([6]; [7]; [8]; [9]) to aid agile supply chain decision making under uncertainty and the remainder of the paper is structured as follows. We first describe the agile global fashion industry supply chain in more detail and highlight some of the key decisions, in particular for the retailers, whilst exploring the relevance of earlier research and literature. We then outline the modelling approach and an equilibrium solution in such a supply chain. The methodology of prediction capability using phase plane analysis is then illustrated with an example from the agile fashion industry making use of simulation. The paper ends with a conclusion and details of further research and collaborative work in progress.

THE AGILE FASHION INDUSTRY

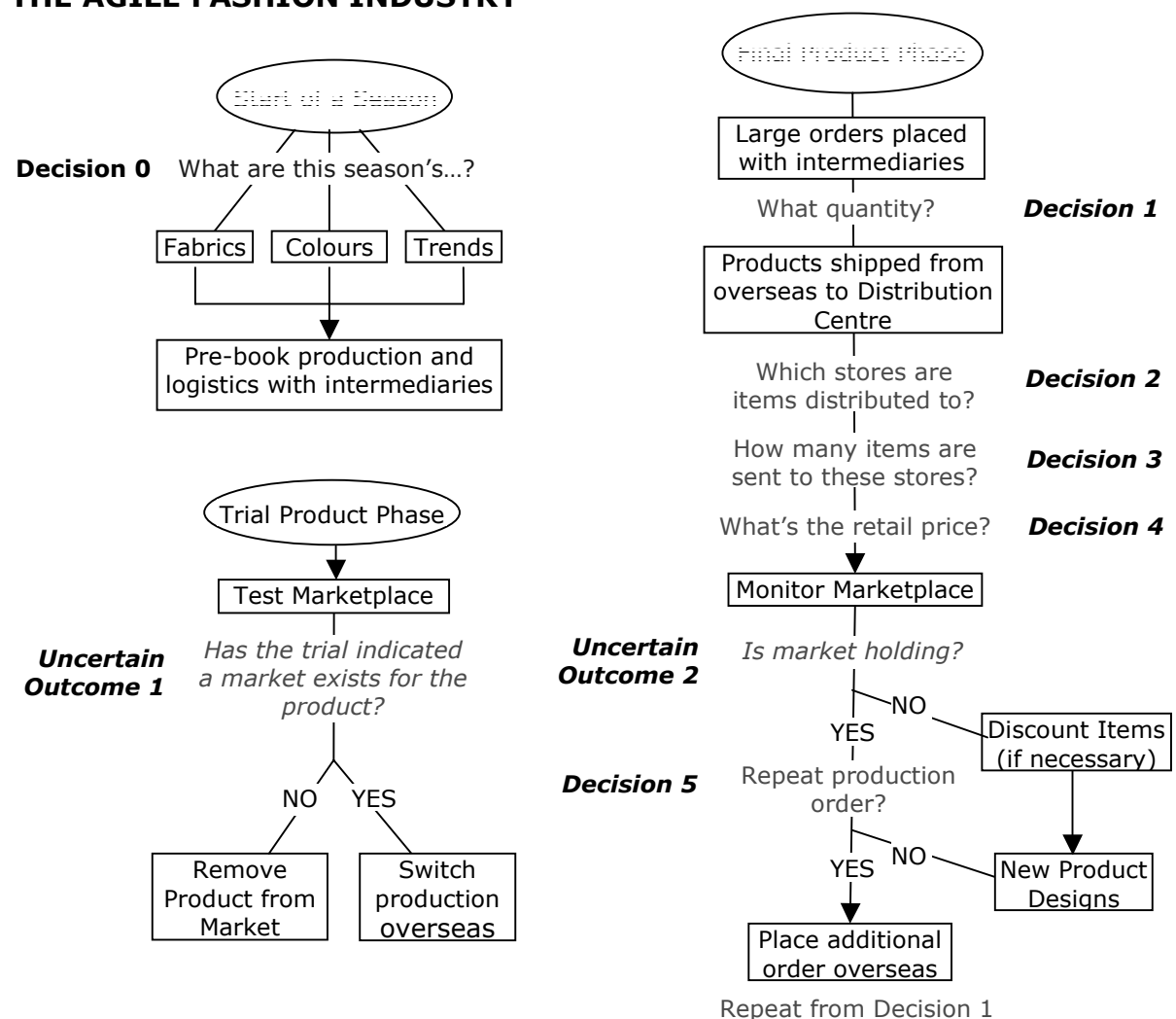


Figure 1. Key Retailer Decisions

In attempts to exploit the unpredictable UK market, high fashion retailers introduce new products to their stores as frequently as possible which in most cases requires global sourcing. Figure 1 illustrates their key decisions throughout

this process of introducing new products, from the start of a season to the final product phase.

The process begins with the UK retailer's product design conception at the start of a season. Market trends will be continuously monitored and once the retailer has made a decision on fabrics, colours and trends (**Decision 0**) which they anticipate will be fashionable for a forthcoming season, the production and logistics are pre-booked. This relates to a tactic known as postponement, which is based on the principle of early product design and the delaying of final production until the final market destination and/or customer requirement is known ([1]). In this case postponement allows for any changes the retailer wants to make to the product specification before its introduction into the market. The pre-booking is predominantly done through overseas intermediaries who are agents with no manufacturing capabilities or assets (if they do own assets it is normally major logistics capability), but have access to an appropriate supplier network, which their role is to manage. At this stage, before the product definition and launch, the intermediary would select preferred fabrics and suppliers.

Once the product design is complete it may go through a trial period in the retailer's flagship store (this is not always the case). At the trial stage the product can often be sourced and produced locally in small quantities (<20 items). The outcome of the trial (**Uncertain Outcome 1**) determines whether the production is switched overseas in large volume (>500 items) or the product is removed from the market.

When the production is switched overseas a large order is placed with an intermediary (**Decision 1**) who is responsible for sourcing the product at the lowest cost and lead time possible. The most common approach to sourcing ([3]) is through competitive auctions, organised by the intermediary, for garment manufacturing by passing product specifications and volume requirements to approved manufacturers in the supply network base. Manufacturers send back an "offer package" based on price and lead time and the best "offer" would be selected. The finished products would undergo quality checks by the intermediary and then dispatched to the retailer's distribution centre.

The remaining decisions the retailer has to make are when the finished product has been delivered, regarding its distribution amongst the stores and complete introduction into the market (**Decisions 2-4**). The average time such products exist in the market is 6 weeks, but can be as short as 3 weeks. During this time if customer feedback indicated the market was holding for the new product (**Uncertain Outcome 2**), a repeated order may be placed (**Decision 5**). Otherwise the products are discounted or sold through less fashion conscious outlets toward the end of its 6 week life cycle ([3], [5]).

MODELLING APPROACH

The approach adopted in this paper firstly recognises the distinct difference between the specialist skills of forecasting and those acquired by decision makers in operations management. Given an environment in which customer demand is increasingly uncertain, errors in forecasts are expected and when these errors are acknowledged and shared, real strategic progress can be achieved. The

methods we use identify phenomena of practical interest, such as push and pull effects which occur in manufacturing systems, marketing strategies and the bullwhip effect, whereby variability is pushed upstream through a variety of transactional strategies and agreements ([7]).

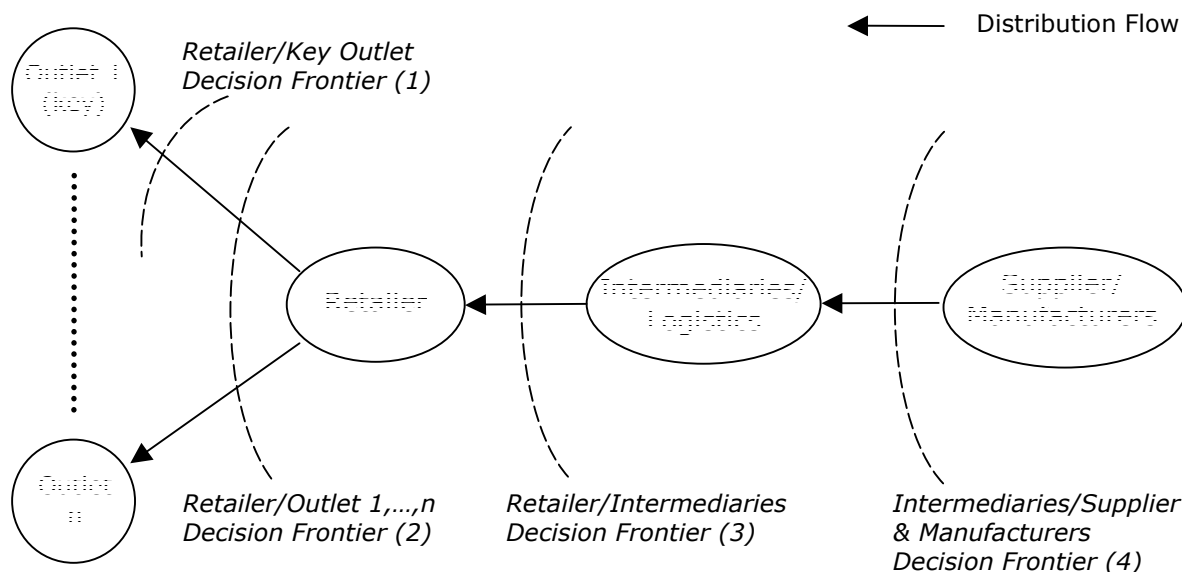


Figure 2. Decision Frontiers for a Typical Agile Supply Chain Network

The problem type, which is a specific case of a general type of mathematical problem, the two-echelon (primal-dual) problem, is illustrated in Figure 2 where the distribution of new products in the agile fashion industry (from the base of suppliers to the retailer) is divided by one of four possible decision frontiers. Each decision frontiers acts as a line-cut and divides the connected network into two components, which can be treated as primal or dual ([6]). There can be as many decision frontiers as there are line-cuts in the graph representing the network, each generating a set of decisions and efficient frontiers. For instance, the two-echelon problem defined on Decision Frontier 3, where an intermediary determines the cost to charge a retailer, and a retailer determines the amount of inventory to order through an intermediary and the retail price.

The objectives in this problem are to increase profit, reduce waste and improve customer service in a coordinated way under current business practice. At Decision Frontier (3), for example, this requires a profit maximizing solution to the decision set $\{\mu, \eta, \sigma_e(\mu, \eta)\}$, which is derived from the variables μ_D (the mean demand) and μ_Q (the mean supply) by applying the primal-dual transformation, i.e. $\mu = \mu_Q - \mu_D$, $\eta = \mu_Q + \mu_D$, and σ_e is the standard deviation of the combined forecasting errors for the demand and supply. The following formulation is based on the model described in detail in Pearson ([9]), which assumes that unbiased demand and supply fitting or forecasting techniques are already applied and the prediction errors are normally distributed. The primal-dual objective is to maximise:

$$E\{\text{Profit}\} = E\{\text{Contribution from captured demand} - \text{Costs of overage} - \text{Costs of underage}\}$$

$$= \mu_D c_p - \{(\varphi(k) - k(1 - \Phi(k)))(c_{u_1} + c_{o_2} + c_p) + (k\Phi(k) + \varphi(k))(c_{o_1} + c_{u_2})\} \sigma_e \quad (1)$$

$$\text{subject to: } \mu - k\sigma_e = 0, \quad (\text{Newsvendor Constraint}) \quad (2)$$

where $\varphi(k)$, $\Phi(k)$ are normal distribution density and cumulative distribution functions, respectively, for safety factor, k . The contribution to profit is c_p which includes the contributions from the retailer and intermediary. The overage and underage costs of the retailer are c_{o_1} and c_{u_1} , respectively, while for the intermediary they are c_{o_2} and c_{u_2} . An interesting feature of the problem and the way it is formulated is that the retailer's (primal) overage is the same as the intermediary's (dual) underage, though they may have different attitudes to these phenomena resulting in unequal costs.

The equilibrium solution under conditions of constant variability is described by the following equation ([9]):

$$\Phi(k) = \frac{c_{u_1} + c_{o_2} + c_p}{c_{o_1} + c_{u_1} + c_{o_2} + c_{u_2} + c_p} \quad (3)$$

The equilibrium solution under conditions of changing variability is described by the following equations ([9]):

$$\Phi(k) + \frac{\partial \sigma_e}{\partial \mu} \varphi(k) = \text{Const} \left\{ = \frac{c_{u_1} + c_{o_2} + c_p/2}{c_{o_1} + c_{u_1} + c_{o_2} + c_{u_2} + c_p} \right\} \quad (4)$$

$$\varphi(k) \frac{\partial \sigma_e}{\partial \eta} = \text{Const} \left\{ = \frac{c_p}{2(c_{o_1} + c_{u_1} + c_{o_2} + c_{u_2} + c_p)} \right\} \quad (5)$$

Equation (4) is the 'mix' (overage/underage) solution, which tracks the way partners across decision frontiers synchronize their efforts to reach optimality, and equation (5) is the 'global' (volume) solution. Together they form a dynamic system of stochastic differential equations which trace the optimal solution in circumstances where uncertainty increases or decreases over time and with relation to differing contractual and marketing strategies.

The model outlined here fulfils many of the requirements of modern agile supply chain networks. One of the requirements is the incorporation of non-deterministic demand, lead-time and supply mechanisms into the modelling methodology ([10]). The patterns identified in such contexts frequently do not match deterministic assumptions, which are more generally associated with periods of stable operation. The complexity of events occurring in a local context is particularly difficult to express in a simple model. Nilsson et. al. ([10]) describe the need for complex adaptive systems (CAS) and agent-based modelling (ABM). Our approach to the study of network flow uncovers a duality between networks as knowledge structures and networks as decision making structures ([11]) across naturally occurring decision frontiers ([6]). The approach also identifies through the use of phase planes the way in which two decision makers (agents) coordinate their efforts to achieve capable solutions in environments experiencing changing variability and increasing uncertainty ([7]; [8]). Patterns in the 'local' phase plane reflect the way in which endogenous variables, such as negotiated costs and contractual agreements between agents ([12]; [13]), affect the

optimal solution. Patterns in the 'global' phase plane reflect the way in which exogenous variables (such as pricing promotion strategies and quality of forecasting in the global market) affect the optimal solution. The two phase planes are significantly uncorrelated ([7]). Each phase plane has an efficient frontier derived from the solution of the stochastic differential equations (Equations (4) and (5)). This is now demonstrated in the following section.

ILLUSTRATION

We illustrate the use of prediction capability and phase plane analysis at Decision Frontier (1) with an example representative of a high fashion product which has been introduced for the first time into the market, such as a woman's camisole or vest top. The contribution to profit is $c_p = 6$, and $c_{o_1} = 5$, $c_{u_1} = 0$, $c_{o_2} = 0$, $c_{u_2} = 1$. The equilibrium solution is found to be $k = 0$ (derived from Equation (3)). Simulation is used to demonstrate the strategies employed in the marketing of high fashion clothing and data was simulated based on this illustrative example using a Java program. In this simulation the forecast demand is calculated using simple exponential smoothing with smoothing constant 0.2 and the forecast supply is calculated using the coordination constraint, $\hat{Q} = \hat{D} + k\sigma_e$, with $k = 0$. The demand, D , is randomly generated from the standard normal distribution whose mean increases for the first three weeks and decreases for the remaining six, and similarly for the supply, Q . This is presented in Figure 3 for a 9 week period which is representative of an average life cycle for a high fashion product in a retail outlet, where sales peak in weeks 3-4 ([5]).

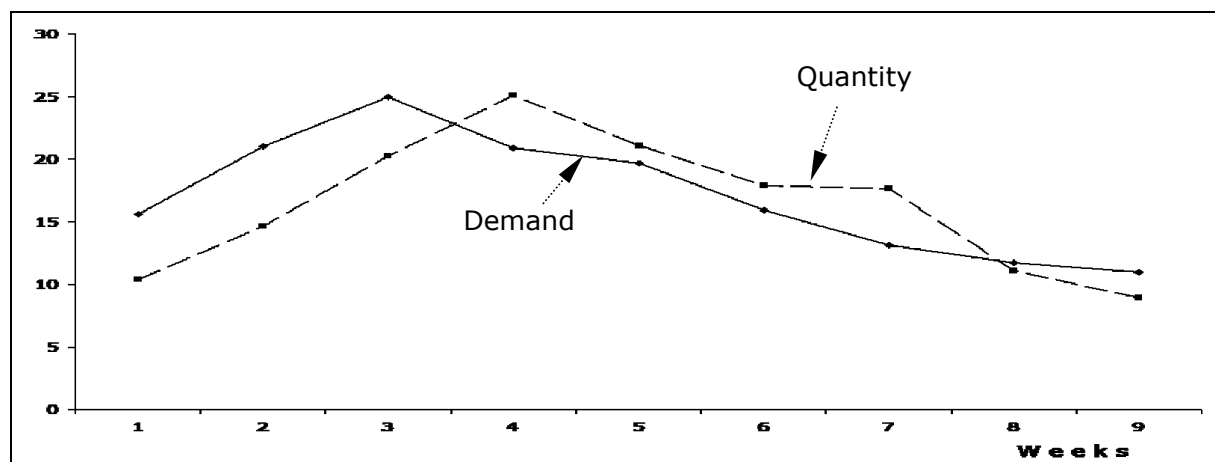


Figure 3. Time series life cycle of high fashion product over 9 week period

From Figure 3 the supply for this example product displays a lag behind the demand. This describes a common approach in marketing a new product, whereby the retailer attempts to generate demand for a high fashion garment in the early stages of its life cycle, pulling the quantity amount up gradually, and branding the product as exclusive, then in the latter stages of the life cycle as the demand drops it pulls the quantity along with it, after a delay. Associated with this is the product's profile illustrated by the global and mix phase planes in Figures 4 and 5 respectively. The global phase plane identifies changes in the error variability, σ_e , to the expected volume, η , of trade as new markets are investigated and the mix phase plane identifies the way in which two decision-

makers (agents) coordinate their efforts to achieve capable solutions in environments experiencing changing variability and increasing uncertainty.

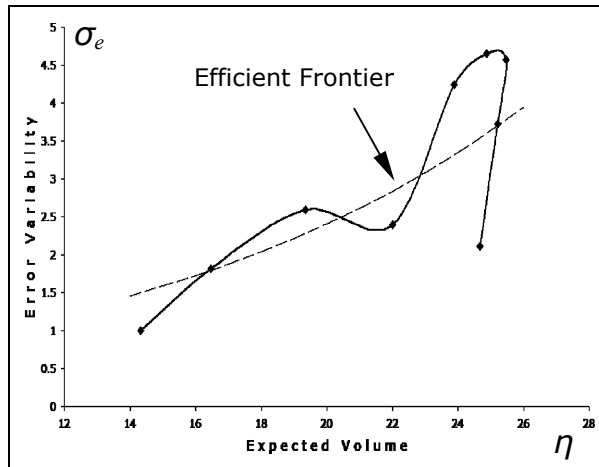


Figure 4. Global phase plane

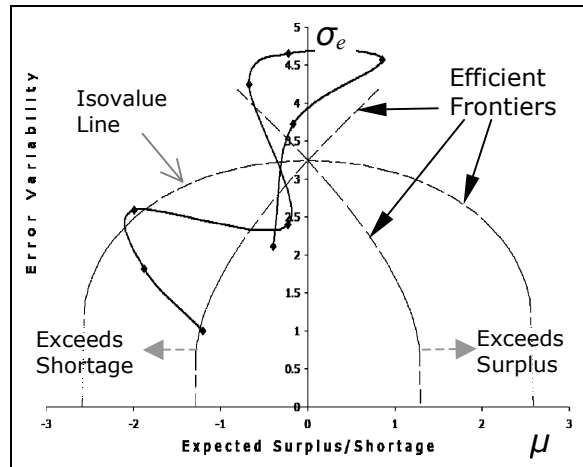


Figure 5. Mix phase plane

The profile in Figure 4 displays a typical increase in variability as volume increases. The efficient frontier for optimal allocation of stock volume can also be mapped onto this phase plane. Market operation along this efficient frontier ensures maximum profit levels for a desired area of risk. Figure 5 illustrates the relationship between the two operators functioning across a decision frontier by mapping the changes in error variability, σ_e , against the expected surplus/shortage, μ . So in this example it shows how well the retailer and the outlets coordinate the flow of the product upstream in the SCN and the way in which error variability (and hence risk) varies through this process. The variability we speak of here is not just demand variability but the joint variability experienced by both operators on either side of the decision frontier. The path of variability in Figure 5 (bold line) displays an overall clockwise movement, indicating a 'pull' effect, which corresponds to the description for this product's life cycle presented in Figure 3. Also mapped onto the mix phase plane are three efficient frontiers. The isovalue line shows, using k as a parameter, the efficient frontier for solutions which have the same profit level as that obtained by the maximum profit solution (at $k=0$) which achieves the desired target levels of surplus and shortage. The other two efficient frontiers, which are derived from parametric equations given constant surplus and shortage targets ([9]), plot the area of capable optimal solutions using k as a parameter again. The optimal solution occurs at the point where all three efficient frontiers meet, so that agreed targets on customer service and overproduction match the maximum profit achievable in the area of market uncertainty for which the product is retailed.

CONCLUSION

Agile supply chain networks, which are characterized by their complexity and flexibility due to the extended global networks of different suppliers required for high product variety, operate within high risk levels. There is therefore a requirement for more suitable decision-making models as management tools to monitor and audit, as well as improve, supply chain performance. The model outlined in this paper incorporates non-deterministic demand, lead times and supply mechanisms into the methodology fulfilling many requirements of agent-based modelling (ABM) and complex adaptive systems (CAS). It identifies the

non-linear behaviour of the product's market area and the relationship between operators in the SCN across explicitly defined decision frontiers, which can be used to enhance the decision-making for businesses operating in such volatile markets. Much research has been carried out in lean supply chain networks but relatively little quantitative work has been done in agile networks. Furthermore, although the methodology we have proposed can be applied in both the lean and agile contexts, the innovative facility to map changes in variability is a key feature which should enhance research and understanding of the mechanisms occurring in such supply chains. The next stage of research will involve developing a commercial model through collaborative work which will aid the decision-making throughout the whole process of introducing a new product into the market.

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SECTION 3

SUPPLY CHAIN PERFORMANCE ASSESSMENT

OCEAN TRANSPORT SERVICE QUALITY ASSESSMENT

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ABSTRACT

Today, there is less distinction between manufacturing and service firms because manufacturing firms intensively include service activities into their product packages. Ocean transportation is certainly a service activity that is one of the key logistics functions. The level of customer service relies very much upon the quality of transport operators, particularly offshore business operations. However, quality of service is difficult to identify. This study proposes the direction to assess service quality of ocean carrier by focusing on service discrepancy between service expectation and performance perception of the selected case in Indochina market. Additionally, this study enables the researcher to understand current status and improvement opportunity of the selected ocean carrier in Indochina market.

The analysis of the selected cases in Cambodia, Thailand and Vietnam reveal that the "Service Quality Gap Model" is useful to assess service quality but it ought to be used with care. Nevertheless, this research has already proposed measurement indices for shipping industry in particular to avoid non-related universal index to shipping industry. The result reveals that service quality is perceived differently by the frontline staff and customer in each country. This is because different determinants dominate the expectation of people in each country although service provided by companies are standardized. Moreover, tangibility features of service quality do not have much importance to the customer in determining service quality of shipping company. Certainly, to lift the level of quality, service customization for the customer in each country is necessary. Customer know-how and strong commitment from management of all levels is the prerequisite for firms.

INTRODUCTION

In the global competition arena, we can see the dramatic growth in external trade (both import and export) of Thailand. In recent years, the growth has driven higher demand on ocean transportation services. According to Banomyong et al (2005), in Thailand, it was found that ocean transport is the most preferred transportation mode. However, we have very rare information of this service sector in particular. In contrast, the ultimate goal of logistics is to maximize satisfaction of customer, but people tend to focus on measuring of manufacturing sector rather than service sector. Because service possesses the intangible characteristics which is difficult to measure, therefore, service quality tends not to be measured and organizations tend to measure what is easy to measure and quantify and are reluctant to use soft qualitative measures (Stock and Douglas, 2001).

The primary objective of this study is to introduce methodological guidelines as well as proposed predictor variables which can be used for measuring service

quality for ocean transport service. The secondary objective of this research is to seek a greater understanding of problem and current status of the selected carrier in providing services, and meantime explore the opportunity to improve service quality. Although company provides standard service to its customers under the same policy region-wide, but we believe service quality in each country is perceived differently. This is because services are delivered under different environment, conditions, and culture. Thus, we would set the hypothesis for this research as:

$H_0 : \mu_{kh} = \mu_{th} = \mu_{vn}$ *Service quality perceived in each country is not different*

$H_1 : \text{at least one pair of } \mu_{kh}, \mu_{th}, \mu_{vn} \text{ is not equal}$ *at least Service quality perceived between two countries are different*

METHODOLOGY

The case study was selected from a Thai regional shipping line. This study is limited to Indochina region only which is consisting of Cambodia, Thailand and Vietnam. Sample represents the respondents from managerial level, frontline staff and customers of the selected company in three countries. The data was collected through questionnaires with 350 respondents and only 334 questionnaires were returned (95.4%). On customer side, the sample was randomly drawn from a listing of customers during past 12 months in Cambodia, Thailand and Vietnam. The type of companies represented by the respondents includes manufacturing, trading, freight forwarder and shipping line.

There are a lot of service quality assessment model which depends on how the researcher defines service quality. On this study, service quality gap model (SERVQUAL) is utilized because it is easy to use, analysis and understanding. Although SERVQUAL tend to be universal model for measuring service quality across industry, there is a concern regarding the reliability of comparing service expectations from a general industry sector with the actual service quality perception of a particular company. Expectation and perception may not be correlated and can cause varying result from different respondents. A possible solution to the problem is to tailor each SERVQUAL study to the particular company or industry under investigation (Baggs and Kleiner, 1996). Ocean transport is a vital part of logistics; therefore, there is the need of tailored SERVQUAL rather than universal indication. To tailor SERVQUAL, measurement indices are collected from various sources, including SERVQUAL's universal indices. The former literature is a very good source of information for service quality assessment indices and many indices on this context are from there. Finally the indices are required to validate by the panel of expert which consisting of expert from shipping and logistics industry, and expert from importer and exporter. The indices will be examined by using content validation method whether the content of indices is appropriate for measuring service quality in shipping industry. Importantly these indices will be utilized in constructing of questionnaire.

Service quality assessment is measured in accordance with SERVQUQAL model which intend to measure Gap in five parts;

- Gap-1, not knowing what customer expects
- Gap-2, the wrong service quality standard
- Gap-3, the service performance gap
- Gap-4, when promises do not match delivery
- Gap-5, customer's perceived service quality shortfall

Additionally, ANOVA is used for testing the hypothesis of customer's perception in each country toward service quality renders by to company. In the final stage, multiple regressions are used to identify the factors which influent the perception of customer in each country.

RESULTS

The overall picture service quality (as shown in Figure 1) can be considered as fair because there is slightly shortfall in quality on service specification gap (G2). Management of the firm can understand customer's requirement very well as reflect in the score of G1, but the problem happen during transition of customer know-how to service specification (G2).

The shortfall in quality of service specification is the result of senior management put too little commitment to service quality, especially resources commitment in delivering service quality to customer as it was low scored by manager. This SERVQUAL score is also corresponding with our statistics testing (by using multiple regressions). The formal process for setting service quality goal of company is another factor which causes a large gap in service specification.

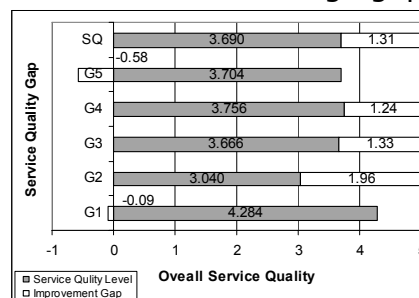


Figure 1 Overall service quality

For whatever the reason from management, when the standard operating procedure are channel down the line to frontline staff, additional service gap incur. Carrier's service quality is fair on the service performance and service delivery. Among frontline office, Thailand contribute the biggest discrepancies and follow Vietnam and Cambodia respectively. The reason behind service performance (G3) shortfall in quality is lacking perceived control when staff is keeping on to (1) solve the uncontrollable problem, (2) lacking of freedom to perform job, (3) service too much customer (4) dependent on other people to perform job.

To confirm this service perception of customer in three countries, we used ANOVA to test the relationship of customers' perception against services provided by the selected carrier in each country, the result reveal that there is a significant difference between customers' perception and country operated, $F_{(2,260)} = 4.127, p < 0.05$. Then the H_1 is accepted. From ANOVA testing, it has proven that there is no panacea for service quality if firm is operating in multi-national market because customer perceives service quality differently

The overall picture of service quality in Cambodia is considered as the best comparing with Thailand and Vietnam office. From staff and customer stand point, their service qualities is rated good, but improvement gap for office in Cambodia is 0.86 points. Since the carrier is using centralized management

approach, they apply the same policy to all branches in Asia and Australia. Therefore, managerial service quality gap (G1 and G2) will be the same for all country.

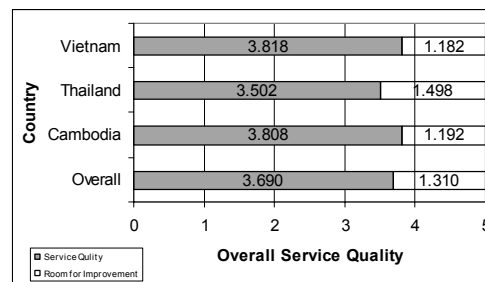


Figure 2 Comparison of service quality in each country

The quality of service performance (G3) in Cambodia is rated well by frontline staff. The largest quality gap is on the tangibility dimension, standard of appearance of equipment, particularly container condition. On the assurance dimension of service performance are the second largest gap, fair quality. It means that the employee just feel alright with the knowledge and courtesy in delivering service to customer that they can perform to meet company's desire. On the empathy aspect, fair quality, Cambodian employees do feel alright with the individualized service paid to their customer. There is reliability and responsiveness of service performance is rated on good quality.

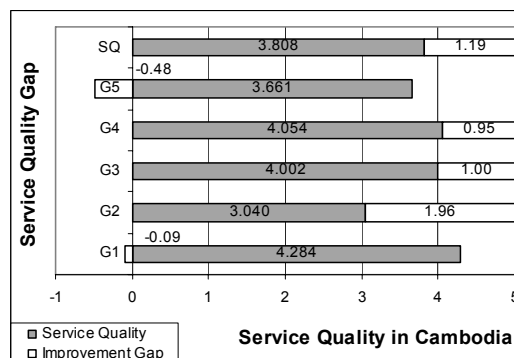


Figure 3 Service quality in Cambodia

Trace back to managerial gap, G1 & G2, it was happening the same while service quality always fall short on tangibility, assurance and empathy. Therefore, we can conclude that from G-1 through G4, service quality shortfall heavily occur on tangibility, assurance and empathy aspect. Customers assess service quality (G5), Cambodia office is perceived good service quality by customer. Service quality shortfall is on reliability, responsiveness, tangibility, empathy and assurance respectively. Multiple regressions are used to identify the relationship between gap-5 and customers' perception towards service. From our study, the result is as follows: By using stepwise method, a significant model emerged (Adjusted R square = .567; $F_{(5,78)} = 22.770$, $p < 0.05$). Significant variables are knowledge to answer question, accommodation of special needs, keep customer informed on vessel delay, global service and willingness of service personnel to help customer.

From Figure 4, the selected carrier provides fair service quality in Thailand where is its home-ground. Service quality shortfall is mainly on G2-G3-G4 which is internal quality. Service performance quality (G3) in Thailand is moderate. This is the quality of employee when they are unable or unwilling to perform job at the desired level. The tangibility aspects are poorly rated. Staff perceives company poorly maintain standard of the appearance of transportation equipment, physical facility and other equipment. This is corresponding to customer's experience in using company's container (P513) with considerable gap of improvement. Staff perceives themselves poorly in delivery the promised service, particularly, the appearance and condition of transportation equipment which is a big area of improvement for service quality in Thailand.

Responsiveness quality is fairly perceived and company often provides prompt service as company's standard to customer, but not every time. Moreover, employees have average ability, knowledge and courtesy to deliver service. This situation leads to average quality when service is actually delivered. On the empathy, service in Thailand is perceived on fair side. There is nothing impressive and disappointed on the caring and individualized attention providing to customer. The problem of the selected carrier's service quality in Thailand stem from following factors: role conflict, supervisory control system, lacking of perceived control and technology-job-fit.

Importantly, Thai customer perceives good service quality from all angles, but the biggest improvement gap is on responsiveness. The study reveals the quality shortfall on the area of prompt service from its service personnel, speedy in releasing shipping document, and speedy on claim. Other points which drag the quality down consist of (1) the condition of container (2) sufficient number of service personnel (3) the ability of contact personnel in keeping customer informed on vessel delay and (4) market communication through internet. By using stepwise method, a significant model emerged (Adjusted R square = .531; $F_{(6,121)} = 24.953, p < 0.05$). Significant variable are sincerity in solving problem for customer, container demand fulfillment, market communication through internet, shipping document releasing flexibility, willingness of service personnel to help customer and global service.

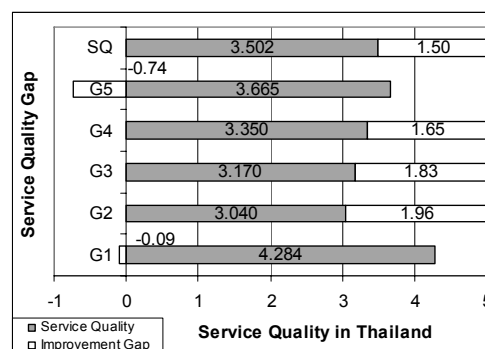


Figure 4 Overall picture of service quality in Thailand

Similar to other two countries, service quality shortfall is mainly on G2-G3-G4 which is internal quality. The overall picture of service quality in Vietnam is on good quality and a small room for improvement. Considering deeper, the room of

improvement is happening internally while the gap between company and customer is narrow. Service performance quality in Vietnam is fairly evaluated when they are unable or unwilling to deliver service at the desired level. The situation in Vietnam is nearly to be good, but not go as low as is happening in Thailand. The largest gap of service performance is the responsiveness quality and reliability quality. Although staff in Vietnam perceive both dimensions of quality on moderate side, but it still have a large room for improvement.

After trace this problem back inside deeper, we found the antecedent to service performance quality majority stem from following root causes that are lacking of perceived control, role conflict, supervisory control system and employee-job-fit. By using stepwise method, a significant model emerged (Adjusted R square = .640; $F_{(1,7)} = 15.207, p < 0.05$). The only one significant variable is right man on the right job.

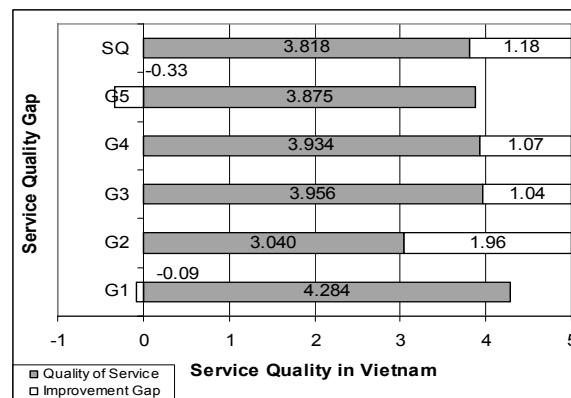


Figure 5 Service quality in Vietnam.

The quality of service delivery is moderate while open a considerable gap of improvement. Vietnamese staffs have the problem originated from internal and need management's attention on this issue immediately. That is the pressure from company to generate new business, under this circumstance, the contact staff is exposed to the over-promise, particularly personal selling. This circumstance stems from the company policy which focusing on selling rather than quality giving to customer. Customers' assessed service quality (G5), in total picture, Vietnam office can perform well to meet customer expectation and open a small gap for improvement. From customers' standpoint, company can fulfill their requirements on (1) providing sufficient service personnel (2) providing service safety policy (3) providing right type and size of container upon their need. SERVQUAL score reveal service quality drawbacks are on (1) internet cargo tracking system and (2) the condition of container provided to its customer. The multiple regression analysis revealed three major factors which have a significant relationship between Vietnamese customer's perception and service quality factors. By using stepwise method, a significant model emerged (Adjusted R square = .352; $F_{(3,47)} = 10.034, p < 0.05$). Significant variables are good container condition, speedy on claim process and ability to obtain assistance from port operator.

CONCLUSION AND DISCUSSION

Through hypothesis testing, it enable us to understand the customer even better because customers' perception in each country towards service quality is different and with linear regression tool enable us to identify how are their perception is different. Not only do we know perception of customer, but on provider side reveals where is the thing go wrong and help management to rectify the problem precisely.

According to Banomyong et al (2005), having said that 'accuracy of documents' and 'updated freight rate' are the most statistically significant for shipper decision making in choosing logistics service provider while transit time is not included. However, from our study, there is a significant relationship between Thai customers' expectation and transit time. If transit time implies service quality, then we believe transit time should be a critical factor influent the customer expectation in buying freight. Additionally, there is a statistically significant difference between the perceptions of quality among the customer in each country. The difference in customer perception is re-confirmed when all predicators variable are tested by linear regression. From the test, it reveals that transit-time is a critical factor for Thailand alone, but not Cambodia and Vietnam. Accuracy of documents and updated freight rate are likewise although both factors may be critical in Thailand, but it is very questionable for other country. Therefore, it is possible that the accuracy of documents and updated freight rate are not the universal answer for the customer, particularly when freight was purchased outside Thailand.

According to Metha and Durvasula, as regards perception, the preferred shipping line were rated tops on assurance and responsiveness, followed by reliability and empathy while perception towards tangibility was on the lowest. From table 1, there are some differences and similarity from our study. The similarity is tangibility dimension that is rated on the lowest. This implies tangibility aspect for shipping line is on the lowest important. Customers perceive service quality on other aspects differently and it is vary from country to country.

Table 1 Comparison of customers' perception towards service quality in each country

Singapore	Cambodia	Thailand	Vietnam
Assurance	Assurance	Reliability	Reliability
Responsiveness	Empathy	Assurance	Responsiveness
Reliability	Reliability	Empathy	Assurance
Empathy	Responsiveness	Responsiveness	Empathy
Tangibility	Tangibility	Tangibility	Tangibility

(by descending order)

For any shipping lines which want to implement service quality policy for the multi-branch, it cannot be done by using single approach. Standard operating procedure laid down by head quarter may be able to use in one country, but it may be a different story in another country. Service quality is dynamic and customized because it involves human expectation which is changing over the time. This situation can be evidence by the result of customer's assessing service quality between Cambodia and Thailand. Although the service quality in Thailand

is scored slightly higher than Cambodia, but improvement gap in Thailand is bigger. This is because customers' expectation in Thailand is higher than Cambodia. Under this circumstance, it implies that good service quality perception from customer in Cambodia is not probably good. The reason behind this circumstance is that the company is providing service in the oligopoly market where there is a few players. There are so many entry barrier for new competitor i.e. availability of port, productivity in port and etc. When service is providing in the oligopoly market, the enthusiastic and willingness to service of frontline staff tend to be deficient comparing with Thailand where the perfect competition market is. This situation can be evidence by comparative SERVQUAL score on customer's expectation. Certainly, customer's expectation in Thailand for service quality is higher because there are a lot of service providers to compare while customer in Cambodia does not have much alternative. In the oligopoly market, the alternative measurement model should be considered such as SERVPERF because this model takes only performance into consideration.

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MULTILAYER SUPPLY PERFORMANCE FRAMEWORK – A CONCEPTUAL DEVELOPMENT

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ABSTRACT

The importance of supply management (SM) has received much attention in management literature in recent years, but there is still a grave deficit concerning the strategic contribution of supply management to corporate success. Especially, the measurement or evaluation of supply performance per se is still in its infancy. Both researchers and practitioners are currently more focusing on operational measures and pay less attention on relating the operational perspective to strategic objectives. Moreover, in spite of the wide recognition of the relational perspective in the supply performance context, relationship impacts in terms of SM on supply performance are often overlooked or relational measures are mainly observed operatively in many supply performance measurement (SPM) models.

In this paper, we propose to address these gaps by developing a strategic performance layer within the supply performance concept, and especially addressing the relational perspective within this framework. Based on the study of Ellram et al. (2002) which identified numerous limitations of linking supply practices and company success directly, we contend that the strategic supply performance layer can serve as an intermediating leverage layer, and it is therefore more appropriate to link this strategic supply performance layer with firm's performance directly.

INTRODUCTION

The overall performance of supply management (SM) and its contribution to corporate success have received considerable attention in today's senior management and academia (e.g. Monczka and Carter, 1978; van Weele, 1984; Dumond, 1991; Goh et al., 1999; Das and Narasimhan, 2000; Carr and Pearson, 2002; Ellram et al., 2002; Monczka et al., 2005). However, an adequate body of

the research focusing on the contribution of SM on the firm overall performance is still missing (Watts et al., 1992), which contradicts the growing scope in responsibility and increased strategic importance of SM.

Furthermore, a review of supply performance literature also shows another considerable deficit in defining supply performance scope and supply performance dimensions strategically. Both researchers and practitioners are more focusing on operational measures and paying less attention on relating the operational perspective to strategic objectives (Hughes, 2005). Strategic supply management literature stresses the importance of transfer and maximization of the supplier value to the supply performance of the buying company and advices to substantiate this value-added generated by the supplier from relational perspective (Watts et al., 1992; Hughes, 2005; Moser, 2007). To fill these research gaps, the research objective of the paper is to develop a supply performance framework with a strategic supply performance layer including a broad set of dimensions, and especially address the relational perspective within this framework.

THEORETICAL BACKGROUND AND LITERATURE REVIEW

Concerning the contribution of SM, there is a wide theoretical basis which can be used to explain the strategic contribution of SM to firm's performance. It includes concepts such as transaction cost theory, market-based view, resource-based view, capability-based view and relationship perspective. These theoretical frameworks build up together a sufficient theoretical background to explain the relationship between SM and the company success.

In the performance measurement literature, performance measures are categorized into performance drivers and outcome measures (Kaplan and Norton, 1992; Walsh, 1996; Ellram and Liu, 2002a). Performance drivers are measures concerning activities and enablers which facilitate outcomes, while outcome measures refer to the final results (Ellram and Liu, 2002a).

According to Howard Lewis (1948) SM is one of the most difficult functions in the firm to measure. Van Weele (1984) views the achievement of supply performance measurement (SPM) as very little and identified that the lack of supply performance definitions and the difference in scope of SM activities are major problems in measuring supply performance. Many companies are still focusing on traditional measures like price and quality in SPM (Hughes, 2005). Although there are some more extensive conceptual supply performance works including or stressing strategic supply performance perspective (e.g. van Weele, 1984; Carter et al., 2005), concrete strategic measures are far less defined. Therefore, a well-grounded conceptual body of strategic supply performance is still missing. In the empirical literature on supply performance, most studies focus on the impact of SM activities or SM capabilities on the corporate performance (e.g. David et al., 1999; Goh et al., 1999; Carr and Smeltzer, 2000; 2001; Carr and Pearson, 2002; Ellram et al., 2002b). These studies intend to link the supply performance drivers and the corporate performance directly. A few other researchers intend to analyze supply performance measures empirically, they either looked at more operative supply performance measures (e.g. Monczka et al., 1979; Chao et al., 1993) such as cost/price, time, quality etc. or involve strategic performance perspective rather by investigating measures of strategic supply capabilities such as negotiation ability, availability, workforce etc. (e.g. Chao et al., 1993; Carter et al., 2005). Investigations of strategic supply outcome performance are less performed.

In spite of enormous empirical efforts of linking activities or capabilities of SM function to the firm's performance directly, some researchers question this direct linkage (e.g. Ellram et al., 2002b; Moser, 2007). Ellram et al. (2002b) identified numerous limitations of linking SM practices and company success directly through her survey research and stated that "it is not possible to make such a linkage" and introduced the term of "bridge" between financial outcome measures and performance drivers" in her other paper (Ellram and Liu, 2002a). Thus, it seems to be a pragmatic approach to define a leverage layer of supply performance between the SM practices and the firm's performance, while investigating the contribution of supply management to company performance.

RESEARCH MODEL AND HYPOTHESES

Performance measurement researchers recommend a strategic perspective for every performance measurement concept (Kaplan and Norton, 1992; Gleich, 2001; Neely et al., 2002). Therefore, we contend that the strategic perspective must be the appropriate investigation level for our research objectives and the developed supply performance levers should be defined as strategic levers. According to the definition of performance drivers and outcome performance, these strategic levers refer to primary results of SM (e.g. outcomes at the functional level) which further drive the final outcomes (e.g. the firm's performance). Based on our literature review above, we propose a supply performance framework with three layers in the paper: (1) supply performance drivers, (2) strategic supply performance levers, and (3) firm's performance. This proposed approach enables an indirect linkage between SM drivers supporting SM's strategic performance levers and its influence on the firm's performance (i.e. final outcomes at the corporate level).

Supply performance drivers

Supply performance drivers refer to a range of diverse SM activities and enablers along the SM process. Different performance drivers can be derived from different theoretical perspectives. In this paper, we intend to embed the relational perspective into this strategic approach in terms of this performance driver layer. Since the existing body of relational performance research mainly refers to the operationalization of relational performance in dimensions such as trust, commitment, adaptation and satisfaction etc. (e.g. Carr and Pearson, 1999; Wagner et al., 2003; Fynes et al., 2005). In this paper, we illuminate the relational perspective from a more strategic perspective by developing the performance drivers linking buyer-supplier strategic alignment. In the strategic SM literature, the strategic alignment has been considered as an important capability of SM to generate competitive advantages (Cox and Lamming, 1997; Cousins and Spekman, 2003; Knudsen, 2003; Consins, 2005). However, most of these discussions have firstly focused on the alignment of supply and corporate strategy within a company. With the recognition of the impact of buyer-supplier relationships on supply performance, researchers might extend the discussions to an inter-organizational context and discuss the value-added of the alignment of suppliers' and buyers' strategies and objectives (Benton and Maloni, 2005; Hughes, 2005) as well as the implementation of this alignment within their business processes. Therefore, the constructs buyer-supplier objective alignment and buyer-supplier activity alignment are developed as appropriate performance driver constructs which sheds light on the strategic relationship quality between the buyer and the supplier. Since the strategic

alignment of the buyer and the supplier also reflect an important capability of SM to enhance its performance by integrating external (supplier) competences, the relationship between alignment constructs and strategic supply performance can also be complementally supported by capability-based view.

Firm's performance

At the corporate level, the successful generation of competitive advantages (Gälweiler, 1986) is proposed to be reflected in companies' financial performance (Ellram and Liu, 2002a). In previous studies, the financial performance is primarily tested by items such as return on investment (RoI), return on equity (RoE), return on sales (RoS), growth of market share or sales volume (Carr and Smeltzer, 2000; Carr and Pearson, 2002; Ellram and Liu, 2002a).

Strategic supply performance levers

While developing the strategic supply performance levers, we consider two questions: which performance outcomes can be achieved by SM at the functional level, and which performance outcomes can further lead to the firm's performance? Based on different strategic and performance frameworks (e.g. Kraljic, 1983; Lynch and Cross, 1991; Rappaport, 1998; Reichmann and Form, 2000; Gleich, 2001; e.g. Gallery and Hughes, 2002; Harland et al., 2003; Entchelmeier and Jahns, 2006), four perspectives can be developed as essential for the strategic performance at the functional level: cost, sale, finance and risk. Numerous evidences in previous articles support the SM's contribution to all these four performance perspectives (van Weele, 1984; Gallery and Brock, 2006). Furthermore, based on Alfred Rappaport's (1998) value-based view, these four perspectives can also be defined as key performance dimensions which drive the corporate company performance. Accordingly, the strategic supply performance can be conceptualized by four leverage dimensions: cost reduction and cost avoidance, contribution to sale increase, reduction of working capital and reduction of supply risk. The supply performance framework can be developed as illustrated in Figure 1.

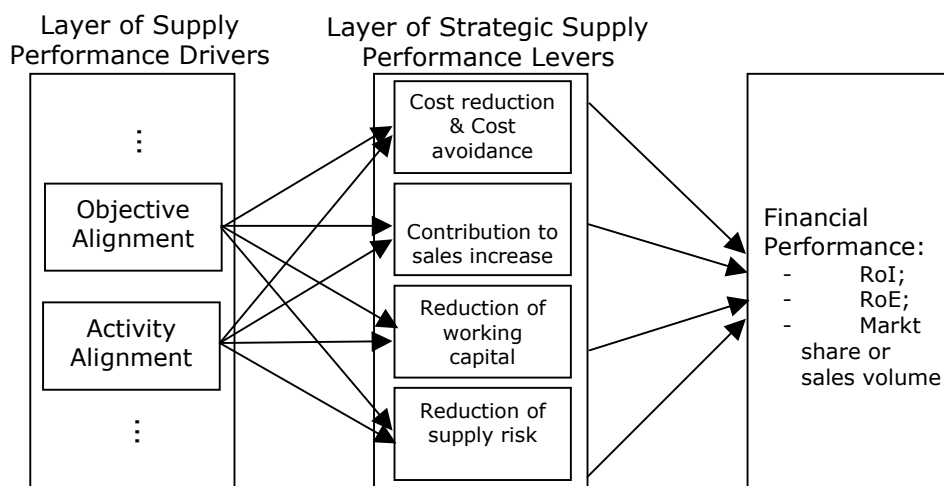


Figure 1: Multilayer supply performance framework

The term cost savings can be categorized in cost reduction and cost avoidance. Effective spend management has become a strategic challenge of firms for long. From one side, researchers, e.g. Ellram and Liu (2002a), Carter et al. (2005) view cost savings as a key contribution to the firm's performance. From the other side, SM is often seen as the responsible function to supply the company with the needed goods at lowest possible costs and viewed as an important direct performer in terms of spend management (Pfisterer, 1988). Based on relational perspective, a strategic alignment between the buyer and the supplier might lead to cost reduction through smoother negotiation and transactional efficiency and contribute to cost avoidance through defining material/service specification with the supplier together. From capability-based view, clever coordination between the buyer and the supplier might generate different competitive advantages. Accordingly, we hypothesize cost reduction and cost avoidance as the first strategic supply performance lever and posit:

H1a(b): Objective (Activity) alignment of buyers and suppliers has a positive effect on cost reduction and cost avoidance.

H1c: Cost reduction and cost avoidance has a positive effect on the firm's performance.

Sales increase is another important strategic performance aspect at the functional level which might directly impact to financial performance at the corporate level through better sales figures and market share. Besides the contribution of marketing department, the contribution of SM to sales increase is also increasingly recognized (Kaufmann, 1999; Gallery and Hughes, 2002). From relational view and capability-based view, SM's contribution to sales increase can be achieved by monitoring the market, alignment with the market in terms of supplier collaboration and integrating the supplier's innovative capabilities. Therefore, we can define the construct contribution to sales increase as another supply performance lever. Accordingly, we posit:

H2a(b): Objective (Activity) alignment of buyers and suppliers has a positive effect on the SM's contribution to sales increase.

H2c: SM's contribution to sales increase has a positive effect on the firm's performance.

Working capital management has emerged as a powerful instrument in context of short-term finance optimization (Pike and Pass, 1987) and can be viewed as an important financial performance aspect at the functional level (Wielen et al. 2006). A reduction of working capital can lead to better financial indices (e.g. RoI, RoE) at the corporate level (Meyer and Lüdtke, 2006) and therefore contribute to the firm's performance. Supported by relational perspective and capability-based view, the SM can directly impact the working capital and also achieve lower weighted average cost of capital (WACC) through effective processing (e.g. improved internal inventory forecasting, vendor-managed inventory) or a financing alignment with supplier (e.g. development of joint financing strategy). Therefore, we hypothesize the reduction of working capital as the third supply performance lever and posit:

H3a(b): Objective (Activity) alignment of buyers and suppliers has a positive effect on reduction of working capital.

H3c: Reduction of working capital has a positive effect on the firm's performance.

In addition to the proposed three positively co-notated performance dimensions, the risk dimension reflects the performance from an opposite side and enables to evaluate if the positive impact of other performance dimensions suffers from any

additional negative effects on the firm. According to Zsidisin (2003a), supply risk can be caused by individual supplier failures or the supply market occurring and result in inability of the purchasing firm to meet its corporate goals such as customer satisfaction etc. Therefore, reduction of supply risk can serve as a leverage construct which links to diverse risk sources in terms of SM from one side and to the firm's overall performance from other side. The positive relationship between SM function and supply risk reduction can be hypothesized based on the proposed theoretical foundation. For example, from the relational perspective, an appropriate supplier development and supplier collaboration can be associated with reduction of supplier risk and of supply market risk (Zsidisin, 2003b; Hallikas et al., 2005; Gallery and Brock, 2006). Furthermore, it is also encouraged by scholars to consider the supply risk management or supply risk reduction as an integrated part of the supply performance management (Carter et al., 2005; Hughes, 2005). Thus, we define the reduction of supply risk as the last strategic supply performance lever and posit:

H4a(b): Objective (Activity) alignment of buyers and suppliers has a positive effect on reduction of supply risk.

H4c: Reduction of supply risk has a positive effect on the firm's performance.

CONCLUSION AND FUTURE RESEARCH

The paper sets up an appropriate bridge between the SM practices and the firm's performance and defines a comprehensive leverage layer with four supply performance levers: cost reduction and cost avoidance, contribution to sales increase, reduction of working capital and reduction of supply risk. The relationships among the developed three layers are hypothesized. Especially, the contribution of the buyer-supplier relationship to the supply performance is explored by addressing two relational constructs at the supply performance driver layer.

Further research includes firstly the empirical testing of the derived hypotheses. Secondly, the proposed framework can serve as a basis for the further development of a pragmatic KPI system. Furthermore, the effect of SM on Profit and Lost statement or balance sheet which is currently a very important topic in practice, might be grasped by linking the performance KPIs, especially linking the KPIs of primary supply performance outcomes (the second layer) and the KPIs of final corporate performance (the third layer).

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Research Paper

**SINO-GERMAN CROSS-CULTURAL COMMUNICATION
APPLYING CULTURAL STANDARDS TO IMPROVE SUPPLY CHAIN
MANAGEMENT PERFORMANCE**

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ABSTRACT

The ongoing concentration of global connectivity in business practice has proven to enhance the number and impact of Sino-German business relationships significantly along the supply chain. A quintessential pre-requisite for achieving successful cooperation is the effective use of communication and the mutual

awareness of cultural discrepancies. This paper constructs a conceptual framework for Sino-German cultural standards by reviewing popular research approaches of culture and subsequently liaising the acquired information with a case study as a real-world business experience. The cross-cultural framework is employed to conclude implications for managers seeking to improve supply chain performance through cultural awareness.

INTRODUCTION

China has been in the center of attention for the past two decades and has marked its reputation as an emerging giant on the stage of world business. Hardly any company acting as a global player has not seen its supply chain cross the People's Republic of China; these days, China is making it equally possible and attractive for companies to shift their production and sourcing as well as selling activities to the Asian continent. This trend indicates the significant power of China and the probable strengthening of its leading role in the future.

Business relationships between multinational companies from abroad and local Chinese companies and employees occasionally suffer from issues based on cultural differences. In terms of academic research, it is a challenging research topic to analyze the impact of cultural and institutional idiosyncrasies on the management of international supply chains with particular focus on supply chain activities taking place in China.

Hence, the objective of this paper is to investigate to which extent expatriate managers experience difficulties with the characteristics of the Chinese culture when doing their daily SCM business and also how they manage to successfully overcome obstacles resulting from cultural differences (Bond & Hofstede, 1988).

Discussing the research topic of culture necessitates a very careful approach and the definition of delimitations in order to avoid the formation of stereotypes and to be able to draw guidelines for a specific area of interest since culture as such is too broad and faceted to be generalized.

CULTURAL STANDARDS IN THE CONTEXT OF MANAGEMENT SCIENCE

This first part aims to introduce the cultural standard concept and to stress its relevance for the field of management science. Furthermore, the concept fundamentals and delimitations are presented together with an outline of four popular cultural standard concepts. Finally, a conclusion is given based on the presented research findings on how culture should to be understood in the context of management science.

Fundamentals of the Cultural Standard Concept

As mentioned in the introduction, the research topic of culture is very broad and multifaceted, with relevance for a number of research areas and sciences other than the management science (Geier, 2000). This complexity generates the danger of creating stereotypes and diffusing unsupported observations by generalizing cultural traits and cultural specificities across all relevant areas. Hence, when analyzing culture and its idiosyncrasies, it is a helpful approach to focus on one specific area of interest as it is in this case the area of management science.

Reducing the investigation to one specific area also carries the advantage of complexity reduction since only a concentrated set of dimensions is being taken into account. This again might enforce the validity of observations and instructions detected towards which behavioural actions can be recommended. In the same context with instructions serving as guidelines for behaviour and action-taking, the concept of cultural standards appears. The intention of applying cultural standards lies in the idea of finding and applying guidelines, categorized according to cross-culture characteristics, which build the foundation for behavioural measures.

In research three characteristics of cultural standards are stressed in particular: Firstly, cultural standards are based on cultural standard polarities. Cultural standard polarities represent the concept of bipolar dimensions within which the individual or culture respectively nation can be attributed to either end of the dimension or to a spot within the range of this dimension (Geier, 2000). Secondly, cultural standards illustrate situations with intercultural overlapping. Once the "cultural social collective" or nation has found its place within the scope of the dimension a so-called "culture-contrastive" comparison can be set up between the nations or cultures and with this potential conflict sources based on the intercultural diversity can be revealed (Geier, 2000). Thirdly, cultural standards are supposed to function as standards in the literal sense; however, it has to be considered that at any time individual and situational aspects might outweigh country specific aspects as defined by the cultural standards. Consequently this finding narrows the scope of application of cultural standards and refers back to the complexity implied in culture (Geier, 2000).

Cultural standard concepts can be classified according to their methodological position and the number of cultural aspects included in the concept (Geier, 2000). In general, the distinction is made between positivistic and interpretive with focus on the methodological position and between culture-relativistic and universalistic with focus on the number of cultural aspects. Concepts comprising a relatively large number of cultural aspects are associated as culture-relativistic; in contrast, concepts with a relatively small number of cultural aspects are entitled universal. In terms of the importance for management relevant practices it appears that concepts with rather not too extreme orientations along both axes are most suitable. The aim in applying a cultural standard concept in management science lies in finding a concept with a tendency towards universal validity and application based on both a concise number of aspects under examination and an approach that is not too strictly interpretive and rather extended by measurable results as it does the methodology of positivistic concepts. As a result, the succeeding cultural standard concepts can be classified as follows (see Figure 1): Hofstede (1984) and Trompenaars (1997) rather positivistic with a tendency towards universalism on the scale of examined cultural aspects; Hall rather interpretive with also a tendency towards universalism; Thomas' (2003) concept of cultural standards can be referred to as the most suitable in the context of management science and intercultural management in particular: With Thomas' definition of cultural standards not only the match of positivistic versus interpretive is created but also a still universally applicable number of cultural aspects is included.

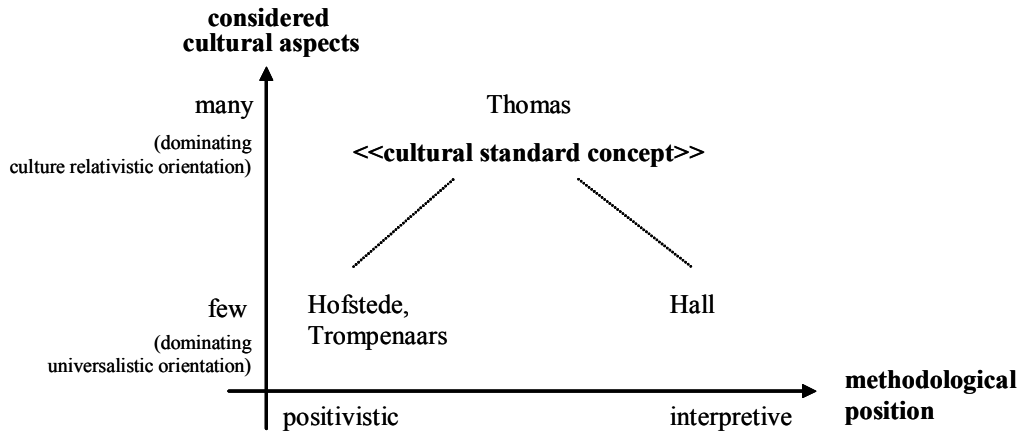


Figure 1: Positioning of the cultural standard concepts

A FRAMEWORK OF SINO-GERMAN CULTURAL STANDARDS

After the introduction of the cultural standard concept this part presents a framework of cultural standards specifically devoted to the idiosyncrasies of Sino-German encounters.

Based on a further analysis of existent cultural standard concepts, the following dimensions can be suggested for a cultural standards framework: time perception (Hall, 1959; Hall, 1966, Bond & Hofstede 1988), relationships (Tung and Worm, 2001), trust, power distance and collectivism; besides that, communication and education, also culture-specific negotiation patterns, risk perception (Rippl, 2002; Hofstede, 1993; Hofstede, 2001), power of institutions and business rituals (Schneider and Barsoux, 2003). To be noted is that depending on the functions or activity fields not all companies or managers get involved with all dimensions or consider them as critical elements of their management activities. Furthermore, the information obtained from nine research case studies within supply chain management area in China helped to define and verify the essential idiosyncrasies and differences between the German and the Chinese culture. More importantly, it also displays the interdependencies among the examined dimensions and supports the choice of cultural standards included in this framework for supply chain management.

Accordingly, the structure of the framework can be determined as in Figure 2. As can be seen from the illustration the framework is structured hierarchically and the presented cultural standards are interrelated (Thomas, 2003; Geier, 2000).

The framework consists of two dominating elements: The core, which represents the culture and accounts for the fact that culture functions as a system of orientation, and the environment around the culture, which is reciprocally related to culture and its constituting elements and idiosyncrasies.

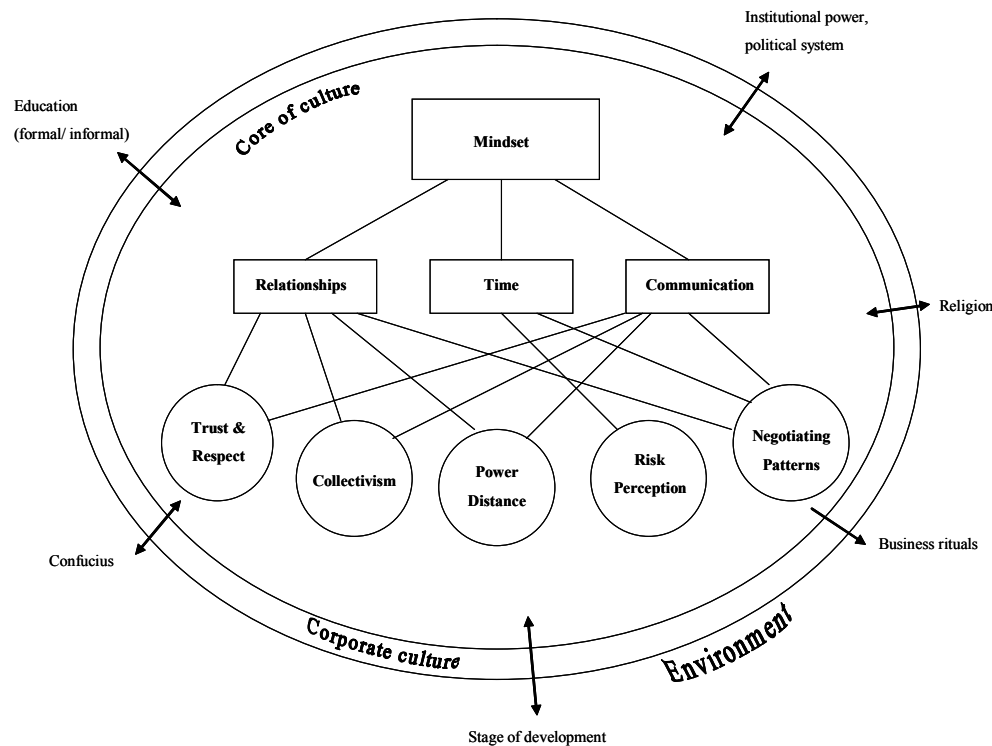


Figure 2: A framework of Sino-German cultural standards

With focus on the core, three levels have been defined: The first level which is superior to the other two levels and does not function as a cultural standard is the "mindset" of a culture. Behind this "mindset" a set of values, norms and attitudes can be found, which has been defined by different researchers (Kroeber & Kluckhohn, 1952; Thomas, 2003; Trompenaars & Hampden-Turner, 1997). This set of values, norms and attitudes is the part of a culture that is anchored in the individuals mind. Values lead the individual to distinguish between "good" and "bad"; Norms determine what is "right" or "wrong". Attitudes are the dominating feeling of an individual towards thinking or acting in a certain way. In some cultures, for instance, one might encounter the attitude that work or management activities are pursued in a very determined, strategic and long-term oriented way while in other cultures the attempt or attitude lies in accomplishing work on a very short-term, operations-oriented basis (Bond & Hofstede, 1988). All three aspects may vary in different cultures and this observation then leads to the formation of cultural standards illustrating the dominating differences and allowing for comparison of cultural idiosyncrasies. Following the insights from the nine analyzed case studies it appears that three dimensions form the second level of the framework functioning as the superordinate level of cultural standards: "relationships", "time", and "communication". These three dimensions underlie a certain set of characteristics. Firstly, they emerge as being predominant in the Sino-German context of intercultural management. Secondly, they are not strongly interrelated and capture three rather independent areas. Thirdly, it is possible to apply these three dimensions universally in any business context that is related to Sino-German encounters, regardless of the industry or sector a company is active in. The third level is more specific and also more complex in terms of interdependencies. From a general view, an interpretation of "relationships",

“time” and “communication” might suffice to outline the three major cultural discrepancies between the Chinese and Germany. A more stringent differentiation, however, is to be preferred in order to highlight and measure the specific problems managers might encounter in China or with Chinese business partners in general. Therefore, this level comprises the actual cultural standards, characterized by their duo-pole structure. As a result of the field research within eight companies five, China-specific cultural standards have been defined: “trust and respect”, “collectivism”, “power distance”, “uncertainty avoidance”, and “negotiation”. At this point, it is very important to understand that this number is not a fixed, preset number. Under different circumstances, with observation of different companies from different areas a differing set of cultural standards might be significant. Hence, it has to be concluded that the set of cultural standards can be extended at any time and this equally applies to the cultural standards defined within this framework. Moreover, it is also very difficult to clearly categorize and separate the individual cultural standards from each other. In different contexts, the cultural standards can be used to explain any of the three superordinate dimensions. An example for this phenomenon would be the cultural standard “negotiation”: Both dimensions of “time” and “communication” can influence the way negotiations take place and create a variety of cultural differences significant in the cross-culture management context. Therefore, the interrelations like they appear in the above examples are only a suggestion based on the research results.

What remains to be explained is how the environment takes effect on culture. Previously it has been mentioned that the environment is reciprocally related to culture and its constituting elements and idiosyncrasies. But before it can be elaborated on how the reciprocity emerges, it first has to be defined which aspects can be observed that, in the Sino-German context, have an impact on culture and vice versa.

In China, there are five visible aspects covering education, the power of institutions and the political system, the stage of economic development, religion, and Confucius’ teachings. On the one hand, aspects like religion, the political system and Confucius’ teachings shaping the “mindset” of a culture and its individuals. On the other hand, the impact resulting from these aspects might as well be based on and rooted in the existing “mindset”. The way how, for instance, formal and informal education is practiced, is the result of culture defining the traits of education and vice versa. Accordingly, the five aspects mentioned represent the origin of cultural and institutional idiosyncrasies. With their help it can be explained what causes differences between cultures and how, within the course of time, cultural differences and idiosyncrasies could actually develop.

A cushion layer emerging between the core of a culture at individual level and its environment is represented by the corporate culture of a company. This may be significant in the context of intercultural management because obviously individuals act as a part of the organizations they work for and it should be also accounted for the effect corporate cultures can have on the individuals apart from the effects of a national or regional culture as discussed in this paper (Hofstede, 2004).

A sixth aspect which has been defined as being part of the environment but not playing a significant role in terms of a reciprocal effect on culture comprises business rituals. They are a product of a culture's "mindset" visible as the outcome of values, norms and traditions. The reason why business rituals have also been included in the framework is that, in the context of cultural differences, they are a fundamental element in business managers have to get accustomed to (Schneider & Barsoux, 2003).

CONCLUSIONS

Hofstede (2004) has made a very suitable remark on culture: "Culture is more often a source of conflict than of synergy. Cultural differences are a nuisance at best and often a disaster". Although this statement may sound very dramatic managers in intercultural environments might sometimes have this feeling when things do not turn out the way they should as a result of intercultural diversity. The first recommendation towards successful intercultural management that should be given is that there is no right and no wrong about a culture and its idiosyncrasies. Therefore, giving judgements about a culture different from one's own culture is a fundamental mistake.

Moreover, cultures have to be understood as very complex constructs and one has to be prepared that in some cases the attempt to generalize might fail. For issues in intercultural management this can also unveil positive surprises as not every individual will follow the idiosyncrasies of its culture and individually contribute to the reduction of conflict sources (Krewer, 2003; Morris, 2005).

Another recommendation that should be given which might help to master intercultural discrepancies is simply to make oneself aware of the differences which exist and look for possibilities on how to eliminate critical interfaces. Cultural standards defined in the course of theoretical research like, for instance, presented in this paper along with active exchange of experience and best practices with managers in the same intercultural environment can have an inspiring, at the same time calming effect (Krewer, 2003).

Moreover, intercultural competence can be a key to successful intercultural management. Intercultural competence defines the understanding a person possesses for other cultures and the attitude with which this person approaches the other culture (Geier, 2000). A quality enriching intercultural competence certainly is the ability to speak the language of the other culture's members in order to develop a more subtle sensitivity towards the culture's idiosyncrasies as many characteristics are captured in the language (Liang, 2003). In more concrete terms, sending the right expatriate managers as well as hiring the right local staff decides about the success of the company and in a narrower sense of its supply chain.

The key lies in finding the right ratio of commitment, respect, intercultural competence, patience and experience making it possible to experience culture as a "source of synergy" and cultural differences as a personal enrichment.

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MINIMIZING OPERATING COSTS THROUGH ONLINE FEEDBACK AND CONTROL

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ABSTRACT

Control of pioneering or undocumented portions of business transactions requires an informal forecast where even experts can hardly hatch a sound decision. In lesser cases, trial-and-error testing drags time before a sound decision can be made. Databases, being the life of any management information system, need to be accurately updated while transactions must be timely captured and filtered. Data collection could not be possible for determination of market share when, even, manual records are unreliable.

For the limited and undependable internal resources and capability as a basis of decision, may not be the real representation of the Feedback. To pursue realistic data is to strengthen and increase resource allocation or further study period. Impending dilemma lurks when pursuing decision support systems is in fact non-revenue generating and of unexpected financial burden or the worst, not at all traceable. Systems Analysis & Design, Methods & Work Measurement, Cost Accounting, Web content and Database design have been used in this study.

Management has to look closely on what processes will be productive or non-productive. The result of which dictates that unproductive processes (indefinite costs) must be passed on sublimely and appropriately to the prospect or client and let them have the share of the responsibility. Whereas, the workforce and internal resources shall be optimally utilized for the equitable distribution of workload, improving the service quality, giving emphasis to client complaints, polishing and updating the bulletin, batch processing, and handling of complaints -- as provided by an extranet. Such extranet is not as a window of the business alone, but as a counter (literally and physically) as well.

Keywords: *indefinite costs, extranet, feedback, control*

INTRODUCTION

Background of the Study. In general, system components include: Input, Process, Output, Management which gets Feedback from the system and in turn, gives out Control/Monitoring to the system (Kluwer Handbook, 1999), and system's boundary that defines it from the influential Environment. Managing the logistics operations requires substantial information system to strengthen operational control.

The subject company has over two (2) decades of flourishing existence not until the grit of financial crunch hit a 60-80% decrease on its expected profit. The top management had delegated the operational control to the middle management and had preference only on selected Feedback (reports). There are three (3) independent, not integrated but automated internal systems (transaction,

invoicing, report generation) while two universal, integrated systems for vendor transaction/ordering are currently in use depending on the vendor affiliation. The latter is not linked to any of the internal systems but which the company has access to replenish order for its supply or stock replenishment. The internal systems were customized and independently designed during various periods for specific internal sub-systems goals.

These systems, together with in-between manual recording, do not satisfy any substantive decision support system due to lack of continuity tracking, data filtering, or incomplete transaction data/fields. As management's thrust to boost sales, it regularly posts promo items to Sunday newspaper Advertisement, motivates incentive-driven referrals, corporate deals, flyers (by fax or by email), and field sales. Come busy Mondays, calls are non-stop, everyone is busy taking down notes on dispensable scratch paper and finalizing it by the use of the system in place. Calls come in *Poisson distribution*: the population of which is highly indeterminable because the telephone lines has no call forwarding or rerouting. Newspaper advertisement's reach and respondents are not monitored either as sales staff simultaneously haggle with prospective, new, and regular clients calling in random sequence.

Since it had been a lucrative business (has grown to a ratio of 1 additional staff per year in 20 years) despite stiff competition, the management is open for incremental (and even inevitable, future radical) innovation that can initiate the preliminary recovery leap. The dilemma lies on the following undecided areas of improvement: Shall it be the upgrading of Telephone System? Shall the staff be increased? (How many)? Would it be better to temporarily have a parallel run with regulated, manual system while reviewing the automated systems? Is it simply integrating the existing systems (but a long-term solution is not a priority)? The first 2 options on Telephone System and Staff allocation still require considerable historical data which is a shortcoming of the current situation. Quick upgrade of telephone system may lead to under/over provision of phone units (the worse can be investing for an understated market reach), or manpower hiring/slashing due to lousy work demand forecast. No other staff can be spared for historical data quick-count hunting. Only one was tasked to conduct analysis and formulate first-hand cure. The Operations is deemed to continue as usual so as not to cripple the financial status more. The company cannot afford a bigger leap on major projects with greater risks and long-term application. It is even uncertain of the effectiveness of its promotional mix, least, can it afford to just wait for walk-in clients without a single marketing effort. It cannot sit comfortably with the existing roster of corporate and regular individual accounts to sustain existing operating costs. There has to be seasonal promo items to sell.

Objective. To come up with an incremental innovation/solution that management can adapt as preliminary recovery leap from the current significant amount of financial crisis with the optimal utilization of current workforce.

Scope and Delimitation. The study covers the Sales and Operations of a certain company. Should there be a reliable data at source, this study could have used queuing theory. Line balancing could have been useful to plot the manpower equipment deployment if sales demand is known. The vast, sensitive issue on undependable market forecast makes sales and operations budgeting

difficult to account. Thus, Systems Analysis & Design, Methods & Work Measurement, Cost Accounting, Web content, and Database design have been used. Website design is dependent on the quality of programmer's output who shall convert the design into functional web. The extent of the website functionality is likewise dictated by the content design quality.

Significance of the Study. Top and middle (for the decision support systems) management as well as those maintaining the data entry (transaction processing systems) can benefit in this study on how to react and manage operations given resources with inevitable limitations whether internally- or externally-motivated concerns. Concerned systems users will no longer be reactive and can attend to multiple clients at the same time and schedule priorities based on previewed records. Practitioners can embrace the beauty of designing systems with interdisciplinary considerations and multitude of purposes (not simply a website for viewing purposes but for decision support records that do not necessitate tedious tallying, counting, rewriting because of automatic filtering incorporated in the web). Prospective and regular clients are not compelled to do the usual inquiry, queue, using fax, email, or phone just to get the initial information on the product that can lead to the same activity during ordering/booking. Ordering can be just a click away if inquiry has been done via log-in.

Review of Literature. The figure below (Figure 1) is the simplest principle that can apply to *governance* of any organization (herein referred to as the *Management*) as the top level; *Monitoring* as two-way direction, from and to the middle management level; the *Feedback* from the *System* (Input, Process, Output) is also captured by the middle management, filtered for the top management's consumption; and the arrow down from Governance means *Control* Measures (in other cases, maintenance and motivational sustenance) down the line and back to the system.

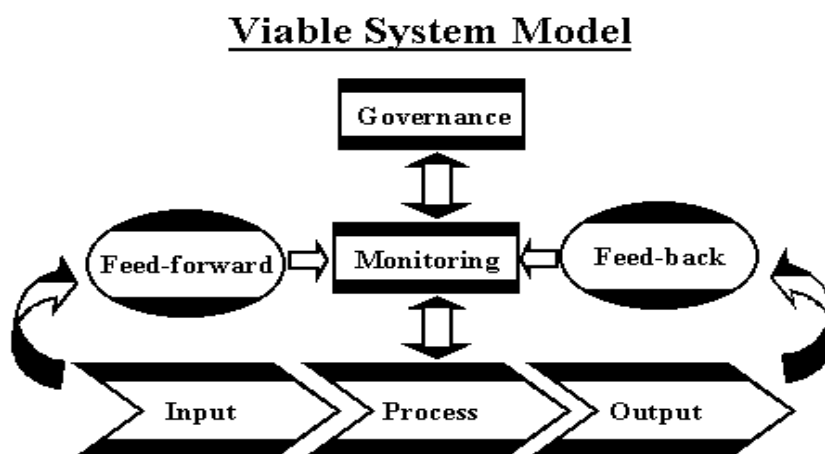


Figure 1. Viable risk management systems can be complex, with many benefits, but a summary model based on Stafford Beer's cybernetics ideas looks like this figure. [<http://images.google.com.ph>] [A version of this article originally appeared in "Organisational Enhancement: Viable Risk Management Systems", *Kluwer Handbook of Risk Management, Issues 27 & 28, pages 6-8/6-8, Kluwer Publishing (16 April 1999/14 May 1999)*]

Figure 2. Overview of Enterprise Information and Manufacturing Control Information used in Operations Management. →

The figure on the right (Figure 2) shows the overview of Operations Management with the vital role of Enterprise Information in a manufacturing set-up (can also be paralleled to a service industry with minor deviation in terminologies and approaches) and the controlling components to fully balance the line or the stages and interrelated sub-processes. Deficiency of any of those components can surely affect the quality of management’s and operational performance.

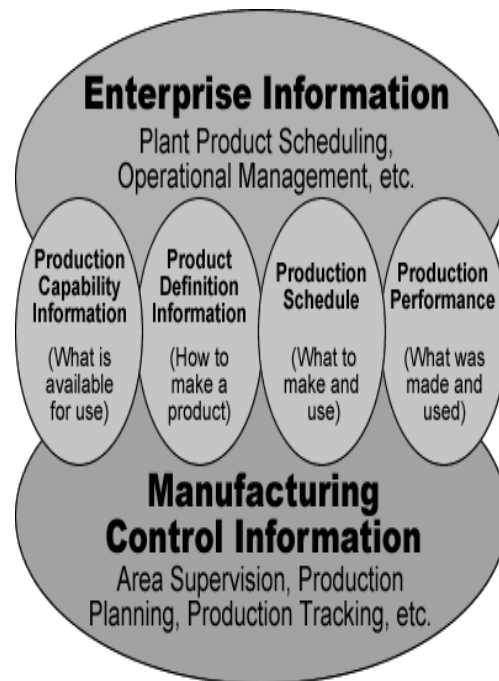
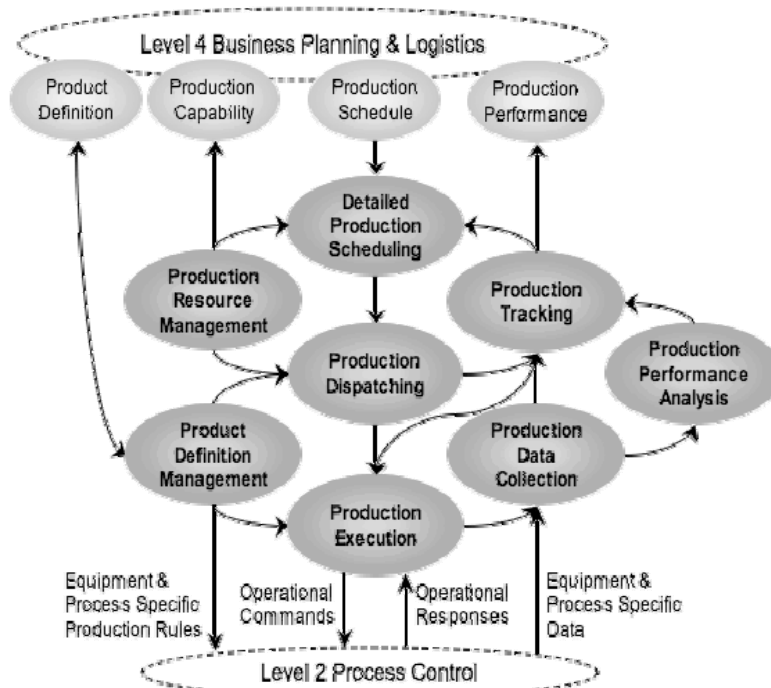


Figure 3 depicts the intricate logistics’ processes at the middle part of the diagram in green representations (a closer look of the yellow highlights of Figure 2 as the Enterprise Information needed to manage and operate the system). Control comes after Transaction Processing or first level transaction has occurred and feedback has been obtained. The transaction processing is not shown here (but will be discussed in the findings). This diagram shows the functions under logistics operations management.



← Figure 3. Sub-Processes involved in Business Planning & Logistics’ Detailed Processes as Linked to Enterprise Information, Operational Processes and Process Control

(<http://images.google.com.ph>)

(originally from www.batchcontrol.com/s95/s95.shtml)

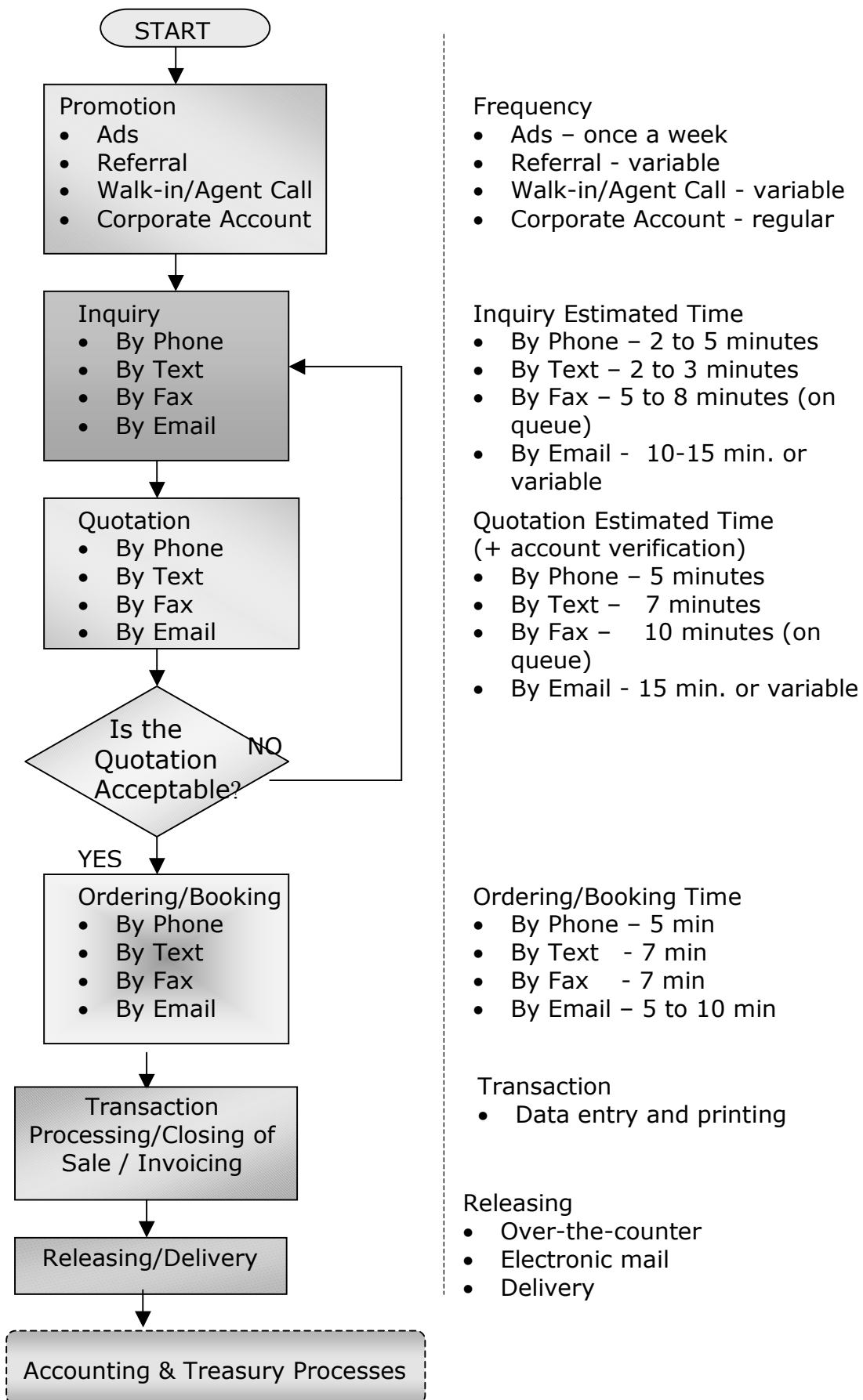
Analysis and Findings. A sampling of one month in 2007 transactions showed that of the total inquiries by phone/email/fax, only 10% have been closed as sales. The 80% are lost time and cost or remains a prospect. But of that 80% or 10% accounted, it did not reflect those who: called but busy line and lost interest in ordering; who were impatient to call again; did not have the time to call except on off-hours as vacant time; and had been attended to but lacked follow-up or with insufficient feed of information that ended in missed sales.

Weekly Newspaper Advertisement for only selected Promo Items costs PhP10,000 per week. It does not include further inquiry calls, fax, or email detailing. The mark-up for the closed sales during lean season is almost at breakeven point. It only escalates during peak season.

Analysis of the backlog revealed that: bulk of the looping in the sequence (*Figure 4*) happens during Inquiry (that can either be a Closed Sale or a Client Canvass that eventually be a Closed or Missed Sale). Client Canvass can be in the form of single or multiple transactions per inquiry. In whatever form of inquiry, the fixed costs are the same with minimal increase in processing time based on differential costing. The inquiry can vary from 2 to 15 minutes by phone/fax/email. Follow-up and clarification of orders could range from 3 to 5 minutes per caller. Closing the order can take 5-10 minutes including printing and invoicing if without vendor-related or payment-related constraints.

As solution, the company has to resort to a Website (that has an approximate cost of PhP150,000 for the design, installation and initial domain hosting exclusive of training and implementation which is equivalent to 15 weeks or 3.75 months of Newspaper posting) to do away with or capture losses during missed sales. As transition phase, the Newspaper Advertisement and flyers shall contain the announcement for the new website and its features. In due time, this shall be totally eliminated when clients are used to the online transaction.

Figure 4. Overview of Sales and Marketing Processes



Apart from the usual, common website sections for public viewing, below are the comparative features of the Existing System against the Proposed Website Design:

EXISTING SYSTEM	PROPOSED WEBSITE DESIGN
Promotion	
<ul style="list-style-type: none"> • Newspaper Advertisement (no pictures, rates: on minimum range) / Flyers/ Brochures) • Referral • Walk-in/Agent Call • Corporate Account Discounts • Dependent on working hours or off-hours direct contact via texting or emailing 	<ul style="list-style-type: none"> • Usual sections plus Web-based highlights/announcements • Newspaper and Flyer only for Introductory/transitory Announcement; and through website referral • All products on display with pictures; rates on the minimum if not registered user; access to exact rates if registered user subject to office approval) • Flexibility of client access • Not dependent on marketing or sales staff time
Inquiry	
<ul style="list-style-type: none"> • No standard format; on dispensable scratch • Not actual demand (No. of transaction is not equal to actual demand) • Manual, Fax, Phone dictation (one-on-one; the bulk), Email, Text • No standard inquiry questioning or answering • No pictures even in the email; Fax may have pictures of the products but in black and white only • As the calls arrive, they are not prioritized as to the urgent or not-so-urgent • Unclosed sales=lost operating cost and mark-up • Individual or grouped transactions may consume almost the same details' gathering time and cost • No 100% capture of inquiry details and/or caller details; missed questioning • Aging of receivables and paying capacity are not clearly established during the inquiry and quotation setting. Those purchased on varied terms and modes of payment may have the same rates (a disadvantage to the financial standing of the company). • Quotation has no standard format of fields or details of the served client 	<ul style="list-style-type: none"> • Online; with standard format that has provision for automatic booking afterwards by only capturing the reference Inquiry Number to the Booking Order which is a closed Sale • Number of viewers and their details are tracked down and available anytime • Planning and scheduling on the part of marketing & sales is easier if by batch processing • No details will be overlooked because fields are compulsory • Spelling of details are processed by the client; lesser errors than dictated and written by the sales staff • Unclosed sales' processing costs are not shouldered by the company • Client inquiry is client-dependent at his own desired pace; client- controlled • Allows editing of the order in this stage, not on the ordering or booking window. • Management can access the entire system, records (editing disabled at the staff level once part of transaction is saved, only trusted administrator has access over editing of processing) • Inquiry can only be edited by the concerned inquiring client • When client cannot go online, the Sales Staff must act as Inquiring Client but Reference Documents such as Email/Fax must be cited. • Quotation is a second instance in the website transaction after the Inquiry has been posted (disabled during Inquiry but enabled during Sales Staff

	<p>processing and linked to the email of the Client once Quotation is done)</p> <ul style="list-style-type: none"> • Client type is determined prior to any online inquiry and paying capacity/credit line/aging of receivables are included in the quotation details. • Net and gross amounts are also indicated in the quotation reference for tracking especially if rates are volatile.
Ordering/Booking	
<ul style="list-style-type: none"> • Repeated calls • Dictation • Another Fax or Email or Text • Prolonged processing and finalizing of order copy • Lost files once invoice is served • No system table and no trending of regular clients every order • Erroneous entry on the final order may constitute a future problem to the client, company, and/or to the Sales Staff concerned. 	<ul style="list-style-type: none"> • Automatic capture from the Inquiry with Quotation File once go signal to book is done • Revision is under the client's care • via Inquiry screen • Notation by the Sales Staff is disabled on the client screen but provided as second instance in the screen of the sales staff • Saved in the transaction file • Dropdown list of system table details (of frequently used data) is available
Processing	
<ul style="list-style-type: none"> • Numbering of transactions are sequential for all staff, controlled and summary of transactions are manipulated by sales staff • Transactions can even be delayed or postponed in the numbering if opted by the staff (can cause understated sales); actual transaction count not reflected on the next day's summary; floating transaction sequences 	<ul style="list-style-type: none"> • Numbering is system generated; not manipulated summary of daily transaction • Actual accounted sales=equal to the transaction sequence as generated by the system

Conclusion. Other consequences shall be the: avoidance of market share's doubtful estimates; actual web capture of market base; optimization of manpower's working hours (effective assignment delegation); cheaper batch processing of transactions; delegation of supposedly internal resource allocation (internet/labor/overhead costs) to the undecided client (unclosed sales); prioritization of orders as service is dependent on vendor confirmation; fully utilized fixed processing costs; single staff for website administration; another staff for unavoidable calling clients and remote/special arrangements; report formats and fast filtering; shorter processing time effected by the database availability; controlled processing of transactions with relation to paying capacity; build-up of customer database out of the online registration and static tables design to serve as dropdown list's source every transaction of repetitive data occurs; and incidental enterprise information for monitoring usage or further study and decision-making.

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A SCORECARD TOOL FOR THE MEASUREMENT OF PERFORMANCE FOR BOTH THE FORWARD AND REVERSE SUPPLY CHAIN

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ABSTRACT

A significant number of performance measurement tools have been developed for the forward supply chain. However the same cannot be said about the reverse supply chain as it has not been considered a core competence by many organisations. A framework for evaluating both the forward and the reverse supply chain is proposed to provide an overall picture of performance in a supply network. Measures included cover supply chain behaviour, responsiveness, reliability as well as costs and return rates. A case study involving a major European mobile phone network operator is used to test the methodology using a high-value handset model. For the product selected, the tool revealed serious inconsistencies associated to order lead times, inaccurate forecasted quantities, excess inventory, cost associated to brand new stock and high return rates (both faulty and non-faulty returns). The proposed framework demonstrates it can be used to capture the performance of the integrated supply chain (both forward and reverse) associated to a given product. The proposed framework has the potential to be used to achieve better customer service and reduction in costs involving shipping, warehousing, labour and call centres. Nonetheless, it provides a broad picture in terms of supply chain performance.

INTRODUCTION

In many industry sectors and for a long period of time, the forward component of the supply chain comprising the movement of transformed materials into finished goods reaching a customer was seen as the only core competence requiring attention. In recent times and for several reasons, the reverse component of the supply chain has grown in importance to a significant number of industries. The closed-loop supply chain involving the forward and reverse components is seen as a way to enable businesses meet the demands set on them regarding the responsible use of resources available and their commitment to social responsibility (Hart 1997). Wells and Seitz (2005) highlight that closed loops in the supply chain acquire distinctive characteristics according to the nature of the product (or sub-product) concerned, the structure of the industry established to provide those products, and the consumption of norms thereby created.

The reverse component of the supply chain has not always been at the forefront of enterprise planning. Several practitioners and researchers have recognised that making arrangements for product rejection may not be seen as part of the organisation's business plan or may not even be considered. The fact is that the reverse supply chain has to deal with situations that involve for example a dissatisfied customer sending back a faulty product, the supplier who retrieves

parts back and the manufacturer of the product who spends significant resources to create and distribute a product nobody needs or wants.

In the view of Prahinski and Kocabasoglu (2006) reverse supply chain management has been identified as the effective and efficient management of the series of activities required to retrieve a product from a customer to either dispose of it or recover value. According to the researchers some reasons about the importance of reverse supply chains include:

- The amount of product returns which can be very high
- Sales opportunities in secondary of products considered previously discarded
- The adoption of recycling and environmentally friendly recycling and disposal policies
- The adoption of laws making manufacturers responsible for handling their products once their life ends
- The emergence of alternatives including repackaging, remanufacturing and recycling

Figure 1 illustrates a number of measures intended to provide a broader picture of the performance of the supply chain. It is evident that a substantial number of extra measures could be added to the framework. However, the intention is that the proposed measures will capture the performance of the supply chain in a concise way, enough to support the adoption of changes that will lead to better performance.

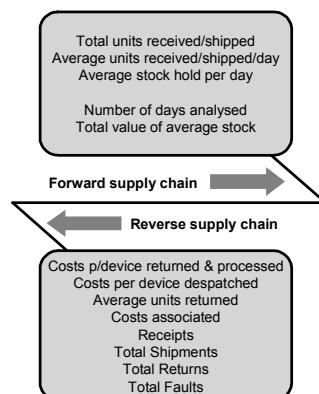


Figure 1. Integral scorecard tool for the measurement of performance of both the forward and reverse supply chain

The diagram presented in figure 1 is supported in the fact that the forward supply chain and reverse supply chain are not mutually exclusive. Indeed, in the view of De Brito and Dekkers (2003) reverse logistics cannot be seen as something entirely separated from forward logistics. In logistics, according to De Brito and Dekkers (2003) the border between forward logistics (from raw materials to end user) and reverse logistics (from end user to recovery or to a new user) is not strictly defined as one can wonder about what 'raw materials' are, or who the 'end user' is, in modern supply chains.

Returns have become now an integral process defined in the Supply Chain Operations Reference (SCOR) Model (Prahinski and Kocabasoglu, 2006) and it

has been acknowledged that managing successfully the rate of return product flow is critical to run a successful overall supply chain. In the view of Hameri and Paatela (2005) the reverse supply chain has been gaining attention due to cost pressures and as means to differentiate in commodities markets. In logistics – inherent and at the core of the supply chain- the level of integration of reverse logistics to other business activities may influence the capacity of an organisation to respond quickly to problems involving technical issues, documentation or packaging in a product (Hameri and Paatela, 2005). Furthermore, managing a reverse supply chain presents unique challenges for any organisation. Several issues that can contribute to make difficult to manage a reverse supply chain include (Prahinski and Kocabasoglu, 2006):

- Delays in returns which can turn to be disastrous for products with a short lifespan (e.g. mobile phone handsets).
- High variability in the quantity of returned products
- Severity of product defects
- Unknown product quality due to information not being communicated along the supply chain

In different industrial sectors the reverse supply chain has become very important because of the impact it can have on the organisation's costs of doing business, ROI and customer service. On the other hand several factors can make difficult managing a reverse supply chain. It has been recognised that the reverse supply chain is critical for service organisations. The logistics associated to managing the reverse supply chain enables organisations to reduce new purchases and decrease inventory costs by quickly moving returns back into usable stock (Cohen, 2006). According to the Reverse Logistics Executive Council, University of Nevada, Reno (2004) the return rates for some popular products such as magazines is 50%, for CD-ROMS is between 18 to 25% and consumer electronics is 5% . In the Netherlands, the mail order company Wehkamp has reported average return rates of 28% in fashion and small appliances, which corresponds to 10,000 items every day (Van Nunen and Zuidwijk, 2004).

The next section presents a case study to illustrate performance measurement in the forward and reverse supply chain.

ILLUSTRATIVE CASE STUDY: MOBILE TELEPHONE NETWORK OPERATOR

The case presented in this paper is based on a research study involving a major European mobile telephone network operator with operations in different European countries and with an annual revenue only in the UK of almost £2 billion GBP. In this industry revenue is generated from the airtime each customer spends. Mobile phone handsets provided by the network operator come at a subsidised price. In recent times the organisation has been interested in addressing the reverse supply chain of the business as forward supply chain operations have received most of the attention before.

The telephone handsets can be of two types. In the first type, handsets received are directly shipped by the manufacturer and sold under the manufacturer's own brand. In the second type, the network operator commercialises handsets under its own brand. Handsets under the network's operator brand are manufactured in the far-east by a consumer electronics supplier and then prepared by a third-

party-logistics operator in the UK. Handsets under the network's operator brand represent a key business.

THE NETWORK OPERATOR'S FORWARD AND REVERSE SUPPLY CHAINS

Forward logistics is responsible for shipping the handsets to the customers which can be very different from each other (types of customers include both corporate, individuals, etc.). The forward supply chain of the network operator comprises the flow of phone handsets from the manufacturer to the network operator's warehouse and from the network operator's warehouse to the customer. Figure 2 depicts the forward supply chain observed in the network operator participating in the case study.

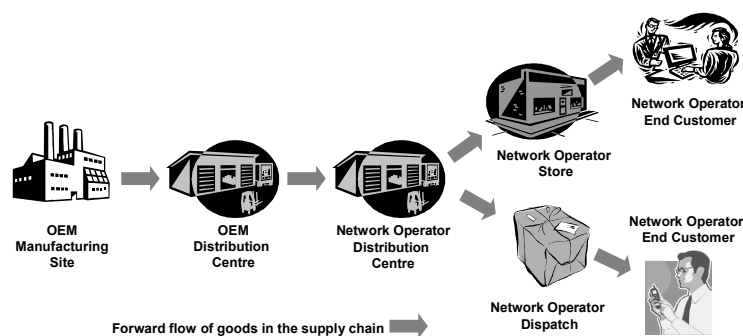


Figure 2. Representation of the network operator forward supply chain

In figure 2, the flow of goods starts with the handsets shipped from the OEM manufacturing site to the OEM distribution centre in the UK, from there handsets are shipped to the Network Operator Distribution Centre. A third-party logistics operator is in charge of running the Network Operator Distribution Centre, and from there handsets can follow two ways. In the first one, handsets are shipped to the network operator stores where they are sold to the end customer. In the second one, handsets can be shipped directly to the end customer.

The network operator has become interested in developing performance measures that incorporate both forward and reverse supply chains. One principal reason for including reverse supply chain measures lies on the growing number of non-faulty units returned to the company. For this mobile network operator the return of handsets that have been recently shipped is a main source of concern because a product which is faultless and is returned within the period of 14 days (money-back guarantee) drops its value by almost 50%. Products that fall in this category cannot be sold as new even if they were used to make a single phone call or just switched on for few minutes. Handsets can be ordered by customers on the Internet or purchased from the company's own stores. Returned handsets is a major issue affecting the profits of mobile telephone network operators. Figure 3 depicts the reverse supply chain of the network operator involved in the case study. When an end customer returns a handset, the device can be sent directly to the network operator reverse logistics centre or the handset can be returned to the operator's store and from there sent to the operator's reverse logistics centre. Once handsets have reached the operator's reverse logistics centre they are classified; those which are broken are sent to a repairs contractor, those in good operating condition are labelled as spare

handsets that will be allocated mainly for customers whose handsets need to be repaired.

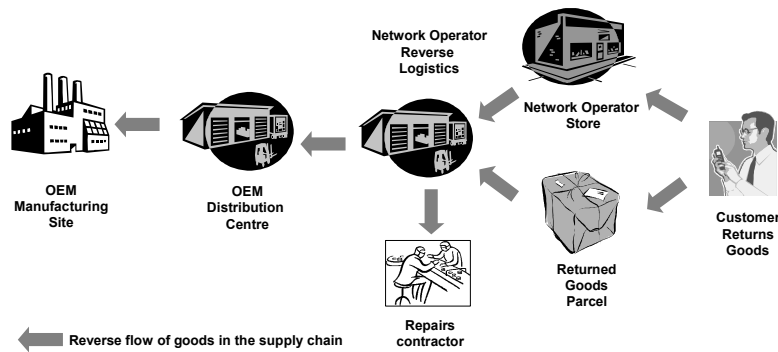


Figure 3. Representation of the network operator reverse supply chain

PERFORMANCE MEASURES FOR THE FORWARD AND REVERSE SUPPLY CHAINS

For the network operator its own line of branded products represents a key business. A high-value product has been chosen for the analysis because its supply chain embodies an accurate description of the behaviour of the supply chain. The high-value product is labelled 'high-value' device. For the analysis presented in this section data collected representing 174 days was used. Table 1 shows the forward supply chain analysis for the high-value device.

Total units received	14,075.00
Total units shipped	22,563.00
Average units received/day	80.89
Average units shipped/day	129.67
Average stock hold per day	3,262.03
Stock hold in days	25.16
Stockout incidents	0
Backorders	0
Number of days analysed 174	
Value of unit	£317.00
Units hold on last day	1,352
Value of stock hold last day	£428,584.00
Total value of average stock	£1,034,063.11
Current stock hold per day 3,262.03	
Value of stock	£1,034,063.11
Proposed service level	0.99
Resulting safety stock	1102
Value of resulting safety stock	£349,334.00

Table 1. High-value device – forward supply chain (inventory) analysis

Figure 2 represents the plotted values of the variability of stock for the high-value device. The variability of the stock is constructed based on the number of units received and units shipped. It is common practice for organisations to

stock high levels of a new product before launch. However, after launch it is possible to appreciate that the levels of stock for that product stays in about 2000 units in the last 100 days of the period examined.

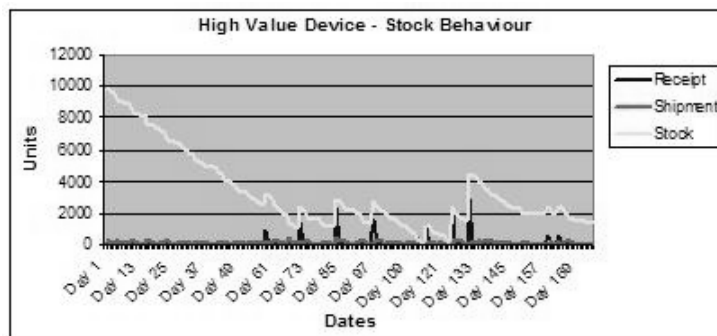


Figure 2. Plotted values for high-value device

Figure 3 represents the plotted values on a monthly basis for the handsets returned of the high-value device. That means that nearly one in four units shipped to the customers will eventually be returned. The plotted values in figure 8 reveal that the number of units shipped each month averaged about 4,000 units before dropping to 3,000 units by the fifth month.

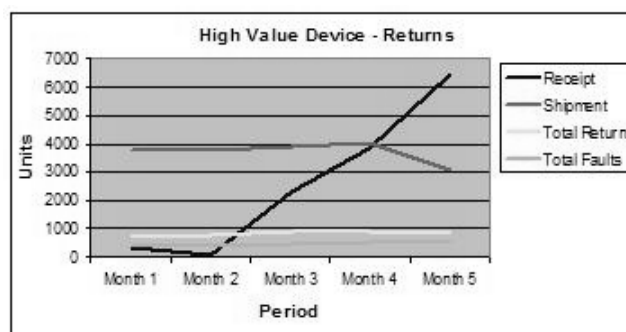


Figure 3. High Value Device - Returns

Table 2 shows the costs associated to the preparation of the high-value device. A third-party logistics operator is in charge of preparing the high-value devices for the mobile phone network operator.

High-Value Device		
	Total	Average/m
Received in period covered	12927	2585.4
	Cost/kilo	Unit w (g)
Third-party logistics operator freight and preparation	\$3.40	285
	Total	Average/m
Total spent in received devices	\$12,526.26	\$2,505.25

Table 2. Costs associated to the preparation of the high-value devices

Table 3 shows that the monthly average number of received units for the period examined was over 2500 units. The number of average monthly shipments was over 3700 units. The monthly average number of returned units was over 830 units with 462 units corresponding to faulty units.

High-Value Device	Month 1	Month 2	Month 3	Month 4	Month 5	Total	Average
Receipt	280	57	2340	3829	6421	12927	2585.40
Shipment	3769	3762	3884	4032	3077	18524	3704.80
Total Returns	720	804	894	903	846	4167	833.4
Total Faults	421	414	461	495	522	2313	462.6
% Returns from Shipments	19.10%	21.37%	23.02%	22.40%	27.49%	X	22.68%
% Faults from Shipments	11.17%	11.00%	11.87%	12.28%	16.96%	X	12.66%
% Returns from Receipts	257.14%	1410.53%	38.21%	23.58%	13.18%	X	348.53%
% Faults from Receipts	150.36%	726.32%	19.70%	12.93%	8.13%	X	183.49%

Table 3. Reverse supply chain analysis of high-value device

The analysis of the reverse supply chain has been expanded to include the identification of the costs associated to the shipment of devices that will eventually end being returned. Some measures covered include average units returned, returns as a percentage of units despatched, and costs associated to returned and processed devices. The table also shows what would be the costs associated if the device achieves a return rate of 5%, which is typical of the consumer electronics industry. Table 4 shows the values for the high-value device.

High Value Device	
RL costs per device returned & proc	£18.27
RL costs per device despatched	£2.03
Average units returned	833.4
% represented	22.68%
Costs associated (returned & proc)	£15,226.22
Consumer electronics return rate	5%
Average units returned at 5%	185.24
Costs associated at 5% (ret & proc)	£3,384.33

Table 4. Reverse Supply Chain values associated to the high-value device

The analysis of both forward and reverse supply chains clearly suggest that the network operator return rates are above industry levels for its own line of branded products, with high 'non-faulty' returns rates. The problem goes beyond the supply chain alone as it seems evident that faulty returns are attributable to faults in the manufacturing process. The manufacturer of the network operator branded devices requires production schedules to be fixed for 8 weeks prior to delivery. This manufacturer could be more responsive if the production lead time can be reduced to less than 8 weeks.

CONCLUSIONS

The case study involving the mobile phone network operator has been used to illustrate the importance of an integral supply chain performance measurement

framework that covers performance measures for both the forward and reverse supply chain. The competitive nature of some businesses like the one represented by the mobile phone network operator exemplifies a sector which can benefit from the use of an integral set of supply chain performance measures.

The performance measurement framework presented in this paper constitutes a more of a template rather than a definite performance measurement tool. However, the framework has demonstrated to be useful to provide a whole picture of the supply chain on how the forward and reverse supply chains are affected and interrelated. The framework can be seen as an effective guide towards the adoption of best practices in reverse supply chain such as intelligent gate keeping, use of advanced warehouse management systems, product-recall provisions, outsourcing reverse logistics and accessibility of information about the disposal of some stock keeping units (SKU's).

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ON AN EVALUATION OF SUPPLY CHAIN AND LOGISTICS MANAGEMENT USING SCM/ LOGISTICS SCORECARD FOR THAILAND'S LOGISTICS SERVICE PROVIDERS

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ABSTRACT

The paper presents the finding from the study where 50 Thai's logistics service providers were evaluated on the supply chain and logistics management perspectives using SCM/ Logistics scorecard. As of the scorecard, the assessment on the 22 supply chain and logistics management criteria can be compared between LSP in Thailand themselves as well as the benchmarking with the Japanese LSP database (42 companies). The result presentation will show the strengths and weaknesses of Thailand's LSP and indicate the improvement direction for future development.

Key Words - supply chain and logistics management, SCM/ Logistics scorecard, logistics service providers

INTRODUCTION

In the last decade, logistics and supply chain management has recently become one of the world hottest issues both in production and service perspective. In Thailand, the issue has been concerned by not only the private businesses but also the government-own organizations. However, there is yet to be any evident corporative action and development on the issue is still only business-by-business and works independently. The issue was also proved since the findings from the research in 2006 showed that Thailand's logistics cost was as high as 23.9% of GDP whereas the developed countries lay as less as 8-11%. [1]

Fortunately, there has been an increasing attempt from the government organization such as the Thailand's National Economic and Social Development Board which lead the strategic plan for Thailand's logistics improvement as well as the Office of Transport and Traffic Policy and Planning, Thailand National Shippers Council, etc. The aims of these attempts are mostly to increase a capability and the infrastructure to cope with any future logistics activities and development. [2]

On the other hand, the private businesses are becoming active. Many companies have started to seriously study and improve themselves, trying to save such high logistics costs and manage the logistics activities as well as the supply chain management which is now taking an important role of doing business.

Here, improvement can be evident yet the evaluation of the improvement and the current status can be difficult to determine. Hence, a suitable means must

be developed or adopted in order to accurately reflect the activities or the development, should it become the right direction. Here in this paper, the SCM/ Logistics Scorecard (LSC) was used. In addition of the evaluation of the company themselves, the comparison to other competitors can be made, not only those in Thailand but also those in Japan.

It shall be noted that the paper focuses on the Logistics Service Providers (LSP) in Thailand which play a significant role in the businesses' supply chain. Here, 50 LSP will be studied based on the LSC perspective.

SCM/ LOGISTICS SCORECARD

SCM/ Logistics Scorecard (LSC) is one of the tools that can evaluate the company's supply chain and logistics potential (see Figure 1). It was developed by Enkawa Laboratory of Tokyo Institute of Technology, Japan with the corporation of Chiang Mai University. It is easy to use as the evaluation can be self-assessment with the standard score that can be chosen unbiasedly. With the database of 800 companies world-wide, the benchmarking is possible and fairly confident. [3]

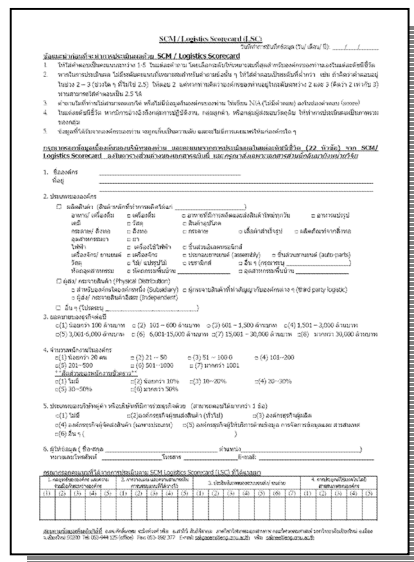


Figure 1 LSC

The scorecard only focuses on 4 sections, accumulating of 22 supply chain and logistics criteria, which is simply to answer yet indicative to the key supply chain and logistics potential. The sections of interest are as follow:

1. Corporate strategy & inter-organizational alignment (5 criteria), ie, (1.1) corporate strategy regarding logistics and its importance, (1.2) definition of supplier contract terms & degree of information sharing, (1.3) definition of customer contract terms & degree of information sharing, (1.4) system for measurement and improvement of customer satisfaction and (1.5) system for employee training and evaluation
2. Planning and execution capability (5 criteria), ie, (2.1) strategies for optimizing logistics system resources based on design for logistics, (2.2) understanding of market trends & accuracy of demand forecasting, (2.3)

accuracy and adaptability of SCM planning, (2.4) control and tracking of inventory accuracy and visibility and (2.5) process standardization and visibility

3. Logistics Performance (7 criteria), ie, (3.1) Just-In-Time, (3.2) inventory turnover & cash-to-cash cycle time, (3.3) customer lead time, (3.4) delivery performance and quality, (3.5) supply chain inventory visibility (3.6) Environmental activities and (3.7) total logistics cost
4. IT methods and implementation (5 criteria), ie, (4.1) Electronic Data Interchange (EDI) coverage, (4.2) usage of Automatic Identification and Data Capture (AIDC), (4.3) effective usage of computers in operations and decision-making, (4.4) open standards and unique identification codes and (4.5) decision-making systems and support to supply chain partners

As of an existing database, there are 42 Japanese LSP that can be benchmarked to as well as Thailand's 182 companies, which, in fact, cannot be directly compared yet the result can be indicative in some area.

RESULT PRESENTATION

The results of interest are as follow:

1. General information and cluster building for LSP of Thailand
2. LSC analysis for LSP of Thailand
3. Benchmarking between LSP of Thailand and of Japan

3.1 General Information and Cluster Building for LSP of Thailand

LSPs in Thailand mostly act as freight forwarder and custom brokers. The service are not well coverage and less competitive as multinational large enterprises in term of technology and cost efficiency. However, the development of the business sector is promising with the clear development strategies of Thailand government. [2]

General information gained from the data collection of 50 Thailand's LSP are as follow:

- Thailand's LSP are mostly small size enterprises as 52% of them have the yearly sale lesser 50 million Bahts.
- 62% of the companies have less than 100 employees.
- 60% of the companies invest less than 5-million-Baht capital.

3.2 LSC analysis for LSP of Thailand

Figure 2 shows the overview of Thailand's LSP based on 22 criteria of interest.

The preliminarily investigations of the data are possible as the radar chart indicate the cause as:

- Thailand's LSP is very strong in some criteria such as the responsiveness in term of customer lead time and the implementation of Electronic Data Interchange (EDI) and the implement of the computer in decision making.
- The weakest issue is the implementation of the tracking system, ie, Barcode or RFID.

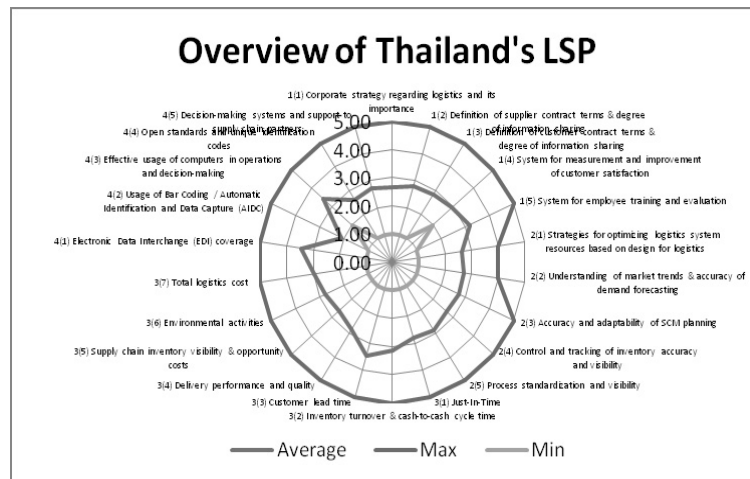


Figure 2 Overview of Thailand's LSP

Whilst compared with other type of business in Thailand, it can be seen as shown in Figure 3.

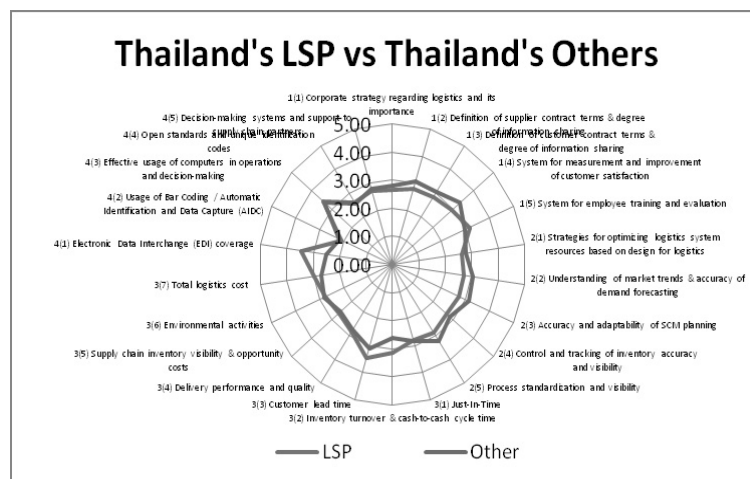


Figure 3 Comparison between LSP and other business type

It can be discussed as follow:

- Thailand's LSP is advanced in the cash flow which can reduce the inventory and warehousing cost.
- Thailand's LSP is advanced in term of customer lead time which can be the nature of the business. Such strength leads to the high responsiveness of the service which can meet the customer requirement efficiently.
- Thailand's LSP is advanced in term of IT utilization and accuracy the data sharing within their supply chain.
- Thailand's LSP is weak in terms of lack of customer agreement and mostly do not have a policy to share information among them which will reduce the strength of the supply chain as the development direction can be dependent.
- Thailand's LSP does not execute the plan efficiently which result in the lack of supply chain flexibility.
- The control and monitoring system as well as the standard working procedure are also among the weakness of Thailand's LSP.

3.3 Benchmarking between LSP of Thailand and of Japan

The section compared 50 Thailand's LSP to 42 LSP in Japan.

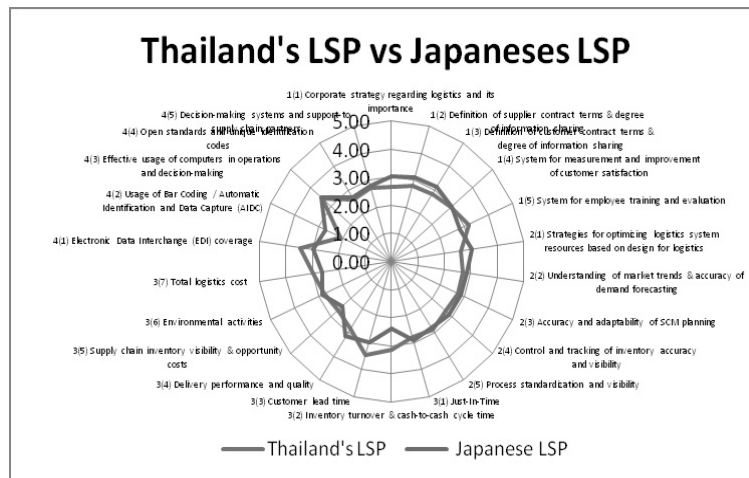


Figure 4 Benchmarking between LSP of Thailand and of Japan

Here, it can be seen from Figure 4 that the potential trend of Thai and Japanese LSP are quite similar. However, Thailand's LSP are relatively advanced in terms of employee training and evaluation as well as the quick response, especially customer lead time. However, Japanese LSP are stronger in term of development of supply chain management strategy and the implementation. In Japan, the utilization of IT system, eg, Barcode and RFID is also more advanced.

RESULT DISCUSSION

From the study and the result shown, Thailand's LSP strengths and weaknesses can be seen. The suggestion from the researchers are arisen as they should improve in some critical criteria such as the agreement within the supply chain which will result in an improved ability of supply chain utilization and will lead to a better service performance and efficiency. The implementation of the supply chain and logistics management should also be included in the organization plan and the organization's structure where the corporative activities can be done efficiently across the company. In addition, the EDI should be implemented in the company as well as their supply chain. The standard number/ code and the high technology tools should also be placed in the system in order to boost the service capability.

It should be noted that above suggestion are only from the investigation from the data. The real implementation can be limited or dependent as of each company's nature. However, the information can be significant for the government or any collaborative, should what issue be taking care of first.

CONCLUSION

The paper presents the means to evaluate the supply chain and logistics potential for 50 Thailand's LSP. The 22-criteria SCM/ Logistics scorecard was used in order to compare and benchmark the company both to those in Thailand

and in Japan. Here, the strengths and weaknesses of Thailand's LSP are revealed. It then leads to the suggestion, should which direction the business be improved and what matter most. The information is not only useful for the companies themselves but also the government or any collaborative attempt in the future.

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AN INTERNATIONAL COMPARISON OF SUPPLY CHAIN PRACTICES AND PERFORMANCE: THAILAND, CELTIC, ENGLISH AND NEW ZEALAND

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ABSTRACT

The vast majority of supply chain theory and publications are based around a US and European context. The central question of the research is to investigate how organisations from other countries are adopting these Western concepts. We have studied supply chain practices and their resultant performance in a wide range of industrial sectors and international settings. To date, 79 value streams have been examined over nine years of ongoing investigation, predominantly via a rigorous supply chain diagnostic approach known as 'Quick Scan' (Naim et al., 2002). Supply chain integration maturity has been assessed through close examination of four types of uncertainty; demand, process, supply, and control (Mason-Jones & Towill, 1998). While an overall assessment indicates that the majority of value streams studied are struggling with the concept, a limited number of exemplars do demonstrate the feasibility of supply chain integration. The original contribution of the research is the international comparison of supply chain practices and performance between Celtic, English, Thai and New Zealand value streams.

INTRODUCTION

Despite over twenty years of academic publications, there is still a significant gap between theory and practice. The latter is often perceived to be better than it actually is due to the natural tendency to publicise "best practice" companies. However, a comprehensive site-based study of the European automotive sector by Towill et al. (2000) found that only 10% of supply chains could be regarded as fully integrated. Similarly, an American survey conducted by Poirier and Quinn (2003) found that only 10% of supply chains had achieved external integration.

Supply chain integration (SCI) has been studied at first hand by the authors in a wide range of industrial sectors and international settings. To date, 79 value streams have been examined over nine years of ongoing site-based investigation, predominantly via a rigorous supply chain diagnostic approach known as the 'Quick Scan' (Naim et al., 2002). During these investigations a range of performance data was collected allowing us now to assess the overall take-up of supply chain management in practice and an international comparison between, English, Celtic, Thai and New Zealand organisations.

In the following sections a thorough review of the performance measures and practices studied are presented, followed by a description of our particular research method, the Quick Scan and the resultant pool of 79 value streams. The analysis section exploits basic comparative statistics. The penultimate section discusses the results and endeavours to answer the key research question and also highlights future areas of research. Concluding remarks and practitioner implications are provided in the final section.

SUPPLY CHAIN PERFORMANCE

SCI originates from a systems perspective (Handfield and Nicols, 2002), where optimisation of the whole value stream achieves better performance than a string of optimised sub-systems. The argument is that via integration, trade-offs and wider ranging decisions can be made based on shared information and co-ordination. Lee (2000) suggests three powerful dimensions by which to examine the extent of SCI:

- organizational relationship linkages;
- information integration; and
- co-ordination and resource sharing.

Similarly, van Donk and van der Vaart (2005) propose four comparable dimensions by subdividing co-ordination and resource sharing into the two categories of flow of goods, and planning and control.

Many authors assert that integration is an essential attribute of modern supply chain management (e.g. Christopher, 1998; Narasimhan and Das, 2001), and even go as far as using the two terms almost interchangeably. Bowersox et al. (2002) provide a very insightful explanation of how integration increases competitiveness via the creation of three types of value:

- Increased economies of scale;
- Increased market value, through convenient product assortment; and
- Increased relevancy value, by offering customised products.

The advantages of integration have been investigated via a number of surveys that have evaluated the impact on performance. Gimenez and Ventura (2003) show a positive correlation between external integration and performance in a survey of large Spanish grocery manufacturers. The same conclusion was also reached by Frohlich and Westbrook's (2001) international survey of fabricated metal products, machinery and equipment manufacturers.

However, it is important to emphasise that the debate in the literature is not about "full integration" versus "no integration". Rather, it is about "how much integration is justified", and "under what circumstances." The answer to these questions depends very much on the nature and purpose of the individual value stream. For example, it is difficult to envisage any circumstance where internal integration will not prove essential to enabling competitiveness. Indeed, as described by Busalacchi (1999), for companies responding to electronic auctions this may be the single most important action that they can take.

Supply chain performance will be measured by seven scales in our study. Firstly, the adherence to an operational toolkit to enable integration based around 12 rules of simplified material flow will be assessed. Secondly, uncertainty in four key areas will be calibrated in order to assess the overall level of integration. The organisation's wider profit margins are calculated and compared across the sample. The total cycle time, often referred to as an area for supply chain improvement (Christopher, 1998) is assessed for the 79 value streams. The fifth measure used is a binomial audit of the resultant symptoms of complex material flow. One of these symptoms, demand amplification, is double checked by assessment of the schedule instability of the sample. Finally, the performance of the managers at minimising supply chain uncertainty is assessed and compared for the four geographical groups. How the base data was collected will now be explained in the following section.

RESEARCH METHODOLOGY

The unit of analysis was a 'value stream'. This has been popularised by Womack and Jones (1996) and is defined as "the special activities required to design, order, and provide a specific product, from concept to launch, from order to delivery, and from raw materials into the hands of the customer". In many respects 'supply chain' and 'value stream' are synonymous. A practical interpretation is that a supply chain consists of a bundle of one, or more often multiple, value streams.

A site-based Quick Scan (QS) audit methodology was used to audit 55 of the 79 value streams analysed. These covered a wide and varied spectrum of value streams including several European automotive system suppliers, multiple New Zealand dairy processors, and several family-owned Thai value streams (Banomyong et al., 1995). Table 1 provides a more detailed overview of the value streams analysed.

During a QS audit, material and information flows are process mapped, key managers are interviewed, company archival information is evaluated and attitudinal questionnaires are completed for the interfaces of each value stream. As a result, an in-depth understanding of the value stream is obtained and then comprehensively documented. The QS process is explained in considerable detail in Naim et al. (2002) and need not be repeated here. Suffice to say that, given the resources and adequate shop floor and managerial access, it has proven to be a rich and time-effective method of investigation. Due to the large commitment of management time required by the focal organisation, it has not been possible to select the sample randomly.

Country	Sector	Frequency
England (28)	Automotive component and system supplier	11
	OEM, non-automotive	5
	Lighting product manufacture	4
	FMGC producer	4
	Automotive heat treatment subcontractor	2
	Steel fabricator	1
	Utility service provider, utility and logistics	1
Celtic (15)	Automotive component and system supplier	5
	Machining and assembly, non-automotive	6
	Steel fabricator	3
	3 rd party logistics provider	1
New Zealand (26)	FMCG, consumer foods	6
	Engineering service provider	5
	Dairy producer	5
	Service provider, hospital and cold storage	5
	Pulp and paper mill	2
	Casting	2
	Retailer, mass merchant	1
Thailand (10)	Small manufacturer	5
	Cable manufacturer	2
	Steel fabricator	1
	Service provider, scanning	1
	Concrete producer	1

Table 1. Value stream sample overview

In the case of the remaining 24 value streams that were not formally Quick Scanned, considerable archival material was available for scrutiny and further analysis by the investigators. Much of this is available in the open literature (Lewis, 1998; Waddington, 2001; Sabri and Beamon, 2000). Structured

interviews were then conducted with product champions from the organisation in order to obtain an even deeper understanding of the product delivery and information flow processes. The experts were selected for their overview and knowledge of the specific value stream under scrutiny. Examples of the types of managers interviewed include European Logistics Manager, Global Purchasing Manager, Production Manager, and Managing Director. Statistical analysis has previously validated the alignment of the QS and structured interview data collection methods (Childerhouse and Towill, 2004). Hence, we may have confidence in treating the 79 value streams as comparable with a sample of supply chain practice.

RESULTS

The results section is split into four categories; firstly, the operational toolkit pertaining to the 12 rules of simplified material flow are explained and assessed for the four groups. Secondly, the resultant operational performance is assessed via comparative analysis of the total cycle times for the four groups and the average presence of the symptoms of complex material flow. The third category assesses the overall supply chain performance and contains measures for schedule instability, profit margin and the most significant, supply chain integration. Finally, the performance of the managers in mitigating and reducing supply chain uncertainty is assessed for the four geographical groups.

Operational Toolkit

Simplified material flow has been shown to be desirable and can be achieved via the application of the 12 simplicity rules (Towill, 1999). These rules are based on the fundamental theoretical and practical work by Jack Burbidge (1962) and Jay Forrester (1961), which has been tested, integrated, and further extensively developed by Towill (1999).

The original author, Towill (199) explains the objective of the 12 simplicity rules as "... the emphasis is on 'clean' i.e. unbiased and noise-free information flows; time compression of all work processes; achievement of consistent lead times; choice of smallest possible planning period; adherence to the schedule i.e. elimination of pockets of 'Just-in-Case' materials, selection by simulation of the 'best' supply chain controls; and finally, matching the simulation model to the real work process via process flow and information analyses." Hughes et al. (1999) similarly emphasise the need for simplicity when they argue for the need to apply a wide range of initiatives across the supply chain, to drive out complexity.

An important part of a QS audit involves interviewing a range of managers during which they are asked to assess the extent to which they consider each of the 12 rules when making operational decisions. A Likert scale having values from 1 to 4 is used, with 1 representing 'this rule is not considered' and 4 representing 'this rule is always considered when making key decisions'. The degree of simplification is then calculated as follows:

$$\text{Degree of Simplification (for sub-sets)} = \frac{(\text{Sum of simplicity scores for the 12 rules} - 12)}{\text{Maximum simplicity score} - 12} * 100\%$$

Table 2 shows the average degree of simplification for the four groups and the resultant ANOVA p-value. The difference in the average scores are statistically significant at the 95% level and show English value streams have the most simplified material flow, whilst the Celtic sample is the worst performer.

Indicator	Maximum IS preferential
Total Sample	43%
England	51%
Celtic	32%
Thailand	42%
NZ	40%
ANOVA P-value	0.03**

** = statistically significant at the 95% level

Table 2. Comparative Assessment of the Degree of Simplification

Operational Performance

The total cycle time for each value stream is simply calculated by adding the average purchasing, production and delivery lead times. Although this is not a perfect measure of the total cycle time, it is a fair indicator of the average time material takes to pass through the value stream. If material flow is not simplified, numerous symptoms are clearly visible that result in ineffective product delivery process performance. Towill (1999) identifies twenty-four symptoms categorised into Dynamic, Physical, Organisational and Process. Many of these symptoms are clearly visible to the trained eye when visiting production and warehousing sites and, with a few pertinent questions, their presence or absence can soon be ascertained. In effect, this performance measure assesses the resultant observable effects of poorly integrated supply chains. For each of the 79 value streams, a simple score of 1 (present) or 0 (not present) was assigned for each of the 24 specific symptoms. The average for each of the four areas was then calculated, and these in turn were averaged to give an overall measure for the presence of complexity symptoms.

Table 3 provides the results of both of the operational measures for the four sub-groups together with the ANOVA p-value for each. The Celtic group have a statistically significant extended total cycle time and is clearly the worst performing group. It also has the largest frequency of complex symptoms, and this result is also statistically significant at the 95% level. The ten Thai value streams perform the best in regard to complex symptoms with, on average, 42% present.

Indicator	Total Cycle Time	Complex Symptoms
	Minimum IS preferential	Minimum IS preferential
Total Sample	64 Days	53%
England	45 Days	48%
Celtic	108 Days	61%
Thailand	41 Days	42%
NZ	44 Days	57%
ANOVA P-value	0.02**	0.04**

** = statistically significant at the 95% level

Table 3. Comparative Assessment of the Operational Performance

Supply Chain Performance

Three supply chain performance measures are used to compare the four groups. Schedule instability is an excellent indicator of supply chain chaos and is clearly linked to demand amplification. Those supply chains that can mitigate schedule instability more often than not significantly outperform those supply chains that suffer from demand amplification (Childerhouse et al., 2008).

The second indicator is based around uncertainty and its indication of supply chain integration. Numerous authors have identified the need to manage, minimise and remove uncertainties from their business in order to increase

control and co-ordination and improve the effectiveness of their decision making processes. This also holds true in a supply chain context, as Christopher (1998) explains, "One of the main reasons why any company carries safety stock is because of uncertainty. It may be uncertainty about future demand or uncertainty about a supplier's ability to meet a delivery promise, or about the quality of materials or components." This point is further emphasised by Bowersox and Closs (2002) when they state, "... a basic objective of overall logistical performance is to minimise variance." Further, Sabri and Beamon (2000) state, "Uncertainty is one of the most challenging but important problems in supply chain management." Wilding (1998) has utilised these principles in the development of a supply chain complexity triangle, specifically for the identification of uncertainty generation in the supply chain. Both Davis (1993) and Mason-Jones, and Towill (1998) have segmented supply chain uncertainties into four areas, so that root causes and methods for minimisation can be developed. The latter identifies the four areas of supply, demand, control and value adding process as illustrated in Figure 1. By evaluating the uncertainties in each of these four areas, the overall effectiveness or integration of a supply chain can be calculated.

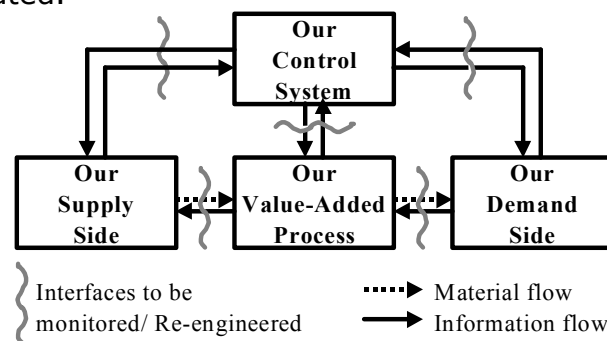


Figure 1. Uncertainty circle principle (Mason-Jones and Towill, 1998)

The QS team codified each of the four areas of uncertainty by ranking them from 1 to 4, with a value of 1 representing low uncertainty and 4 indicating high uncertainty. The Euclidean Norm is then used to evaluate the overall level of SCI because a chain is only as strong as its weakest link. The following equation shows the simple calculation performed to assess the overall level of supply chain uncertainty.

$$\text{Euclidean Norm (for a particular value stream)} = \left(\left[\begin{array}{c} \text{Process} \\ \text{Score} \end{array} - 1 \right]^2 + \left[\begin{array}{c} \text{Supply} \\ \text{Score} \end{array} - 1 \right]^2 + \left[\begin{array}{c} \text{Demand} \\ \text{Score} \end{array} - 1 \right]^2 + \left[\begin{array}{c} \text{Control} \\ \text{Score} \end{array} - 1 \right]^2 \right)^{\frac{1}{2}}$$

The third measure of supply chain performance is profit margin. This is simply an indicator of the sales price minus the value stream costs. Although this may seem an obvious measure, it contains multiple other factors, such as competitors, market circumstances, exchange rates and branding.

Table 4 illustrates the average performance of the four groups for these supply chain performance measures. Although the New Zealand and Celtic groups have worse average uncertainty scores, the variation in the sample is too great to say if this difference is statistically significant. In the same way, the excessive schedule instability in the Celtic group seems much larger but is not statistically significant. The New Zealand value streams have, on average, a larger profit margin but again this result is not statistically verified, even at the 90% level.

Indicator	SC Uncertainty	Schedule Instability	Profit Margin
	Min. IS preferential	Min. IS preferential	Max. IS preferential
Total Sample	3.8	37%	14%
England	3.6	37%	11%
Celtic	3.9	51%	12%
Thailand	3.6	13%	17%
NZ	4.1	32%	23%
ANOVA P-value	0.42	0.13	0.24

Table 4. Comparative Assessment of the Supply Chain Performance

Supply Chain Management Performance

The supply chain integration maturity is well assessed by the uncertainty evaluation. However, different value streams suffer from broader environmental uncertainty that can reduce integration, despite the best efforts of management. Hence, we developed a final performance measure to take into account these external uncertainties and thereby only measure the performance of the management at applying accepted supply chain management concepts. Three further areas of uncertainty were measured for each of the 79 value streams in line with Table 5. These scores were then included in a modified uncertainty equation as follows:

$$\text{SCM Perf.} = ((\text{Demand} - \text{CMV})^2 + (\text{Supply} - \text{USS})^2 + (\text{Process} - \text{PDPTI})^2 + (\text{Control}-1))^{\frac{1}{2}}$$

Uncertainty	Abbreviation	Underlying question	Low, 1	High, 4
Consumer marketplace variability	CMV	How hard is it to serve the end consumer?	Stable, predictable or functional	Chaotic, random, seasonal or fashionable
Product Delivery Process technology immaturity	PDPTI	How refined and predictable are the production processes?	Mature, predictable, stable, repetitive or refined	Leading edge, more of an art, variable
Uncertainty of supply source	USS	Is the supply of raw materials reliable?	Steady, predictable, commodity	Seasonal, scares, innovative, leading edge or variable

Table 5. Assessment Criteria for Environmental Uncertainty

Table 6 illustrates the average performance of the four groups for the supply chain management performance measure. The English and Thai value streams are managed the best on average, but this result is not statistically significant according to the ANOVA result.

Indicator	Maximum IS preferential
Total Sample	2.4
England	2.6
Celtic	2.3
Thailand	2.6
NZ	2.3
ANOVA P-value	0.56

Table 6. Comparative Assessment of the Supply Chain Management Performance

The supply chain performance measure rates value streams from 0 to 7. Figure 2 illustrates the ranking of the 79 value streams, together with their group affiliation. The largest single category is mediocre with 38% of the sample. This is also the sample average score with what can be seen as a normal type distribution spread on either side. Disappointedly the top two categories are

unpopulated with none of the sample achieving world class, let alone the theoretical optimum of seamlessness. The four groups are relatively evenly distributed across the bar chart, the English and Celtic groups have a larger variance but nothing that is statistically significant. Referring back to Table 6, the average scores for the Thai and English value streams are marginally more proficient than the other two groups.

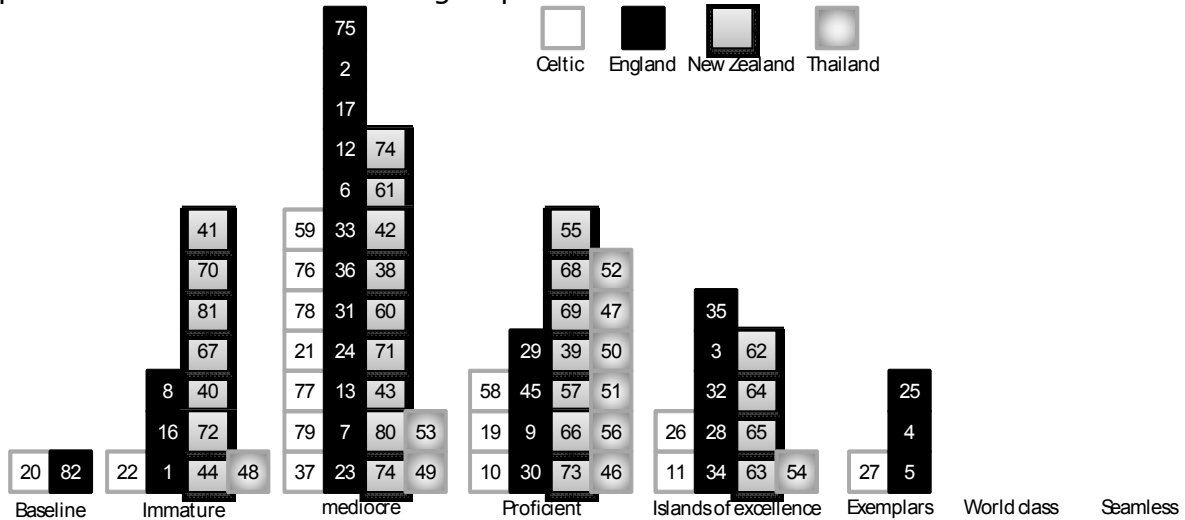


Figure 2. Supply Chain Management Performance

DISCUSSION

On the whole, the results are somewhat of a mixed bag. The average performance of the total sample for the seven measures is rather disappointing, with most of the value streams struggling with basic management concepts. The four groups are not that dissimilar, with most of the ANOVA results showing limited statistical significant results. Figure 3 pictorially displays all the results, the darker the shade of grey, the worse the comparative performance. Overall the English and Thai value streams perform better than their New Zealand and Celtic counterparts. However, this result is not verified by the stats tests, due to the large degree of variation in the 79 value stream sample.

	Operational Toolkit	Operational Performance		Supply Chain Performance			Management Performance
	Simplified Mat. Flow	Total Cycle Time	Complex Symptoms	SC Uncertainty	Profit Margin	Schedule Instability	Uncertainty Reduction
England							
Celtic							
Thailand							
NZ							

Figure 3. International Comparison of Supply Chain Practices & Performance

The geographical split of the sample into the four groups is questionable and could have been better subdivided. In particular, the Thai group is significantly smaller than the other three groups. Clearly, considerably more data is required to perform a more complete international benchmarking study, but as a minimum, this paper has highlighted a range of performance measures that could be applied universally. A large proportion of the sample is from the automotive sector, whilst another considerable portion of the sample is from primary industry. These two groups could make up an interesting follow-up study, while, once again, considerably more data is required to compare more

industrial sectors. The quick scan audit methodology has been refined and tested in a range of international settings. However, different researchers are applying this approach and the resultant data requires continuous calibration.

CONCLUSIONS

Over a wide range of supply chain performance measures, there is nothing to pick between the Thai, English, New Zealand and Celtic groups. Although the central concepts of supply chain management and certainly most of the case examples are from the US and Europe the uptake is equally bad in a range of international settings. On average the performance is mediocre. However, at least 46% have proficient supply chain management practices, whilst four stand out value streams provide much needed examples of exemplar practice.

Practitioners can take two clear messages from this research. Firstly, if you are struggling with supply chain in practice, you are not alone as most organisations seem to be mediocre at best. Along the same lines, it only takes a small increase in supply chain competence to jump ahead of the competition. Secondly, the lack of any significant difference between the four international groups suggests supply chain concepts are global and the 'won't work here' resistance is misplaced.

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The authors would like to thank the original SC2001+ team that helped in developing the QS methodology and the more than 27 multinational researchers who have since participated in the QS audits over the past nine years.

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TAXONOMIC APPRAISAL OF SUPPLY CHAIN MANAGEMENT MODELS

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ABSTRACT

Supply Chain Management (SCM) is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders. Suffice it to stress that companies and corporations involved in a supply chain by exchanging information regarding market fluctuations, production capabilities, distribution network, and other complex and large activities that can rationalise the processes involved in the SCM resulting in mutual gains, lower cost and competitive advantage.

It is perhaps based on the complexity of the system, that one of the five sciences that define SCM-Operation Research (OR) is always used to investigate and optimize large and complex system. OR can therefore be applied successfully to virtually any complicated problem where the optimal solution is difficult, if not impossible, especially solutions that involve trade-offs between different advantages as common in SCM.

It is in the light of this that the paper catalogued and appraised various SCM models that involved: Fixed vs. General Networks; Specialised vs. General Nodes; Linear vs. Non Linear Costs; Single vs. Multi commodities; Uncapacitated vs. Capacitated activities; Single vs. Multi modal and Static vs. Dynamic programming, as presented in the literature in recent years.

The analysis used for the paper was strictly qualitative with a view to evaluating the models and their respective applications of their particular features. The paper further concluded that no single model can solve large supply chain problems; rather a stepwise solution method will be ideal.

Key Words: Taxonomic, Appraisal, Supply Chain, Models

INTRODUCTION

Supply Chain Management (SCM) is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders. Suffice it to stress that companies and corporations involved in a supply chain by exchanging information regarding market fluctuations, production capabilities, distribution network, and other complex and large activities that can rationalise the processes involved in the SCM resulting in mutual gains, lower cost and competitive advantage.

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METHODOLOGY

Methodology employed for this paper stems from the complexity of system, as well as, tenet that is often used to define SCM (Operation Research-OR). It is in the light of this that the paper catalogued and appraised various SCM models that involved: Fixed vs. General Networks; Specialised vs. General Nodes; Linear vs. Non Linear Costs; Single vs. Multi commodities; Uncapacitated vs. Capacitated activities; Single vs. Multi modal and Static vs. Dynamic programming, as presented in the literature in recent years.

The analysis used for the paper was strictly qualitative with a view to evaluating the models and their respective applications of their particular features.

THE SUPPLY CHAIN MODELS

A supply chain models is defined on a network that consists of two sets of nodes; facility nodes and customer nodes. Facility nodes are the nodes controlled by the supply chain, and represent the sites where raw material component products and final products are being extracted, stored or sold. Facility nodes are often further subdivided into source nodes, which are producing products, and distribution centre nodes (DC's) which are used for transshipment and storage. The customer nodes have no production or storage capabilities, but have a demand on the product produced by the sources and stored by the DC's which has to be fulfilled.

It is interesting to note that the aim of any supply chain model is to optimise the flow through a networks while minimising a given cost function, which is based on the characteristics of the problem. Similarly, the flow in the network is generated by the demand of the customers. Hence, the customer demand is always a necessary input, and means that for any problem the customer demand must either be known or high-quality demand prediction must be on hand. These demands are fulfilled by the sources and DC's, which therefore need to have adequate production and storage capacities respectively.

In a related development, optimising the flow many supply chain models are also concerned with optimising the network itself. In other words, the supply chain is optimised by minimising an objective function that consists of the costs involved with the processes that occur in the network. A linear transportation cost is associated with the flow on the links in the network while a fixed cost is associated with the infrastructure elements whole optimal location is part of the objective. It is pertinent to stress that supply chain models have several variations extensions and complication. This is more pronounced when formulating a mathematical model for any problem with environmental variables to be considered. Suffice it to stress that for a model to be relevant at all, it is necessary that it is complex enough to give relevant answers to the question

which it is formulated to answer. On the other hand, it is also necessary for the model to be simple enough to be possible to solve in reasonable time. This in turn strike a balance between making the model sophisticated enough to be relevant and simple enough to be usable/solvable.

Eight characteristics that can extend the basic model are stated below, and will be briefly explained. The first six of these characteristic are recognised by Andersen and Hoff (2000), while the remaining two are included based on their relative importance.

Linear Vs Nonlinear Costs

Linear costs, that is, costs linear in amount associated with transportation, production and storage are the simplest costs to model. The assumption that trace costs are linear though, does not always describe the problem at hand satisfactorily; consequently, decide if non linear cost have to be modelled.

Simple Vs Multi-Commodity

If several products, or commodities are involved in a problem, and these cannot be aggregated, it becomes necessary to include these commodities in the model. Specific demands, capacities and flows therefore have to be modelled independently for the different characteristic regarding size production and flow costs etc. which can therefore lead to differences in the constraints needed.

Fixed-echelon Vs general-echelon network structure. If it can be assured that the flow in the network will always have a specific structure, for instance pass one Dc on its way from source to customer, is it reasonable to model a structured network, however, if the flows are expected to be more complex, it can be necessary to define more complex networks, and in the most extreme case, a fully connected network.

Deterministic Vs-Stochastic

If too much uncertainly surrounds the data involved or if errors in the data are known to have dramatic effects if can be necessary to model the problem stochastically, because optimising on average data in this case can lead to results of insufficient quality.

Static Vs Dynamic

If it is of interest to optimise the supply chain over a long time span, but the customer demands are more time-specific, it can be of interest to model the problem as a dynamic problem. In a dynamic model, the production can, to fulfil a given demand occur in an earlier time period, but the resulting product can be stored at the DC's till they are to be delivered.

Single Vs-Multimodal

Different transportation modes can be involved in a distribution system or supply chain. If these modes differ in transportation time or transportation costs, it can be necessary to include a modal choice for the flows in the network to properly optimise the system.

Specialised Nodes Vs General Nodes

Finally it input for certain problems be relevant to define the network as consisting of any of simple set of nodes rather than several sets of specialised nodes. This can be effective when geographic areas are aggregated to nodes. These areas might therefore both include customers but also facilities and the corresponding nodes will need to includes both capacities and demands.

Fixed Networks Models

Geoffrion and Graves (1974). This model involves complicated multi-echelon distribution models, and is a mode that is even total used as a reference for much work. More specifically it introduces the strict two-echelon flow networks where the optimal DC location is part of the objective and the customers are serviced directly from the DC's. It uses path variables to model flow. Pirkul and Jayaraman (1996). The model is chosen because it considers a problem which is basically identical of the one above, but takes a difference approach regarding the flow modelling are arc variables are used for flow modelling. These two first models therefore demonstrate the difference between the two flow modelling techniques that exist.

Morales (2000), this model is a simplication of Pirkus and Jayaraman (1996) as it is single commodity and no facility location is considered. It is nonetheless analysed because it is dynamic, and is therefore a very simple introduction to dynamic programming in distribution network design.

Perl and Daskin (1985): Once more, the model considers basically the same problem, but the mood is analysed because the customers are served through routing rather than by direct servicing. This is therefore a location-routing problem.

Ambrosino and Scutella (2001). This mood generalises the routing model of Pirkul and Daskin (1985) by adding a further two echelons to the network considered.

Elson (1972) is among the oldest of the kind of models. It considers a problem identical to the one of Geoffrion and Graves (1974), but uses are variables to models flow. The DC location feature is general, as the DC's from the outset can be either open or closed, and both opening, closing and resizing of the DC's is part of the objectives.

Kaufman et al (1977): this is once more a two-echelon model and flow is modelled by flow variables. In this model the DC's and source can be opened at the same nodes, and DC's are forced to open at sites where sources are opened.

Cole (1998), this is a two-echelon model using are variables to model flow. The intermediate facilities in this mode are merging centres, where produced commodities are merged to create new commodities that are to be delivered to the customers.

Barabarasoglu and Ozgur (1999): A well known and much referred to model, which considers a 2-echhelon, multi commodity dynamic problem. This is quite general model as it also includes the opening of transportation links.

Boland et al (2004). This is actually only a slight generalisation of the models. It defines the flow to be strict three-echelon despite operating with a generation-echelon network flow is modelled by double indexed variables with an additional origin index.

Melkote and Daskin (2001). This model also operates with a general flow on a general network, but considers a much different problem, where only a single facility services. The customer, while there is only costs associated with the link flow, but not with the flow through the nodes.

Croxton et al (2000): The model considers a strict two-echelon flow between nodes in strict two-echelon network. The source of Dc flow cost though is nonlinear while DC to customer flow is linear.

Lapierre et al (2001). This model equally considers a strict two-echelon network. All links have associated cost functions that are nonlinear in two variables. This model is also interesting since it is in fact not completely formulated, since it is not be solved any other way than heuristically.

CONCLUSION

Based on the theoretical analysis, it can be concluded that no single model can be used to solve a global supply chain management problem. No simple formulating can model the problem effectively, since too many aspects are of importance for the optimal solution. Similarly, a generic model that includes all important aspects will become too complex with too much data.

Above all for the model to be effective, there is need to be based on a completely general model which can be related and fitted to cope with specific problems.

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ENHANCING SUPPLY CHAIN EFFECTIVENESS THROUGH A STRATEGIC BUSINESS MODEL

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ABSTRACT

The ability of a company to accurately measure its success in implementing business process re-engineering (BPR) projects is crucial to creating an economically sustainable business. Successful implementation of BPR enables improved process responsiveness and increased manufacturing capacity and capability. The key areas for study in this particular paper are; increased demand, process integrity, and effective robust controls. These areas all contribute significantly to supply chain effectiveness. The initial Quick Scan Audit Method (QSAM) application yielded current performance benchmarks and identified a series of short, medium, and long term projects. The resultant BPR framework was developed and aimed at comprehensively moving the company towards improving its delivery capabilities and hence securing its position within the supply chain.

Following the implementation of these BPR programmes, a second QSAM audit was undertaken. The actual achievements resulting from this framework for change were analysed in detail. The paper fully documents the improvements made against the initial benchmark performances using the Uncertainty Circle and the 12 Simplicity Rules. This paper will also identify those elements of "best practice" observed in the cast product supply chain and compare them to previously measured uncertainty scores from other industries.

INTRODUCTION

The specialist casting company (TSCC) in this case study had grown in size and prospered on the back of manufacturing nickel and cobalt base alloys used for high temperature brazing, hard surfacing and cast products. To maintain this position and grow, the business the company must continue to improve its performance to counter potential threats from lower labour cost countries. Long term sustainability requires growth in sales, and a decrease in manufacturing costs. TSCC had grown steadily between 2004 and 2006, although in 2006 they were facing a struggle to keep up with the increased demand from their current customer base. Eventually the company started to lose some of their smaller customers and were on the brink of losing a number of key customers who were critical to the survivability of the company. This was due to poor delivery, not delivering to promised lead times and adherence to the schedule. To move the company forward and gain a better understanding of the current performance, a proven methodology and a systematic approach needed to be adopted. This paper will look at how TSCC used proven methodologies to audit the position of the business within the supply chain, developed a framework for change implement that strategy. A detailed analysis of the results pre and post BPR will be carried out.

METHODOLOGY

Quick Scan Audit Methodology (QSAM) provides a holistic systems approach to analyse a company's supply chain. The term was originally developed by Eindhoven University of Technology used by their postgraduate students (Lewis, et al. 1998). Since this early work it has been developed into a robust diagnostic tool through the work of the Logistics Systems Dynamic Group at Cardiff University (Potter et al. 2006). The aims of the QSAM is to understand and document the supply chain and associated material, information, cash and resource flows (Childerhouse et al., 1999). It targets quick hits (but not quick fixes) improvements and longer term action plans for the supply chain. The quick hits target non-value adding activities typified in lean thinking, and longer term plans concentrate on reductions in value added activities. The QSAM is usually completed over a two-week period and is built up of a multi-disciplined team of researchers, engineers and managers, the data collection is extracted using techniques such as; process mapping, interviews, questionnaires, SWOT analysis and numerical modelling (Towill et al., 2002).

At the heart of the QSAM lies the analysis of a company's Uncertainty Circle (Mason and Towill 1998). The uncertainty circle concept is relatively simple which uses four identifiable areas based on control engineering approach to systems design (Parnaby and Billington et al., 1976). These four areas are:

- Process uncertainty* – Affects the internal ability to meet production targets, can be competition between products for available resources
- Supply Uncertainty* – Results from poorly performing suppliers not meeting production needs
- Demand Uncertainty* – Associated with poor customer relations and transparency of information
- Control Uncertainty* – Concerned with how internal decision making affects the ability to orders into targets

(Towill et al., 2002)

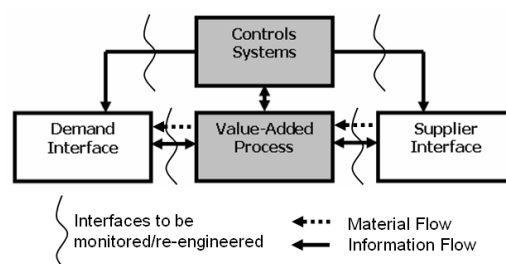


Figure 1. Uncertainty Circle (Source: Mason-Jones and Towill, 1998)

Previous uses of the uncertainty circle conclude that reducing uncertainty has resulted in substantial improvements in bottom-line performance (Childerhouse et al., 2002) therefore the uncertainty circle was used to measure the supply chain in this paper (Figure 1).

Alongside the Uncertainty Circle the QSAM auditors also analyse the company's capabilities against the 12 Simplicity Rules. These rule were identified by Towill 1999. Simplicity of material flow is very important to supply chain operations, it can be achieved via the application of the 12 Simplicity Rules (Childerhouse and

Towill et al., 2003). The rules have come about from the work started by Forrester (1958) and Burbidge (1961) and have since been developed further by Towill (1999). It is not expected that each rule is equally applicable and relevant to every company. The emphasis placed on each rule will depend on the type of product delivery process (PDP) or market being served (Childerhouse et al., 2004). The 12 Simplicity Rules are shown with the results section of this paper.

INITIAL QSAM

The QSAM diagnostic is based upon four sources of data; (i) attitudinal and qualitative questionnaires, (ii) process maps, (iii) semi-structured interviews and (iv) archival information (Naim et al., 2002). Up to eleven qualitative attitudinal questionnaires are completed during the Quick Scan Audit. These questionnaires are undertaken with key members of the company ranging from; managing director, production manager, purchasing, supply chain managers, quality manager, HR manager etc.

INITIAL QSAM FINDINGS

VSM - It was calculated that 80.94% of the total time undertaken for cast and machined product manufacture was considered to be Non Value Adding (NVA). Analysis of the VSM by the team from TSCC and LSDG identified that some of the major areas contributing to unnecessary NVA activities was across both the casting and machining areas by means of, delays between operations due to lack of scheduling control, production of an excess over-make quantities, Searching for tooling and materials during operating time, No schedule to work to, and Queuing due to re-worked parts. In general the company responded quickly but not particularly effectively to a busy and highly competitive market. The controls in place (scheduling systems, project management, resource allocation, quality control, on-time delivery analysis etc) were insufficient and where OTD was achieved this was done by a concerted effort (overtime, weekend working etc) as opposed to any well structured and suitably planned approach to meet customer demands. The demand was high but relatively steady, and the supply of raw materials was robust enough to cope with production demands. The uncertainty circle and 12 simplicity rules scores from the initial QSAM can be seen in the results section of this paper.

DEVELOPMENT OF A FRAMEWORK FOR CHANGE

If costs continue to rise faster than Sales grow, it can result in a decreasing and possibly negative profit margin percentage. Also, if costs rise at the same rate as sales grow, the overall profit margin percentage will decrease. Neither of these is generally acceptable. To achieve sustainable growth with a healthy sustained profit margin over the long term, costs and sales have to move in opposing directions (Phillips and Thomas et al., 2007). Taking into account the results and recommended outcomes from the initial QSAM, TSCC decided to embark on a business process re-engineering (BPR) approach to change the supply chain. As part of this decision they developed a business model in collaboration with Cardiff University LSDG. This business model was given the name, the Strategic Business Model (SBM), see figure 2.

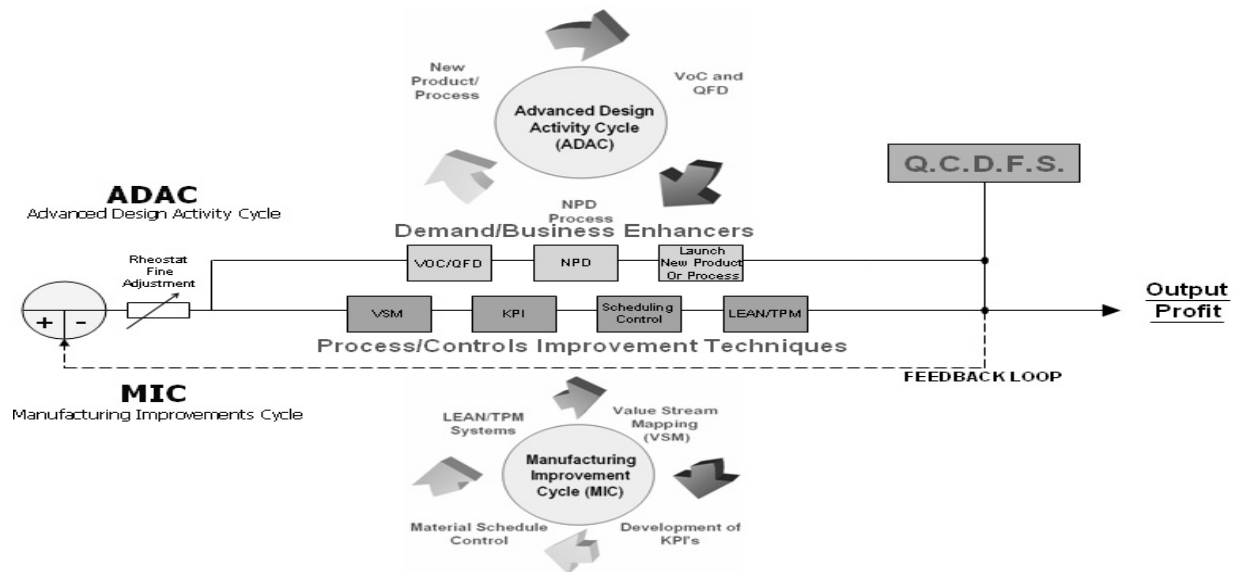


Figure 2. Strategic Business Model (SBM)

This model is split into two distinctive halves, the advanced design activity cycle (ADAC) and the manufacturing improvements cycle (MIC). The top half, ADAC represents activities that are undertaken to achieve new business, increased sales, new products or services. The bottom half, MIC represents activities that can be undertaken to reduce running cost and improve current system controls. At the top right of the model sits the box containing Quality, Cost, Delivery, Flexibility and Service (QCDFS), these act as the measures against which each part of the SBM are measured. Quality, cost and delivery (QCD) applies across many manufacturing industries. It offers a straight forward method of measuring processes and also represents a basis for comparing businesses (Ref www.wikipedia.com, 2008). During the development of the SBM, flexibility (F) was added to the acronym to represent responsiveness to customers when faced with unpredicted product strangers, and service (S) was added to ensure that the voice of the customer was heard. QCDFS ties into the seven key measures used within the manufacturing industry to track continuous improvement, raising levels of customer satisfaction and greatly improving the management of production (www.industryforum.co.uk, 2008). By continuously linking Quality, Cost, Delivery and Flexibility with each part of the ADAC and MIC of the SBM, TSCC can achieve sustainability and increase profits.

By correlating the seven measures with the categories set out on the SBM, we are able to identify classifications of relevance (table 1). This acts as a referencing tool to be used with the SBM. It allows you to identify what affect a particular KPI has on the problem at hand. In the case of TSCC, delivery and service were the main problem categories, but not all of the KPI's used were relevant. This helps re-evaluate the improvements to ensure that value added changes are being made to the supply chain and no wasted resources are used to focus on the wrong areas.

	Quality	Cost	Delivery	Flexibility	Service
Scrap Reduction	1	1	1	4	2
Productivity Improvement (No. of Operators)	4	1	4	3	4
Decreased Stock Turns	3	1	2	1	2
On Time Delivery	3	2	1	2	1
Overall Equipment Effectiveness	1	1	3	3	2
Sales Per Person	4	1	3	4	4
Space Utilisation	4	1	2	2	2
Totals	20	8	16	19	17

1 Highly relevant
 2 relevant
 3 Slightly relevant
 4 Not relevant

Table 1. Matrix between QCDFS and seven industry measures (Source Author)

IMPLEMENTATION OF A STRATEGIC BUSINESS MODEL (SBM)

For successful use of the SBM, the MIC and ADAC needed to be developed and defined in more detail. The initial QSAM gave the basic outputs but more detail and direction was required.

Defining and applying the MIC – Understanding the requirements of the MIC was key to choosing which tools and techniques to use. The main aim of the MIC was to remove the constraints out of the system to free up space, time and money to become more efficient and allow new opportunities to be pursued. Each of the tools selected were scrutinised for their applicability to the problems identified. Each of them was carried out by a team within the TSCC consisting of Project Coordinator, Managers, Supervisors and Operators working in a continuous improvement culture.

Defining and applying the ADAC – For the full benefits of applying the SBM it is equally important that the ADAC is defined and utilised. The introduction of Finite Element Analysis (FEA) as a new service was the result of the earlier techniques used such as Voice of the Customer (VoC), Quality Function Deployment (QFD) and New Process Development (NPD).

SECOND QSAM

To measure how the company had changed during the implementation of the SBM a second QSAM was required. There were several reasons why this second QSAM needed to be carried out.

- Analyse the current position of the supply chain within the business
- Analyse if the tools and techniques were successful
- Analyse the changes in the uncertainty circle scores and adherence to the 12 simplicity rules.

The second QSAM was carried out in the same standard way with all the same personnel involved. The uncertainty circle and 12 simplicity rules scores can be seen in the results section of this paper.

ANALYSIS OF RESULTS

By using the QSAM before and after a BPR program it is possible to correlate the results and identify which areas of the business have changed. In the case of TSCC it resulted in a successful transformation (see figure 3). It is plain to see how each of the 7 measures within QCDFS has changed for the better during the BPR period:

- Scrap rates have fallen from 8% to 1.25%, this is significant to the service to customers

- Productivity improvements in relation to the number of operators, 7.6% reduction (66 -61)
- An increase in stock turns has allowed there to be less kept in stock, this is a decrease of 26% (£132,000 down to £ 98,000)
- An increase of 3% in space utilisation now allows for development of operations and products
- The increase in OEE from 71% to 83% now places the company as world class
- OTD has increase from 75% to 94.8%. This will ensure contracts are renewed.
- Value added per person has increased from £17300/month per man to £28600/month per man.

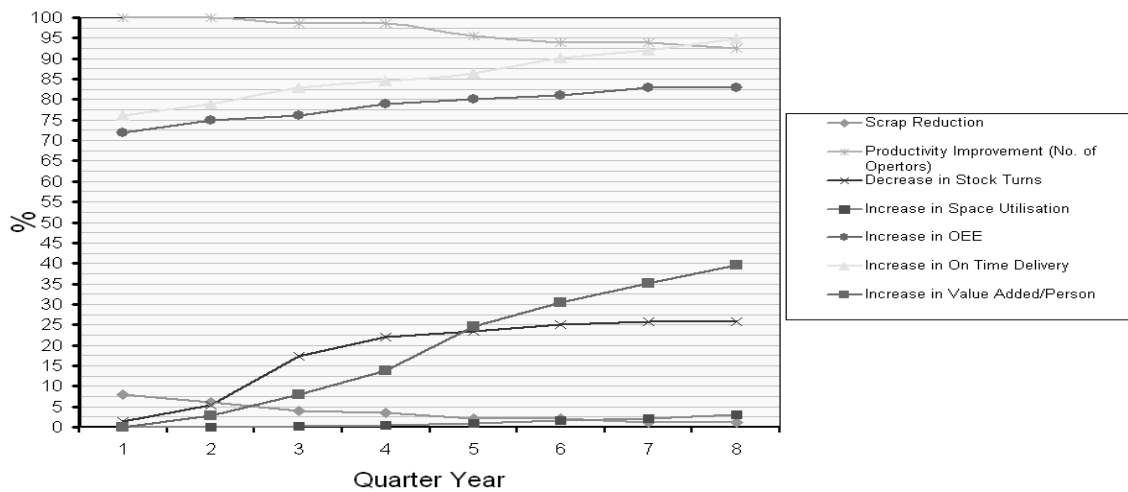


Figure 3. Correlation of results over the duration of the SBM implementation

It is now possible to compare the Uncertainty Circle scores from before and after the implementation of the SBM due to the two-stage QSAM approach. As shown in Figure 4.

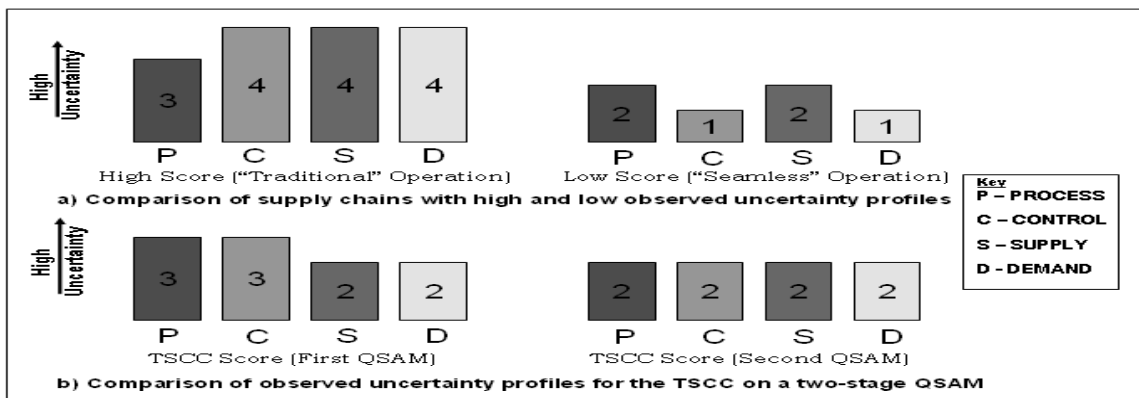


Figure 4. Uncertainty Circle scores from the first and second QSAM

The supply chain has been balanced to scores of 2, where the process, and control interfaces had previously scored 3's. This indicates that the areas that were identified as most in need of improvements (process and control interfaces) have been positively affected, plus any danger of the supply score worsening through lost decreased orders has been avoided. This proves that the tools and

techniques which were carefully selected during the definition stage of the SBM were correct. The second measure against which the company was scored was the 12 Simplicity rules. As explained earlier in this paper these rules when adhered to promote simplified material flow which should be desirable for any manufacturing supply chain. These rules are scored for adherence within the selected supply chain, 1=never, 2=sometimes, 3=most of the time or 4=always, figure 5, shows how the company's supply chain was adhering to them before and after the two-stage QSAM.

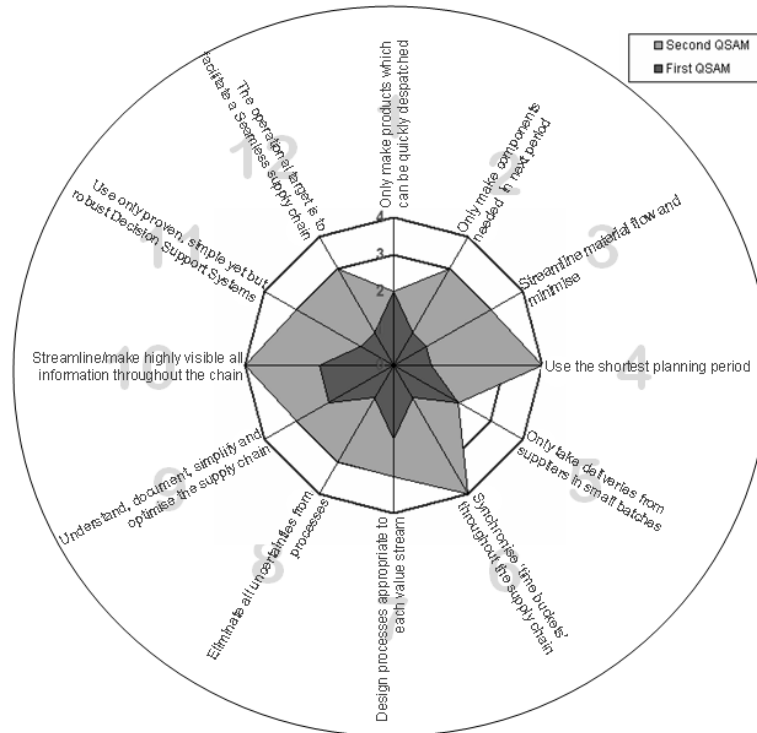


Figure 5. Ranking of Simplicity from the first and second QSAM

There were major changes to many of the rules apart from rules 1 and 5. The reasons for this was the company wanted to follow the schedule produced by the new software, this removed the flexibility in the system. In other cases there were major changes such as rule 4, 6, and 10. These can be explained through ability to recognise when orders could be batched for less run time, the introduction of new scheduling software that controlled material through the process was able to dictate start times and pull when required and the introduction of work-to lists which were able to assist production in working on the required orders when needed according to the master schedule. Apart from rules 1 and 5 all other rules were found to have improved in their adherence, this was through the manufacturing only what was required rather what was available, analysis of the process mapping to ensure direct movement of materials at the correct speed, and forming families of products which can take advantage of the changes within the value stream.

GENERAL CONCLUSIONS

- This paper has shown how QSAM can be used to measure a company's supply chain, suggest changes to be made, and then re-measure to validate results

- In the case of TSCC it has been a successful strategy that has seen benefits for both academics and industrialists
- The SBM was key to this particular company and the problems they faced as it gave a clear definitive direction
- The theory and design of the SBM ensures it could be applied across many different industries and sectors
- MIC and ADAC was done with no significant problems, this is testament to the support that the TSCC gave to the strategy
- MIC has had an instant impact on reduced running costs and increasing service levels to their customers
- ADAC has witnessed stronger relationships with existing customers as well as winning new orders from the FEA facilities
- Full benefits of the ADAC will not be seen for up to 24 months
- Recommendations for further: Third stage QSAM, comparison to other BPR programmes, check the suitability of the SBM and QSAM working together within a different company.

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SECTION 4

GLOBAL OUTSOURCING

INCORPORATING LOGISTICS IN THE MANAGEMENT OF INTERNATIONALISATION PROCESSES – A COMPARISON OF HOW CHINESE AND GERMAN COMPANIES ENTER FOREIGN MARKETS

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ABSTRACT

Over the past decades the world economy has reached an unprecedented level of global integration and for companies the ability to successfully enter foreign markets becomes increasingly important. Our literature analysis as well as our responses from our partners in manufacturing and retail has shown, that currently research in International Management and Global Logistics shows little integration, and that in practice strategic management decisions in the context of foreign market entry show little consideration of logistics issues. This gap is being addressed by this paper. Based on a survey conducted in China and Germany three key components of integrated strategies for setting up shop in new markets are identified.

Keywords: International Supply Chain Networks, Foreign Market Entry, Internationalisation Process, Global Logistics

INTRODUCTION

Global logistics systems form an important pillar of the global economy which is strongly benefitting from the increasing international division of labour. Almost every company today is part of a network of global supply chains all relying critically on efficient and reliable logistics. Logistics systems have to bridge the gap between cost efficiency in the global value chain and adequate customer service. For academia, this means that the disciplines of International Management and Global Logistics Management are gaining in importance to ensure companies' success in the global market place.

Though, the existence of globally interlinked supply chains is not a static situation: Since markets are being liberalised and trade barriers are continuously being removed, companies are in an ongoing dynamic process of internationalisation to tap growth potentials in new regional markets and leverage cost advantages of locations with specific factor endowments and cost conditions. They set up shop in foreign countries, open up new outlets in regions they haven't operated in before, and develop suppliers in emerging markets etc. Besides a dynamic environment, facilitation of internal and external processes as well as a selective cooperation with partners along the supply chain have to be kept in mind when going global. In order to ensure these internationalisation processes to be successful, it is intuitive that business strategic considerations and logistics issues have to be closely integrated. But in fact, this issue is rarely recognised.

The main question of this paper is how companies plan, structure and manage their internationalisation processes and how to integrate logistics in a way that it will be leveraged for a successful foreign market entry.

LITERATURE REVIEW

The investigation starts with a brief review of the most influential concepts in economics and business management literature followed by the main scientific logistics concepts related to internationalisation. All be evaluated according to their contribution and potential for the main question of this paper. Of course, this cannot be complete here, but a selection of the most relevant milestones in literature will help to get an overview and to mere into the topic.

The exchange of goods over long distances and global trade can be traced back to the early days of human civilisation. It has found its way into formal scientific investigation at least as early as 1776 with Adam Smith's work on "the wealth of nations" and his theory of absolute advantage. Various schools of thought have emerged and evolved over time and contributed to our modern understanding of globalisation and its impact on everybody's wealth and welfare. All of these concepts focused on the nation as unit of analysis, hence, by its nature, these approaches are not applicable to the questions raised above in this paper.

It took until the second half of the 20th century that concepts with a business perspective on internationalisation appeared: with the firm as the unit of analysis. In 1966 **Vernon** [1] published his approach of International Investment and International Trade in the context of the product life cycle. He divides the product life cycle into three phases in which (1) a new product is being initially invented in a developed country (here: USA) where it is produced for domestic demand and for export. As the product matures (2), production expands to other developed countries, so that the country of origin shows imports and exports for the product and finally, (3) production of the now standardised product is shifted more and more to less developed countries. Therewith, the inventing country becomes a net importer. Albeit Vernon's conclusions refer to international trade patterns on a country basis, his propositions are based on the behaviour of the firm that invents, produces and markets a new product over its life cycle. Hence, the core value of Vernon's model for this investigation is the consideration of a dynamic internationalisation process with a company as unit of analysis. Though, his conclusions stay descriptive in nature with little advice for the managers concerned. Along with that it follows a deterministic view which neglects the effects of strategic management decisions.

In 1973 **Dunning** [2] introduces an eclectic framework (integrating theories on FDI, transactional cost and industrial location problems) to explain the occurrence of international production along the so called OLI-Paradigm. He states that a firm will pursue foreign production when these three advantages are given: Ownership-specific advantages, Location specific advantages and Internalisation advantages (OLI). It is Dunning's merit that he integrated different formerly isolated theoretical concepts into a broader framework. Today his eclectic theory on internationalisation is probably the one with the broadest acceptance among scientists. Its critics argue that its predictive power is limited and that it is only applicable to large multinational corporations, because the framework emphasises strongly on overall cost assumptions and on ownership specific advantages. For the investigation of this project, the 3-tiered OLI-framework is valuable as it contributes to the understanding of a firm's motives to go abroad and gives managers hints for the evaluation of foreign markets.

Based on the thoughts of Johanson and Vahlne from 1977 [3] emerged the so called **Uppsala school** of thought which describes the internationalisation

behaviour of a firm as a series of incremental steps. This pattern is explained by the "Establishment Chain" and the "Physic Distance Chain". The Uppsala Model is probably the most popular approach in International Management literature [4], [5]. Its contribution to our research is the inherent process view on the internationalisation phenomenon from a company perspective. Compared to the research question of this project, the Uppsala Model uses a different level of granularity: While Uppsala is looking at the internationalisation of companies over a time period of years and decades, we have a comparatively atomic view: on foreign market entry in terms of a single project. Summing up a series of such foreign market entries over a longer time period would represent the unit of Uppsala's analysis. Despite its popularity the Uppsala Model has been widely criticised, for theoretical as well as practical reasons [6].

The second part of our literature review focussed on the most influential logistics concepts dealing with internationalisation. Dealing mainly with issues of international manufacturing, **Ferdows** presented in 1989 his work on the strategic role of the plant [7]. His concept gives answers to typical questions managers raise when it comes to internationalisation: How many international plants do we need, where should they be located and which functions should they fulfil? Therefore he introduced different roles a plant may overtake in a network: Off-shore, Source, Server, Contributor, Outpost and Lead Plant. They are distinguished according to their site competences and the strategic reason of each site. Albeit logistics was not his intended focus, his typology is an important contribution to the management of the flows of goods and information in globally dispersed production systems, which is the core of global logistics management.

In 1993 **Cooper** [8] published his work on Logistics Strategies for Global Business, which was probably the most advanced and comprehensive global logistics framework at that time. Based on the idea that products have different levels of value density and logistics reach and that logistics systems can be either centralised or decentralised, he derived with four global logistics strategies: Unicentric strategy, bundled manufacturing, deferred assembly and deferred packing. Each strategy fits products with different characteristics in volume, weight, value as well as purchasing and sales market specifics. Furthermore he defined five archetypes of global networks, which he calls Invaders, Settlers, Outreachers, Barons and Cloners. While Ferdows took a rather atomic view at the single plant of a network, Cooper chose the network design as his main subject of analysis. For this project Cooper's thoughts most importantly show the interdependencies of corporate strategy and market specifics with logistics strategy. Hence, it underlines the necessity of an integrated view on international management and logistics management, especially for the process of internationalisation and foreign market entry.

Of course, until today a multitude of further approaches have emerged regarding global logistics management. Still none of these logistics concepts contribute significantly to the research question of the paper. The analysed economic and business management literature has shown to be mostly descriptive in nature, i.e. it provides little indications for how to structure, design and organise the internationalisation in terms of advice for the managers involved. The global logistics concepts remain mostly static typologies for network design and the roles of different locations resp. sites. The dynamics of internationalisation processes are mostly being ignored. Regarding the integration of the two

separated fields of International Management and Global Logistics Management, we see a clear gap in research regarding foreign market entry.

RESEARCH OBJECTIVES AND METHODOLOGY

This paper is an excerpt of the results from a comprehensive research project on the internationalisation of logistics systems [9]. The objective was to develop a clear understanding of companies' internationalisation process and how especially logistics managers cope with the challenges they face herein – both from inside and outside the organisation. The research project was conducted by the Competence Center for International Logistics Networks (funded by the Swiss Kuehne-Foundation) at the Berlin University of Technology, Germany, in close cooperation with the Supply Chain & Logistics Institute at the Huazhong University of Science and Technology in Wuhan, China. The questionnaire based approach aimed at logistics managers from manufacturers and retailers (excluding logistics service providers), with global activities or with the intention to internationalise their activities. The questionnaire was distributed among Chinese and German companies with a return of valid replies of 70 and 50 respectively. By utilising a Likert Scale as well as common statistical methods, the data set was analysed jointly by the two project partners. Additional discussions with logistics practitioners enriched the interpretation of the results. Firstly, this paper specifies the challenges and difficulties in international logistics from a country-specific as well as a transnational perspective. Secondly, the following sections focus on three key components that have shown to be mandatory to be integrated in any global logistics approach, namely dynamic environment, standardisation, and collaboration with logistics service providers (see Fig. 1).

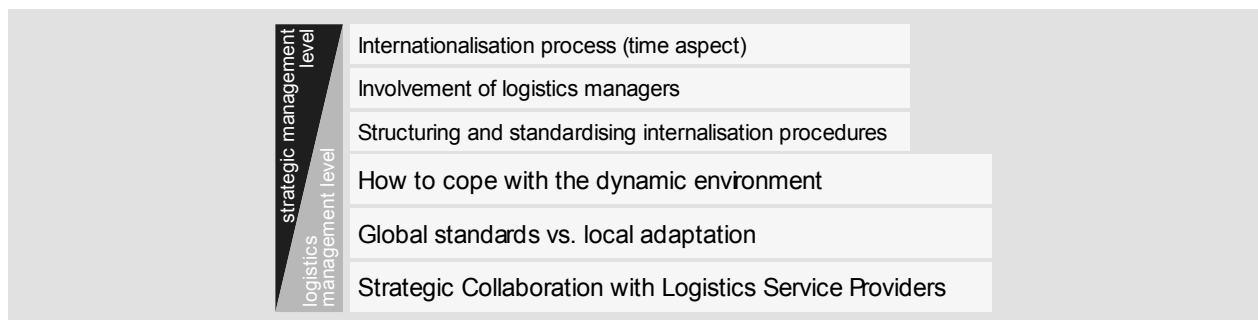


Fig. 1: Framework of internationalisation topics (Source: own illustration)

CHALLENGES AND DIFFICULTIES IN INTERNATIONAL LOGISTICS

The most important challenge for international logistics activities is heterogeneity. In global logistics, a great many of differences between the involved countries have to be considered in order to design and manage such a global network. Nowadays, standardized procedures for trade and transportation are implemented to some extent, but in large part they depend on national specifications. Therefore, a universal view of logistics conditions both within involved countries (country-specific issues) and also transnationally (transnational issues) is crucial in order to deal with the environmental heterogeneity of global networks.

Country specific issues in global logistics include infrastructure, security issues, intercultural issues, personnel, logistics market, political and legal conditions, etc. As the facilitation of transportation is one of the main factors governing the growth of economic power, logistics infrastructures vary dramatically between

nations at different levels of development [10]. Developed countries usually benefit from both nationally interlinked industrial centres and internationally connected neighbouring countries. In developing countries, several reasons such as rapid economic growth, neglected focus on infrastructure development, and the like might have led to insufficient logistics networks and facilities. It is estimated that in developing countries, the share of logistics in total cost is about double compared to developed countries [11].

Intercultural issues and the level in which they are perceived is clearly related to the cultural distance between the home country and the new target market. Differences in life habits, mentalities, languages, beliefs, values, customs, and environmental concerns are significant key challenges for global logistics in a highly interconnected business world [12]. The results of the survey show that both Chinese and German companies label intercultural matters as the most considerable country-specific issue. Furthermore, political and legal conditions, the level of development as well as financial risks of the target market have to be considered [13],[14].

Transnational issues in global logistics include complexity and uncertainty, interdependencies in case of disruptions, customs duties and procedures, global IT linkage, and the like. Among others, one main reason for complexity and uncertainty is the high amount of persons, companies, institutions, and other intermediaries that are involved in the fulfilment of customer demand [12],[15]. The more instances are involved in logistics networks the more integration among them is required, not limited to physical treatment of goods but especially for directing data flows. Furthermore, minor disruptions (either man-made or natural disasters) in one part of the supply chain may cause difficulties in another part. The majority of the Chinese companies (80%) name this as a major problem in their network, less than 20% of the German companies see this as an essential issue.

In order to handle the multitude of possible challenges and difficulties, we identified three key components that are mandatory to be integrated in any global logistics approach, especially for foreign market entry.

DYNAMIC ENVIRONMENT

The capability of coping with changing environments and the uncertainty in logistics networks significantly impacts the success of the internationalisation process. Since logistics conditions, e.g. infrastructure, legal regulations or administrative matters are subject to change in different countries in different ways, the design and management of global logistics systems are challenging and error-prone tasks. According to our survey, 80% of the logistics managers claim that dynamic changes of the business environment account for the most challenging issue in today's internationalisation process. It is not sufficient to incorporate just the AS-IS situation. Future developments are subject to uncertainty. Hence, the forecast of future developments will most likely be inaccurate.

Dynamics and uncertainty have various origins, e.g. shifting of customer's preferences over time or changes in legal restrictions. The EU enlargement, China's WTO accession or the shifting process of investments in logistics facilities from China's coast line to China's hinterland, represent examples for changing environments. These examples substantiate once again the significant impact of

incorporating dynamic aspects into the planning activities. Those companies who do not realise immediately the transformation consequences to their market might lose their competitiveness pretty quickly.

Logistics flexibility has different dimensions, ranging from a system's responsiveness to short-term changes in customer demand, to the ability to alter the network structure dependent on major geographical shifts. Based on a company's business model, different methodologies are applicable: postponement strategies, agreements for flexible working hours, outsourcing concepts, etc. Logistics managers need to be aware that their logistics system has to be agile enough to fulfil future unpredictable business requirements.

Flexibility of a logistics system also implies the ability to retreat from market in case of failure. The retreat of Wal-Mart from the German retail market or the retreat of the famous German home improvement OBI from the Chinese market, are recent examples for failure. Hence, logistics systems should be supportive for a rapid expansion and, at the same time, they should provide the possibility to retreat from a market with a minimum of sunk costs and residual overhead costs. The incorporation of failure into the logistics strategy is often neglected, 35% of the surveyed German companies and 30% of the Chinese companies do not consider the possibility to fail. Only 10% of the surveyed German companies and 35 % of the Chinese companies always include an exit option in their logistics strategy. Apparently, Chinese companies seem to incorporate flexibility in their internationalisation process in a better way than German companies, which could be explained by the fact that Chinese companies are exposed to a more dynamic environment than German companies.

The findings of the survey have shown that there is quite little attention paid to flexibility compared to quantitative measures as costs or performance. Considering today's severe dynamics, the uncertainty of today's business and the potential risk resulting of inflexible logistics system, flexibility does not seem to be incorporated in an adequate way.

GLOBAL STANDARDISATION AND LOCAL ADAPTATION

Due to the huge number of locations, intermediaries, and suppliers involved in logistics networks as well as due to customers working with different methods and routines under distinct logistics conditions, global logistics management is an increasingly complex task.

As a result of standardisation, logistics practices are similarly applicable at any place in the network. Companies are able to establish worldwide transparency, enhance the supervision and management of logistics networks, reduce costs, save time, and increase the reliability of operations. All kinds of inbound, in-house and outbound processes can be subject to standardisation including partners, customers, and suppliers.

However, in different countries and regions, differences in legal framework, infrastructure and customer expectations call for local adaptation of logistics processes. For example, the German retailer Metro needs to offer goods in smaller packages at a larger number of small shops in China or India compared to Europe or the U.S. This represents the necessity to adapt to local conditions when companies go global and lead to the question, to what extent companies apply standardised logistics processes when entering foreign markets, and how

much adaptation it takes to meet the requirements of their target regions (see Fig. 2).

	Chinese	German
“We have no country specific strategy. Our logistics system is rolled out into new markets without any local adaptation.”	12%	3%
“Our logistics system is rolled out into new markets with a minimum of local adaptation.”	60%	39%
“We develop a completely new logistics system for each and every market.”	28%	58%

Fig. 2: Balancing global standardisation with local adaptation (Source: own illustration)

The discrepancy between the Chinese and German majority's approach can be explained in two parts. Firstly, Chinese companies offer mostly low cost products and standardisation is adequate for their customer's purchase decision. Their German peers offer products of higher sophistication providing superior customer service and therefore prefer to develop country-specific systems. Secondly, Chinese companies mostly apply a push strategy for entering foreign markets through a Greenfield approach with well designed and systematically planned standardised processes. In contrast, German companies have grown their logistics networks mostly according to the foreign customers' requests over time.

Basically, the majority of all respondents appreciate the beneficial aspects of process standardisation for their logistics networks. The differences in the results are caused by the requirements of an individual country-specific system in each business sector and should be balanced to what degree the regional adaptations would accept the global standard of the company.

COLLABORATION WITH LOGISTICS SERVICE PROVIDERS

The sector of logistics service providers (LSP) strongly grows in developed economies. Nowadays, LSPs offer various logistics services and basic logistics activities like transportation, warehousing and handling up to complex network solutions including information processing.

Outsourcing logistics activities is a strategic decision and LSPs penetrate further into their customers' operations and supply chains. Less than one-third of the reviewed companies in this survey indicated that they need to have self-run logistics assets and operations to maintain the right quality and service levels for their business. 71% of the Chinese and 61% of the German managers would rather prefer helping a new LSP to develop in a new target market without adequate and capable LSP than investing in dedicated self-run assets.

The most important objective of logistics outsourcing when going global is to ensure a quick market entry by leveraging the LSP's existing global network. For Chinese managers, the LSP's specific know-how and service quality are most important factors for outsourcing. Additionally, outsourcing minimizes the need for investments when setting up shop in new markets. This clearly shows the strong coherence of foreign market entry and global logistics outsourcing.

The majority of logistics managers, with 72% of the Chinese and 42% of the German, outsource specific activities to several LSPs (see Fig. 3). Only 14% of Chinese and 9% of German respondents do not outsource any logistics

activities. Generally, Chinese companies show significantly lower outsourcing levels than their German peers. 45% of the Chinese respondents prefer working with only one partner, hence, a simplified coordination. Only 14% of the German companies do rely on a single LSP. The residual part of German companies does not want to depend on the performance of one single third party.

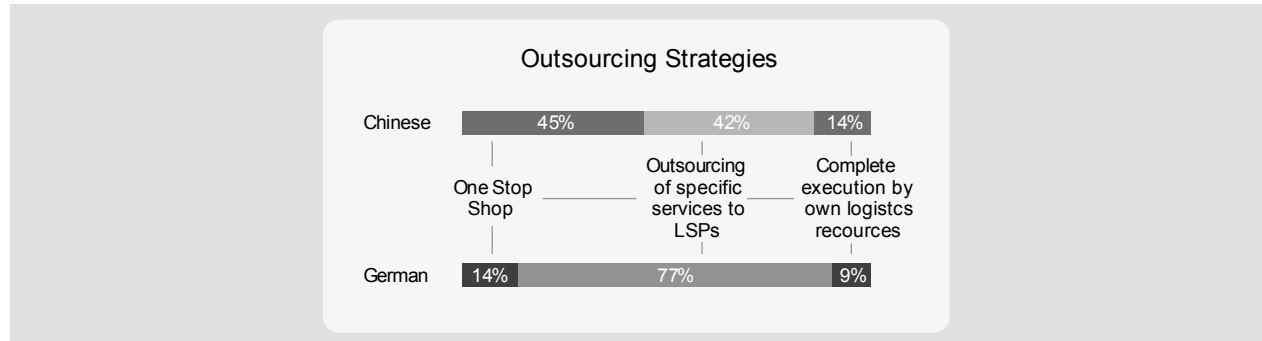


Fig. 3: Outsourcing strategies (Source: own illustration)

The two most important criteria for selecting a LSP when setting up shop in foreign markets are the price as well as quality and reliability of the services provided. Both should be balanced in particular because of potential for savings can outweigh the direct price for the LSP's services in order to improve logistics efficiency by considering other issues such as quality, operations, and technology. The third most important criterion is the experience gained from former cooperation.

Through their global expansion, companies require complex and specialized logistics solutions from their LSP who needs to improve their capabilities and facilities continuously. Because of the competition in the logistics industry the logistics service contracts become sophisticated. Only a few of the LSPs can ensure that a project is properly implemented worldwide and that their own people work directly with customers in all locations.

CONCLUSION

Internationalisation is a complex issue that demands a holistic management approach including both business management science and scientific logistics concepts. Different business models, strategies, and market peculiarities make it necessary for every company to find the logistics concept that matches best with its individual needs. In general, however, logistics as well as the consideration of logistics issues from the very beginning of the internationalisation process are of particular importance in order to achieve time and money savings as well as competitive advantages. Internationalisation is not a standard procedure and the related issues are by no means completely clarified. In practice, a lot of issues have to be solved by gut feeling and pragmatism – still, a multitude of questions remain unanswered and provide more than enough starting points for future research.

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PREDICTING EFFECTS OF THE CHINESE CULTURE ON THE IMPLEMENTATION OF SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The purpose of this paper is to explore how the Chinese culture influences the implementation of Supply Chain Management (SCM). Based upon the SCM and the culture literature, three conditions of SCM implementation are identified and critical elements of Chinese culture that has been deeply influenced by the Confucianism are defined. The research develops a framework which serves as the basis for research model that links cultural elements to critical factors encouraging successful SCM. The research is limited in literature review; a further empirical validation using mathematical methods is thus required. Yet the research establishes a starting point for researchers interested in enhancing the understanding of the cultural phenomena in SCM. The results of this article further discussion of the understanding of Chinese culture and its role in the successful implementation of SCM. The application of the framework through empirical research will help the actors in international supply chains, especially those who do the deals with Chinese firms, to recognize the problem of cultural clash and to offer the clues to resolution. The value of this research consists in filling the literature gap by crossing the culture, especially Chinese culture, and the conditions for success of SCM implementation.

Key words Supply Chain Management Culture Confucianism

INTRODUCTION

The importance of culture in implementation of SCM has become recently recognized by both academic literature and executives. Research, however, has only begun to explore occidental cultural characteristics of SCM to better understand its implementation and development. A sound understanding of the building blocks of oriental culture, especially Confucian culture, which influence firm's behaviors in this specific cultural context, is still limited.

The purpose of this paper is to explore how the Chinese culture impacts the implementation of SCM. The framework will serve as the basis for propositions suggesting likely conditions of SCM implementation and also linking these conditions to critical elements of Chinese culture. Finally, conclusion and implications related to further research on this subject are presented.

CONCEPTUAL BACKGROUND

Supply Chain Orientation is a strategic choice of the firm, which allows achieving the double objective of efficacy-efficiency, by cooperation based on relationship management. Under the SCM paradigm, the managerial processes cross the functional boundaries within the firm, and link the partners and consumers outside the firm. Compared with Adam Smith's division of labour, the SCM could be understood as a neo-division of labour, which is illustrated by table I:

	Division of labour (Adam Smith)	Neo-division of labour (SCM paradigm)
context	Supply < Demand	Supply > Demand (diversified)
Posit	Perfect rationality Selfish	Limited rationality Altruism
motivation	Personal benefits	Personal and collective benefits
Relationship between firms	Competition	Cooperation
consequence	Winner-Loser Growth of individual welfare	Winner-Winner Improvement of individual and whole chain performance

Table I: Understanding of SCM paradigm

The conditions of SCM implementation are not clear in the literature. We conclude yet three conditions as follows:

Cooperative norm

The first condition is cooperative norm. It can be defined as the perception of the joint efforts of both the supplier and distributor to achieve mutual and individual goals successfully, while refraining from opportunistic actions (Siguaw and al., 1999). In another word, the cooperative norm construct reflects the belief that both parties in a relationship must combine their efforts, or cooperate, to be successful (Cannon and al., 1997). However, Saubesty (2003) argues that the cooperation between several actors implicates existence of the will to cooperate, which is the result of the individual calculate about the cooperation benefits. Combining these two opinions, we argue that the cooperative norm has two elements:

1. Anticipation of value through cooperation

In order for the parties involved to avail themselves of the implementation of SCM, those parties, according to value expectancy theorists, must expect such implementation to create value, which prove it worthwhile. According to Hamel (1991), the anticipation of value is an important factor that affects the strategic alliance success.

2. Belief of elimination of opportunistic behavior

Being different from the classic economics, the SCM paradigm emphasizes the elimination of opportunistic behavior, as Siguaw and al. s' definition demonstrated. The cooperation is a better choice for enlarging the "cake" rather than opportunistic behavior.

Commitment

The second condition is commitment of firms. Morgan and Hunt (1994) define relationship commitment as an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts in maintaining it. Firm's commitment allows a relationship on the long run, by reinforcing agent's will of cooperation (Ring and Van de Ven, 1994; Cullen and al., 1995) and by refraining from opportunistic action (Cook, 1977; Fein and Anderson, 1997; White and Siu-Yun, 2005; Anderson and Weitz, 1992). Therefore, it is a key factor for the Supply Chain integration.

Information

Information is one of the principal elements to exchange in SCM (Croom and al., 2000). Several empiric researches confirm this opinion. Gavarneni (2002) demonstrates that the benefices of information sharing for manufacturers are significant. Chen and al. (2000) argued that demand information sharing can reduce the Bullwhip effect.

However, two elements remain in question. First is related to the sources of information, in another word, the information access. That means the collective forms of information should be accessible. Second question concerns the will of information sharing. Li (2002) analysed the effects of information sharing on price decision in a supply chain. He found that the retailers did not want to share their information. Similar results could be found in Zhang (2002) and Mishra and al. (2006). According to Croom and al. (2000), not all the organisations are available to share the information, because they consider it as lost of power.

Confucian culture

Schein (1985) introduced a three levels' culture model to demonstrate how a dominant culture or subculture can influence the behavior of the organisational members. In a similar way, we introduce the Confucian culture based on the three levels.

The basic assumption of Confucianism is the self in relationship, which is different from occidental individualism. The values advocated by Confucians are *Ren* and *Yi*. *Ren* is the supreme virtue symbolizing the best qualities of the human, but it is also the global rule in terms of interpersonal relationship management. *Yi* is ritual equity which recovers a very large sense, from the justice to integrity, passing by a certain sense of honor, a respect to rules. *Li* is the rituals, the visible norms, which represent an interpersonal relationship codification system. In conclusion, the Confucianism can be understood as an ethic system in Asian society.

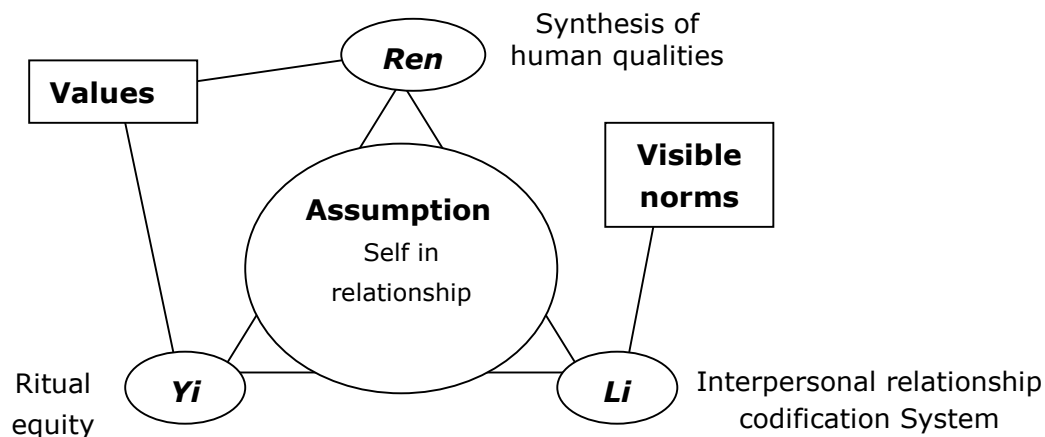


Figure I: Confucianism

Cultural consequences

Under the influence of Confucianism, the Chinese society has two characters: affective society and *guanxi* based society.

About the Chinese society, one can not but notice that Chinese people emphasise at the same time the rationality and the affection (Zhai, 2004), and they always try to find equability and harmony between the two extremes. For this reason, the judgments on events and behaviors are not only on the basis of rationality, logical consideration and formal institutions, but also specific and concrete situations. As a result, social norms play important roles in people's interaction and can be considered as complementary to the formal institutions (Xin and Pearce, 1996; Mellahi and Wood, 2003). The social norms concerned refer to a Chinese term: *Renqing*, which consist of face, reciprocity and long term orientation.

Face

Face refers to a person's claimed sense of positive image in a relational context, gained by successfully performing one or more specific roles that are well recognized by others (Hu, 1944; Bond, 1991). *Face* is a function of perceived social position and prestige within one's social network (Hwang, 1987). It is important not only for Chinese people's personal lives but also for their business lives (Lee and Dawes, 2005). The finding of Redding and Ng (1982) is a good illustration, according to which, *face* is a consistently important consideration for Hong Kong businessmen in their professional interactions and that fear of losing *face* forms the basis for the informal system of contracts and agreements that are common in Chinese business.

Reciprocity

Returning another person's favors is an obligation expected within the whole of Chinese society. Accepting favors but forgetting to return them is blameworthy, leading to

increase pressure for individuals to reciprocate (Luo, 2005). The rules of reciprocal favor require certain social behaviors in Chinese culture (Hwang 1987). For example, it requires that all members of a group perform favors to help those in need and that all favors should be repaid (Lee and Dawes, 2005). In addition, reciprocal favor indicates not only the affective responses of a person, but also a resource that a person can “borrow” to another. Moreover, Wang (2006) indicate that the application of reciprocity rules has to respect a snowball effect, which means one should repay more favors to others than what he received before.

Long term orientation

Members of Confucian societies assume the interdependence of events, and understand all social interactions within the context of a long-term balance sheet. The debit and credit sides of this balance sheet are never in equilibrium, since such a status often means the end of a relationship (Yeung and Tung, 1996). This meets the long term orientation in Hofstede’s cultural dimensions model (Hofstede and Bond, 1988), which includes persistence, using status to order relationships, thrift, and having a sense of shame, and is labeled by Bond (1991) “Confucian dynamism”.

Guanxi based society

The Chinese word *guanxi* is not a term which can adequately be expressed by an English-language equivalent, the concept is too culture specific (Parnell, 2005). *Guanxi* has its historic root in theories and practices of the Confucianism that define social rules and specific values that are still dominant in 20th century (Parnell, 2005; Wong and Tam, 2000; Standifird and Marshall, 2000).

Guanxi has been defined at different levels in different perspectives (Bian, 1997; Tsui and Farh, 1997; Yueng and Tung, 1996; Chen and Chen, 2004). For example, it can be considered as a specific dyad relationship between people, which allows the resources and power exchange (Tung and Worm, 2001; Alston, 1989; Jacobs, 1979; Gold, 1985; Osland, 1990; Pye, 1982), or as social connections based on mutual interests, exchange of favors and reciprocal obligations (Davies and al., 1995; Lee and al., 2001; Arias, 1998). In spite of the diversity of *guanxi* definition, in our article, we define the *guanxi* as the dyad connection between individuals and this connection is associated with social norms above: *face*, reciprocity and long term orientation.

Guanxi based trust

Based on Zucker’s three sources of trust, Whitley (1991) found that in Chinese firms, trust results from interaction process and person’s characteristics, rather than institutions. However, the person’s characteristics here are different from Zucker’s person based trust, because according to Zucker, person based trust is tied to similarities between people. But in China, person based trust is tied to obligation in interaction. In fact, this source of trust refers to a Chinese indigene concept: *guanxi* activity (Peng, 1999). In Chinese business market, personal trust caused by face and reciprocal favor is cognition based, whereas trust caused by affect is affect based (Lee and Dawes,

2005). In Chinese local research, Chen and Gao (1991) argued two sources of trust: (1) *guanxi*, (2) personal ability. Similar result could be found in Zheng (1991), according to which, trust in Chinese society resulted from *guanxi*, loyalty and ability. As a result, the production of trust in China is based on the cultural element: *guanxi*.

HYPOTHESES

Face

The norm of preserving *face* in Chinese society encourages people to play proper social roles, to meet the requirements of and to be liked by peers of the group, and to allow all members to appear good in the group (Lee and Dawes, 2005). Emphasizes on *face* preservation serve as a refraining mechanism of opportunistic behaviors (Heide and John, 1990; Ganesan, 1994). As a result, conflicts within the group are reduced, while harmony is enhanced. For this reason, *face* has an instrumental function in stabilization of business relationship. Therefore, combining the *face* and the conditions of SCM implementation allows the generation of my first two hypotheses:

H1: The norm of preserving face is positively associated with firm's commitment in a long term relationship.

H2: The norm of preserving face has positive influences on prevention of opportunistic behaviors.

Reciprocity

According to Hwang (1987), the norm of reciprocity requires all the members of the group to keep contact each other in order to maintain good interpersonal relationship. Second, if a member gets into difficulties, the others should help him, and the favor receiver should return it as soon as the opportunity arises.

The norm of reciprocity adds a social value in the values generated by cooperation. And the snowball effect reinforces this kind of value. Second, the snowball effect make it difficult to find the end of the relationship, because without clearing *Renqing* debt, those who break up the relationship will be considered to have "no credibility," to have "no conscience," and to be "mean," and they lose reputation, and ultimately all the resources in the *guanxi* network. At last, the reciprocity refers to the exchange of resources through personal ties within the *guanxi* network, it is logical do declare that this norm reinforces the will of information sharing. Therefore, the linkage between reciprocity and the conditions of SCM provides me with three hypotheses, accordingly:

H3: The norm of reciprocity increases the anticipation of value created by cooperation.

H4: The reciprocity has positive influence on commitment of firms to a long term cooperative relationship.

H5: The reciprocity reinforces the will of information sharing.

Long term orientation

According to Noordewier, John and Nevin (1990), long term orientation refers to the

expectations of continuity of a relationship. Lee and Dawes (2005) demonstrate a significant part of a buying firm's long-term orientation toward its supplier is attributable to its personal loyalty to the sales manager. Then, the loyalty at a personal level generates the long term relationship between organizations. Moreover, the long term orientation related to interdependence between parties. According to Kelley and Thibaut (1978), more the cultural context is related to friendly support, altruist attitude and polite behaviors, stronger the will of resources sharing is. So, another two hypotheses follow:

H6: Long term orientation is positively associated with firm's commitment.

H7: Long term orientation reinforces the will of information sharing.

***Guanxi* structure**

Granovetter (1973) argues that weak tie bridges provide people with access to information and resources. Davies and al. (1995) valid their hypothesis that *guanxi* is an important source of information about market tendency and commercial opportunities. On basis of Burt's (1992) structural hole theory, Shin and al. (2007), argue that *guanxi* provides a valuable entrepreneurial tool to bridge gaps in information flows between unlinked firms and between firms and important outside stakeholders: firms develop *guanxi* to broker structural holes and alter the existing network. Thus, we have another hypothesis.

H8: *Guanxi* network provides access to information within Supply Chains.

***Guanxi* based trust**

Even though Morgan and Hunt (1994), Hrebiniak (1974), Achrol (1991) have demonstrated the positive correlation between trust and organizational commitment in the business to business context, the trust in their theoretical framework is the occidental type of trust. The relationship between *guanxi* based trust and firm's commitment is still not clear. According to Wang (1994), *guanxi* based trust has a small scale, but is much stronger, which can stimulate the organizational commitment in a long term relationship. Anderson and Weitz (1992), Heide (1994) also argue that *guanxi* based trust reinforce the will to invest on relationship and the organisational commitment will be pay back in the future. Therefore, the last hypothesis is:

H9: The *guanxi* based trust stimulates firms to be committed in a long-term cooperative relationship.

Based on these hypotheses, we could establish our theoretical model as follow:

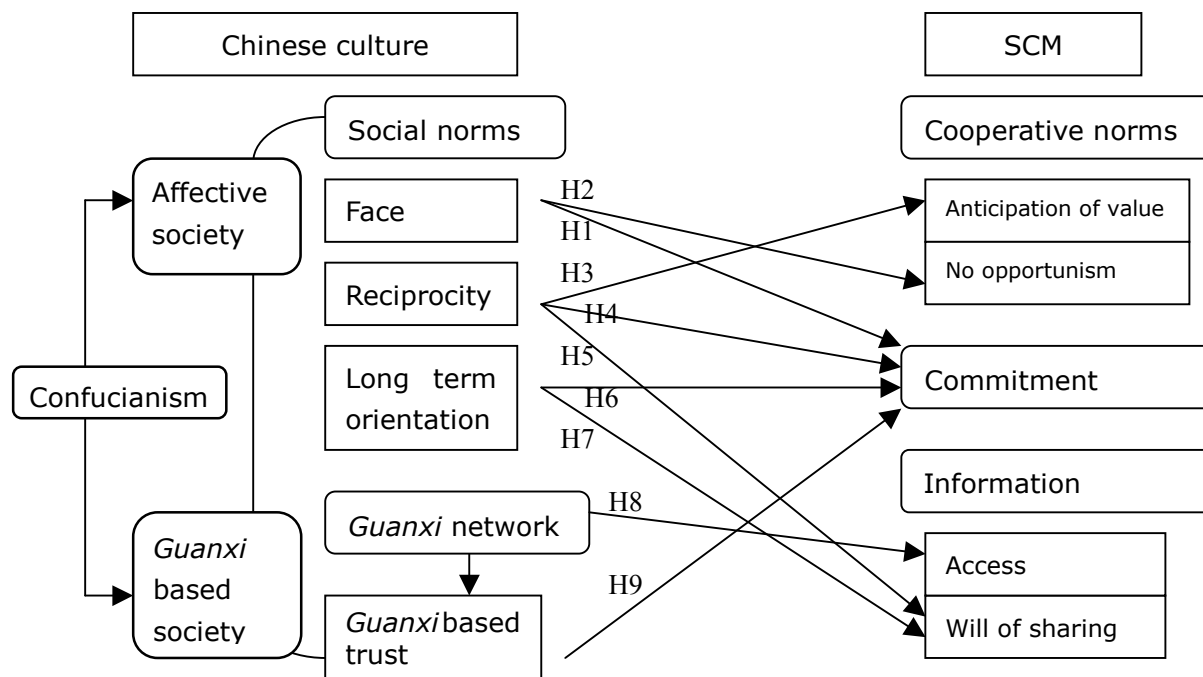


Figure II: Theoretic model

CONCLUSION

In this article, we developed a theoretical framework based upon the identification of Chinese cultural elements and the conditions of SCM implementation. This framework allows us to establish a theoretical model which demonstrates the relationship between the two groups of variables. Our article fills the gap in academic literature linking the SCM and the Confucian culture. The findings of this article suggest that the firms adopting a SCM strategy in China should take into account the Chinese culture who determines the result to a certain extent. An empirical research is necessary to test the theoretical model proposed in this article.

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IMPROVING SERVICE AND SUSTAINABILITY IN RETAIL SUPPLY CHAINS

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ABSTRACT

Purpose: On-shelf availability and its impact on retail customer service and profitability has concerned retailers for many years. Further, globalisation of retail supply chains has meant increased logistics costs, particularly in transportation, and which has also led a call for more environmentally friendly or 'green' supply chains. This paper investigates these issues via two research studies conducted in conjunction with ECR UK at both the on-shelf and secondary distribution positions in UK retail supply chains.

Methodology/Approach: We first discuss the literature regarding on shelf availability and collaborative distribution. Next, we present two independent case studies concerning on-shelf availability and collaborative distribution respectively. Primary exploratory research was undertaken by desk research of data and documents and interviews with managers at the focal companies involved in both case studies. Lastly, we provide conclusions and implications for practitioners and further research.

Research limitations/implications: Although we conducted primary empirical research related to the case studies the research was exploratory; thus there is no expansive empirical study in this paper. Our major output comprises a synthesis of the issues and suggestions for future investigation of these topics.

Practical implications: The profitability versus availability case study found that the most profitable products had the least availability; which affects customer service and profitability. We propose a strategy matrix to improve on-shelf availability and profitability. The collaborative distribution case study found evidence of efficiencies, cost savings and thus improved environmental performance in the collaborative distribution trial. We note barriers to larger scale implementation and provide suggestions for improvement.

Originality/value of the paper: This paper adds to knowledge of how on-shelf availability affects retailer service and profitability and to knowledge of collaborative distribution issues that impact the ability of retailers to ensure proper on-shelf availability and customer service levels are met and maintained.

INTRODUCTION AND BACKGROUND LITERATURE

With retailers increasing their materials sourcing, production and sales on a global basis, meeting both service and sustainability targets in global supply chains have emerged as strategic management challenges. Service for retail consumers is primarily manifested by product or on-shelf availability (OSA); Corsten and Gruen argued that "availability of products is the new battleground in the fast moving consumer goods industry" (2003: 603) while Towill (2005) considered availability is a market winner as opposed to a market qualifier. Availability as a customer service feature is classically 'traded-off' against inventory carrying costs and other logistics-related costs. The rise of retail giants such as Wal-Mart and Tesco has led to a retail-controlled supply chain,

particularly in food retailing. In order to improve operational efficiencies and these trade-offs retailers have streamlined their supply chains, particularly in their home markets: Fernie and Sparks (2004) claimed that the UK had one of the most efficient supply chains in the world in the late 1990s/early 2000s.

Despite these supply chain innovations OSA has emerged as a major concern for British consumers and was reinforced by media attention when the *Sunday Times* published a report indicating that on average Sainsbury's had 10% of items out-of-stock (OOS) in a 30 item shopping basket across 13 stores, with the worst performing store only having two-thirds of items available (Fletcher 2004). This pattern was prevalent throughout the grocery sector and became the focus of attention for Efficient Consumer Response (ECR) UK and IGD, the main UK trade associations for addressing issues pertaining to the sector.

In 2005 three ECR UK Availability sub-groups were established – Availability Insights, New Product Introduction and Promotions and Convenience (IGD 2007a). The latter two groups were established to glean a better understanding of the impact which new product launches and promotions have on availability whereas the former insights group has tended to focus on specific issues (Fernie and Grant 2008). The authors recently conducted research for the ECR UK insights group into profitability versus availability in the chilled juice category and that research forms the first study presented in this paper.

The move towards sustainability and corporate social responsibility brings exogenous factors into play for firms as well as criticism from interested stakeholders such as Friends of the Earth or Greenpeace. Firms should now be incorporating environmental or 'carbon footprint' assessments in their business case analyses (Grenon, Martha and Turner 2007).

A recent example emerged when Young's Seafood Limited in the UK announced they were switching production of Scottish langoustine from a machine-peeling plant in Scotland to a hand-peeling facility in Thailand as it was more economically beneficial. The peeled langoustine are returned to the UK, breaded, packaged and distributed to supermarkets for sale. This change means the langoustine now undertake a round-trip of more than 27,300 km by sea as opposed to a 300 km one-way road journey to Young's final production plant in England (McGinty and Johnson 2007).

This naturally attracted criticism from environmental groups however Young's engaged a consultancy to conduct an environmental impact study. The consultancy evaluated the change in carbon dioxide emissions (CO₂e) taking into account all carbon dioxide sources: energy use, transportation, waste and refrigeration leakage. The evaluation showed there would be no net increases in CO₂e and the Carbon Trust agreed that the methodology used by the consultancy and the results produced were technically sound (Halliday 2007).

ECR UK and IGD have also recognized sustainability issues and have sponsored research into collaborative distribution as one mechanism of improving sustainability (IGD 2007b). Other research has suggested that transport efficiencies can be achieved by optimising transport across a network of retailers and suppliers in a horizontal, collaborative way (Mason et al. 2007). ECR UK, as

part of their continued efforts to increase collaboration between retailers and suppliers, initiated a project in 2007 to look at various aspects of Collaborative Green Distribution. This project's objectives were to investigate different ways retailers and suppliers could work collaboratively to reduce transport costs, improve efficiencies and service and equally importantly, improve the green credentials of the UK food and grocery retail industry.

Again, the authors contributed to this project by conducting a case study of the ways transport networks servicing stores and consumers away from conurbations could be improved; this project was entitled Shared Deliveries to Far Flung Places and is the second study presented in this paper. This study is considered important because there are a number of areas that have very low population densities and require a disproportionate share of transport resources to service, e.g. northern Scotland or East Anglia.

A number of retailers and food service providers maintain dedicated delivery services to customers contributing to overall inefficiencies in the transport network. Additionally, due to the high cost-to-serve, delivery frequency is often reduced which in turn can lead to poorer availability for the end consumer. Lastly, given the lack of manufacturing in some of these areas there is often a flow imbalance; it is more unlikely that backhaul opportunities exist with a trading partner and therefore matching counter flows may well have to come from outside an individual company's trading community.

METHODOLOGY

The research projects comprised two independent case studies (Ellram 1996); the first study on availability investigated the chilled juices category, which has seen significant sales increases over the past few years but has a relatively long and demanding supply chain. This study had two distinct phases: the first comprised the bulk of the study and collected data in a major-multiple retailer's supply chain, including consumer actions to buy, substitute or take no action using data provided by an independent, third-party consultant. Data were collected by on-site observation and interviews with management and operations personnel from both the retailer and its supplier/manufacturer of the products. We cannot identify either firm for confidentiality reasons but both are national and large in terms of scope and scale. The second phase analyzed the findings to consider lessons learned and develop a framework and matrix to provide guidance for retailers and suppliers-manufacturers in determining and managing optimum levels of availability.

The second study shadowed a collaborative distribution trial between a major pharmaceutical retailer and a local distribution company in northern Scotland. Again, for confidentiality reasons we cannot identify either firm. Primary data were collected through telephone and face-to-face interviews. Telephone interviews were conducted with all 11 companies in the ECR UK Collaborative Green Distribution group for background information. Semi-structured, face-to-face interviews were conducted with the champions of the two companies involved in the project: the transport manager of the pharmaceutical retailer and the managing director and operations manager of the distribution companies. Telephone interviews were also conducted with the 16 retail stores located in

northern Scotland, including Aberdeen and Inverness, to check progress during the trial.

FINDINGS

Case Study One - Profitability and Availability

Figure 1 shows the profitability indices and availability percentages of the eight juice stock-keeping units (SKUs) examined for both retailer and supplier. The most profitable SKUs are characterised by below-average availability. This situation may be due to the popularity and relatively higher demand of these SKUs generating a high profitability on the one hand that results in more OOS on the other. Availability in this category is also affected by promotional activities; many 'get 3 for the price of 2' promotions were undertaken during the timeframe investigated that increased demand for these already popular SKUs.

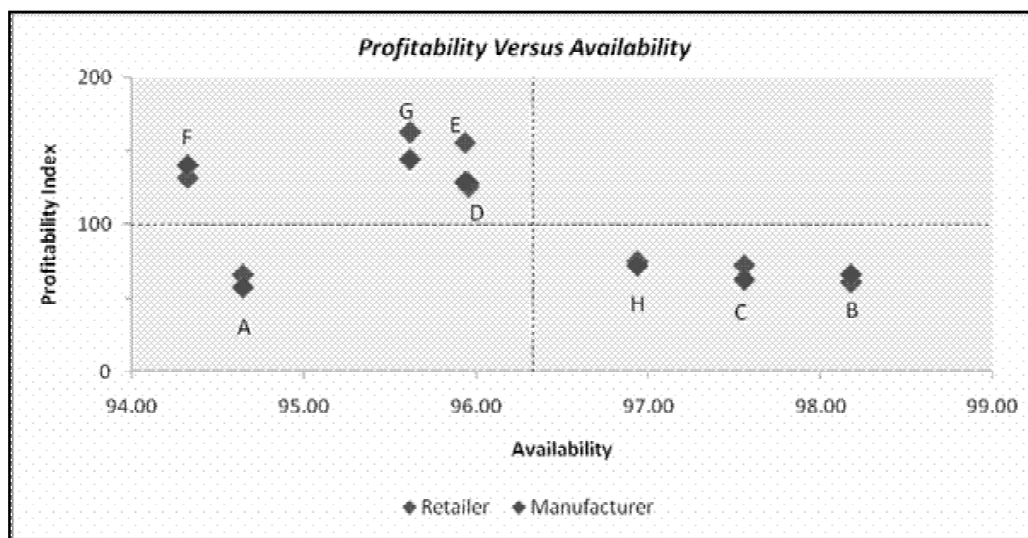


Figure 1: Profitability Versus Availability

The participating retailer and supplier agreed that providing high availability is much easier for slower-moving and less profitable products. Replenishment and distribution time is quick compared to the frequency of sales. At the same time distribution costs are relatively high for these products as they cannot be provided with the same efficiency as fast-moving products. Another outcome was the similar importance of SKU availability to both the supplier's and retailer's profitability. That finding should encourage increased collaboration between retailer and supplier due to their profit profiles associated with similar products.

The most profitable products showed high substitutability scores, i.e. they are easily substituted by consumers. High substitutability helps satisfy consumers even if their favourite product is OOS. The most profitable products have the advantage that they are not only considered as appropriate substitutes for each other but are also available in different pack sizes. Therefore, consumers have the chance to buy the same flavour in another pack size and this eases consumers' decision-making. The availability of such a highly appropriate substitute might keep the consumer in the store buying the same brand.

SKUs with high consumer loyalty were also characterised by a low availability, i.e. the most profitable products. The SKUs in the top left quadrant of Figure 1

will be OOS relatively often but at the same time consumers are very loyal to these SKUs. This isn't a good combination for the retailer as the risk of losing these consumers is increased by such factors. It could be argued that lower OSA is not detrimental as the consumer can easily substitute in the case of an OOS and is probably not too dissatisfied. On the other hand the higher loyalty increases the risk of losing the consumer to another store.

The second phase involved developing an availability/profitability strategy matrix as shown in Figure 2. We assume every retailer would like to provide high availability for highly profitable products thus an ideal overall goal is to always have SKUs placed in the upper right quadrant. If an SKU is within the upper right or lower left quadrant, the relation between profitability and availability is considered satisfactory. However, if an SKU is located in either the upper left or lower right quadrants there is a mismatch and we propose three strategic propositions as shown by the arrows and numbers in Figure 2.

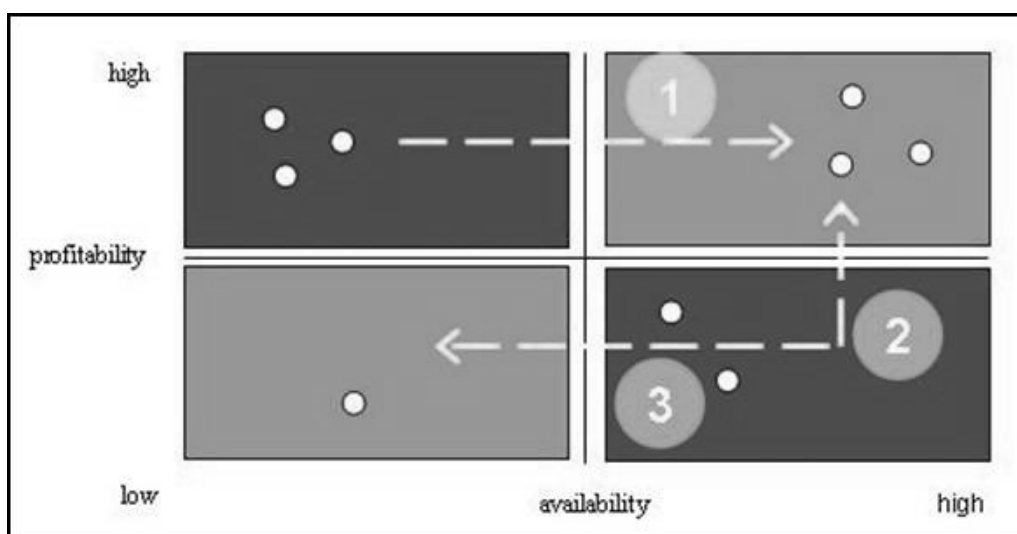


Figure 2: Profitability Versus Availability Strategies

Proposition one is to shift a highly profitable product to a higher level of availability. The major reason for that might be higher customer satisfaction and an increase in sales due to higher availability. Limitations might include that availability is low because of a generally higher demand than supply. A decision to increase availability should also rely on the related costs to do so. A highly perishable product with a low number of sales would probably not justify a high availability as wastage would go up.

Propositions two and three apply for products with a low profitability but a high level of availability. Proposition two suggests raising the profitability of a product but that might be a difficult task to achieve given consumer and competitive pressures to keep costs and prices low. Proposition three suggests reducing the level of availability. If a subsequent cost reduction is achieved this latter option will also contribute increased profitability of an SKU.

Case Study Two - Collaborative Distribution

At the end of May 2007 the national pharmaceutical retailer and a leading local distribution company based in the northern Scotland commenced a unique, two-

year pilot collaboration to deliver the retailer's products its 'far flung' Scottish stores as shown in Figure 3.

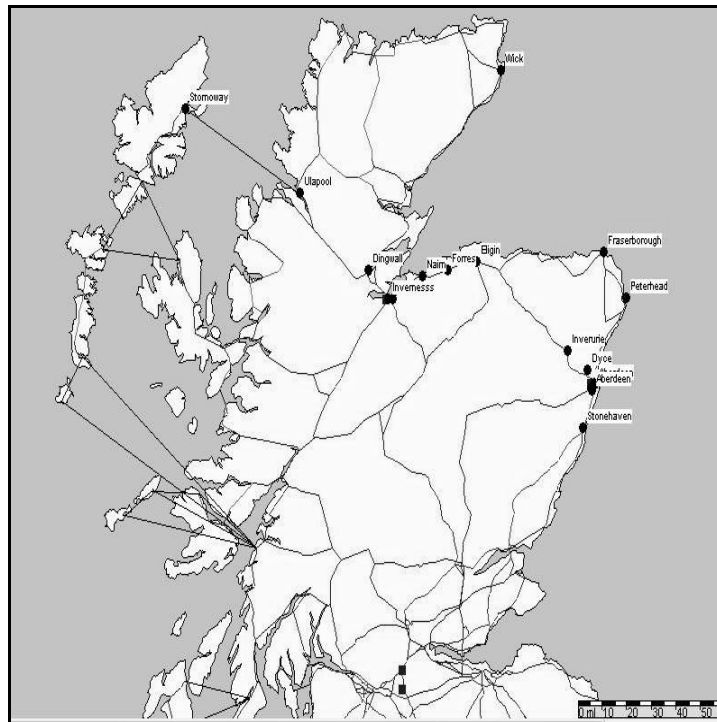


Figure 3: Scottish 'Far Flung' Store Locations of Pharmaceutical Retailer

Prior to the collaboration with the distribution company, the retailer's delivery process was as follows: they operated direct delivery from their distribution centre near Glasgow with a combination of single day and multi-day delivery journeys. However, within single day journeys, there were 2 wagon and drag vehicles with two drivers operating over a 14 hour day delivering and serving the Aberdeen area. Two further 'Artic' and trailer vehicles provided direct deliveries to Inverness, Dingwall and Wick areas. In addition, three vans delivered controlled drugs to all stores, 6 days a week. The result of this process included long stem miles, high number of driver hours requiring two drivers, and empty running of about 50% since they were trunking product directly to their stores and returning empty.

The collaborative delivery process sees the distribution company collect both chilled and ambient products at different time intervals from the retailer's DC. The products are then trunked to the distribution company's depots in Aberdeen and Inverness. Cross-docking and consolidation of the pharmaceutical retailer's loads with other customer loads takes place at the depots delivered to the pharmaceutical retailer's stores at agreed time windows. All empty equipment and returns from the stores are consolidated at the depots and trunked back to the retailer's DC. Also, claims and damages are reported and recorded per the distribution company's procedures. All delivery paperwork is completed per the retailer's procedures and the distribution company reports a daily KPI back to the retailer. The distribution company is also responsible for the three vans used for the delivery of drugs; they have added that to their volumes. Therefore, the

retailer has taken those vehicles 'off the road' and this counts as a mileage saving from their point of view.

The retailer has calculated the benefits of this collaboration as follows:

- Increased store delivery frequency, from 3 days to 6 days per week; thereby increasing service and availability.
- Approximately 6000 miles per week taken 'off the road' and 'out of the network' resulting in almost 150,000 litres of fuel being saved annually;
- Approximately 400,133 Kgs of CO₂e or 12% reduced per annum; and
- A reduction in operating costs and thus an increase in profitability.

CONCLUSIONS

The first study noted that an optimum OSA level is a trade-off between additional sales and additional costs for a customer service level; however it emerged from the first study that costs to serve the consumer are not very transparent. Manufacturers, retailers and transport companies usually agree a price per unit, which is modified by extra payments depending on distance, delivery area, and so on. The additional costs for this part of the supply chain could be simulated wherein inventory levels could be increased to a high level and delivery could happen more often.

The second study yielded good results in the trial however some challenges were identified that could be barriers to full-scale implementation:

- Loss prevention or shrinkage was a concern to the retailer and precautions included applying black shrink wrap applied around all dollies to make it obvious if someone tampered with them.
- Informing retail colleagues was important as the retailer was changing carrier and delivery times due to the increase in delivery frequencies.
- Trunk times from the DC to depot to make on-time deliveries to far flung stores involved some changes in picking frequency at the DC. Outbound times from the DC also had to be rescheduled for earlier in the cycle to ensure they did not affect outbound deliveries for other areas.
- The distribution company required better pre-advice from the retailer to ensure accurate deliveries arriving at the right time. The pre-advice should be sent at the right time and advice accuracy is also important as it affects planning a delivery and delivery efficiency, i.e. planning vehicle volumes for maximum utilization.
- Lastly, because of different service levels and time widows required for every retail company it would be advisable for distribution companies to incorporate new retailers one at a time every three or four months when the process stabilizes.

In summary, these two studies have provided evidence that improving on-shelf availability to provide better customer service and profit is a function of retailers and suppliers working together to better manage operations and processes. The suggested availability/profitability matrix provides a tool for firms to use at the store level. Efficiencies in retail transport networks are also achievable through collaborative distribution that besides reducing costs and improving service also has a favourable environmental effect.

However, all is not a panacea as such efforts require communication between all parties involved, which may involve changing established processes and patterns of behaviour. Such efforts also require a deeper understanding of the entire supply chain; these studies considered two UK retail supply chains however future research should consider longer and global supply chains.

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OVERCOMING THE "LAST MILE" IN SUPPLYING GOODS TO EMERGING MARKETS

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ABSTRACT

This paper considers the challenges of supplying consumers in emerging markets. Modern logistics systems allow products to be efficiently transported to virtually any city in the world, regardless of whether it is located in a developed or developing country. However, in developing countries a number of barriers lie in the "last mile" between the end of the logistics system and the ultimate consumer, including poor infrastructure, undeveloped legal systems and enforcement, and limited purchasing power. Entrepreneurs who are able to navigate around these barriers by creating informal logistics chains are often viewed as threats in the traditional business literature, engaging in gray marketing or counterfeiting of firms' products. However, there is a small, but growing body of literature that suggests these informal networks of entrepreneurs can help established firms distribute their products to emerging markets with less risk.

This paper introduces a conceptual framework for explaining the activities of entrepreneurs and informal supply chains. The conceptual framework is then applied to the case of actual informal traders supplying consumer products to Laos from Thailand.

The results of this investigation suggest that informal supply chains can lower the risk for firms entering emerging markets and that they can be formally integrated into firm strategies for market entry. The paper concludes with suggestions for further research.

Key words: physical distribution, emerging markets, developing countries, informality, parallel imports, gray marketing.

INTRODUCTION

Many multinational firms face stagnant sales in mature markets, and supplying products to emerging markets in developing countries represents the largest potential for future sales growth. At the same time, some scholars suggest there is a fortune to be made at the "bottom of the pyramid" for firms that can reach the more than four billion people living in developing countries on less than \$2 per day (Prahalad, 2005).

Modern logistics systems allow products to be efficiently transported to virtually any city in the world, regardless of whether it is located in a developed or developing country. The differences between supplying developed and developing markets, however, are most evident in "last mile", a term originally used in the communications industry to describe the expensive challenge of how a system must fan out at the last stage to reach lots of individual consumers.

Distribution solutions in developed countries rely on predictable market demand, a strong regulatory environment that honors property rights and contracts, and the relative affluence of consumers in those markets. In such environments, firms can plan and manage tightly controlled supply chains. Efficiency and cost savings are primary drivers, and driving uncertainty out of the system is a key operational requirement. The only stage of distribution with high uncertainty is between retailer and consumer: both demand, and distance to homes, changes from one individual to the next and cannot be predicted. The supply chain does not incorporate this stage; instead consumers are rewarded, with high product selection and low prices, for undertaking some of the logistical activities themselves, including driving to the retailer, picking the goods from the warehouse (essentially what a hypermart or large supermarket is), transporting the goods home, and storing the goods in their own smaller, personal warehouses until they are ready for use.

In developing countries, uncertainty is the norm, caused by a number of barriers between the end of the formal supply chain and the ultimate consumer. Distribution infrastructure is often limited (Arnold and Quelch, 1998), and using intermediaries can be risky as differences in culture, language, legal systems, and basic norms of doing business mean firms are uncertain to what extent agreements will be honoured (Li, 2003). Illegal activities may be prevalent to such an extent, with the acquiescence or even participation of government officials, that these activities become accepted as “normal” (Reid, Walsh, and Yamona, 2001). Finally, many of the consumers in emerging markets lack purchasing power and buy personal goods on a frequent basis, from locations within walking distance from their homes. Firms wishing to reach these customers require a distribution network that can reach lots of individual consumers, buying in small quantities on a frequent basis, at a multitude of locations. As firms compare the increased transaction costs in this environment, the additional investment required to exert control, and the lower market potential, they must consider two apparently unattractive choices: 1) attempt to supply the market at great risk and potential for loss, or 2) give up any attempt to supply the market, foregoing sales opportunities, and potentially opening the door for gray marketers or counterfeiters (Li, 2003).

However, increasingly a third option is being recognized as a viable solution for supplying goods to emerging markets: utilizing networks of entrepreneurial individuals. In networks, no overall authority exists to manage, direct, or arbitrate, and as such networks are organizationally different from the strong hierarchical control exerted by firms. Yet, they often can often effectively coordinate a number of business activities, such as gathering market information, physically transporting and storing products, and facilitating credit and payment, which are not found in pure market situations. Notable examples include using collective billing of entire communities to supply water more cost-effectively to low-income villages in the Philippines; selling building products to groups of low-income families in Mexico, who monitor each other’s construction progress, and pay off debts collectively; and marketing and distributing consumer products to small villages in rural India, using networks of entrepreneurial women (Beshouri, 2006). The question for this research is how

networks such as these are effectively integrated into distribution strategies for emerging markets.

BACKGROUND

Most distribution strategies rely on the transaction cost approach for analyzing market entry in international business (Griffith, Chandra and Fealey, 2005). Firms balance the transaction costs of working with intermediaries in a market versus direct control and correspondingly higher investment (Anderson and Gatignon, 1986). Transaction costs arise from activities such as, acquiring and communicating knowledge about a particular market, including that related to identifying suitable distribution intermediaries who possess valuable local knowledge; negotiating with potential intermediaries, who are assumed to be acting in their own self-interest; and enforcing the terms of any deal. The extent of these transaction costs favors more control by the firm, and doing more of the activities inside, rather than through intermediaries or on the open market (Rugman, 1986).

At one extreme of this trade-off, for example, the firm can enter the market with a wholly-owned subsidiary, providing direct management control and reducing the costs of opportunism and enforcement; however the entire cost of obtaining market information, and all risk, is borne by the firm. At a more intermediate level, a firm can appoint a local distributor, which increases the risk of opportunism, and costs of negotiation and enforcement, but with potential savings in understanding market preferences or navigating regulatory environments. Finally, at the opposite extreme, the firm may simply choose to sell into the open market at a given market price calculated to meet market share and profit goals; this can be accomplished with low investment, but also with little ability to influence the market beyond what is achieved by the pricing strategy.

At the same time, another phenomenon may arise out of this scenario: while some customers purchase for their own use, other, more-entrepreneurial customers may find new applications and new forms of distribution to reach yet more customers, expanding the overall market opportunity. These parties would call on a number of personal entrepreneurial traits, such as deft information gathering from a range of different sources, and the coordination of activities among parties who would not necessarily communicate with each other otherwise (Burt, 1992), and in emerging markets, they would also make use of learned experience, creativity, and a capability and willingness to manage risk, morality, and hassles (Fadahunsi and Rosa, 2002). In doing so, successful entrepreneurs can gain opportunities in the uncertain environments that characterize emerging markets in ways that cannot always be matched by firms (Figure 1).

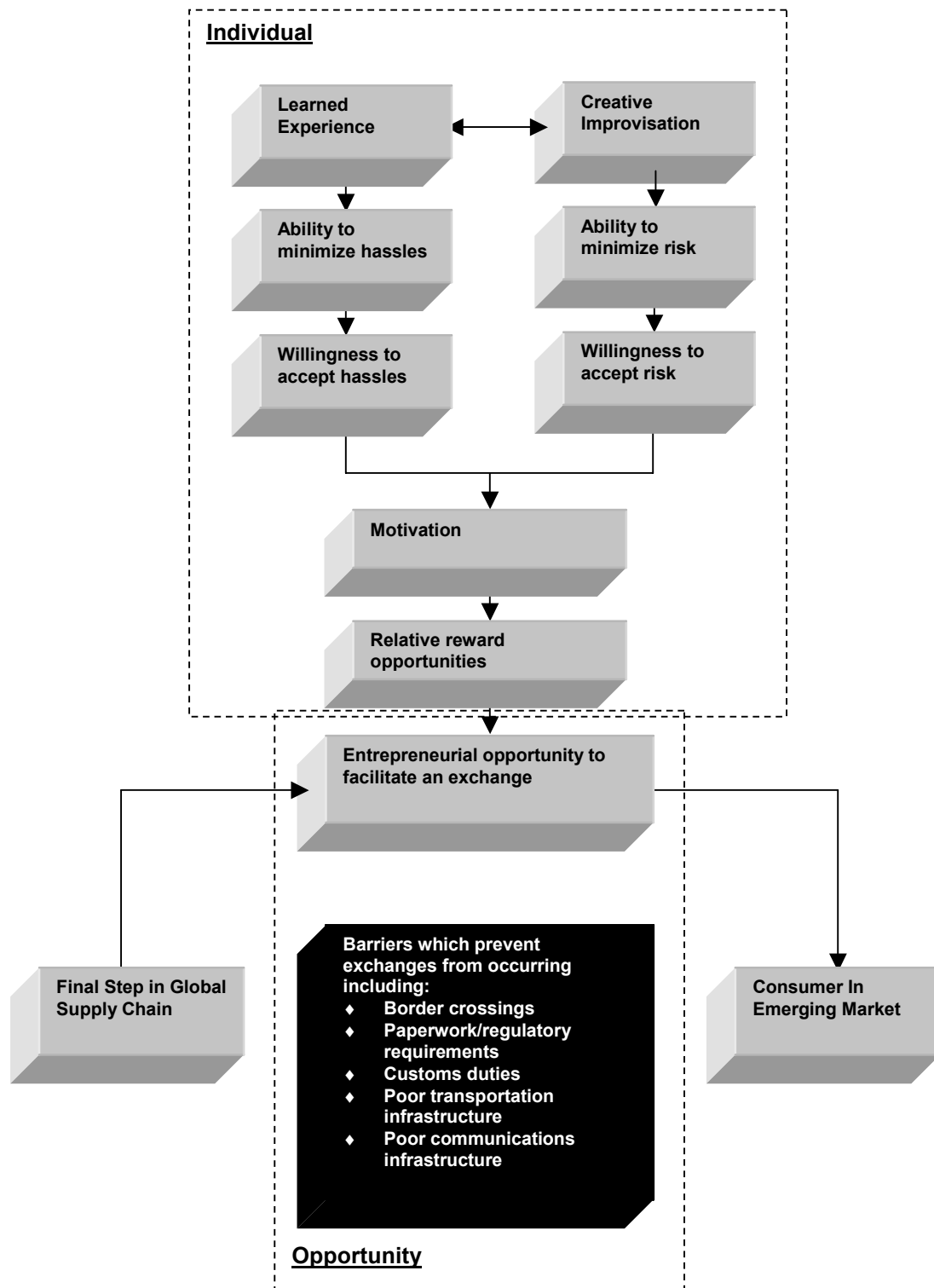


Figure 1. Theoretical Framework for Entrepreneurial Border Traders: Combination of individual and opportunity characteristics (Source: Rubesch, 2008).

While a number of benefits accrue to individuals with the right set of personal characteristics, a number of additional advantages come when these individuals interact in social networks. A network is recognized as a distinct organizational form, unlike a hierarchical organization, which relies on a system of authority to make resource decisions, or a market, which allocates resources purely on

pricing information (Podolny and Page, 1998). Instead, networks are built upon reciprocity and favors accumulated over time (Granovetter, 1985), and provide several benefits: they minimize agency costs through internal control mechanisms (Adler, 2001); they allow rich, detailed information to be communicated (Podolny and Page, 1998); and they facilitate learning among participants (Uzzi, 1997). In a business context, networks have been the focus of a number of case studies analyzing advantages in developing new processes and products (Hakansson, 1987), managing suppliers (Hakansson, 1982, 1987), and forming distribution systems.

Networks allow a large number of individuals to contribute towards a single objective, with each choosing the nature and level of involvement best suited to his or her capabilities. This is done without the arbitrating force of a hierarchical authority, or profit motivation of a market; instead the motivation to perform well, to ferret out poor performers, and to guard against malfeasance comes from a desire to be a valued and contributing member of a given community. Overall integration of individual activities comes from relationships, trust and commitment aligned towards a clear, common need of a social group (Benkler, 2002). Various open source software initiatives, such as the Linux project, represent effective networks that have formed around communities to accomplish a particular objective. The example of the community based billing system noted earlier, where the benefits to the community—continued supply of clean water—encourage the community to police itself and ensure prompt payment of water bills, and credit schemes that require a group of families to be responsible for each others' debts, illustrate how community networks have been implemented to achieve marketing objectives in developing countries.

To incorporate networks into a formal business strategy, a framework must exist for determining when networks might be the best distribution alternative for entering an emerging market. The preceding discussion suggests that there are two variables that dictate this decision process: the degree of certainty in the marketing environment, and the required consistency of the offering.

The certainty of the marketing environment includes factors such as the predictability of sales, the availability of market information, and existing marketing infrastructure, including communication infrastructure, positive regulatory environment, and logistics infrastructure.

At the same time, firms have different requirements about the consistency of the offering they supply to a market. Products which require a high degree of explanation in their use, have inherent safety requirements, or require on-going maintenance, demand a high level of consistency across the offering to the customer, either directly, or through qualified intermediaries. Other customer experiences, such as maintaining a particular brand image through product and package quality, marketing communications, or point or sale promotions, may be slightly less demanding. Finally, some product or service offerings may be essentially commodities, have few service requirements, or their use and maintenance may be well understood by existing providers in the market. In

these instances, the demands on the company to directly control or even influence its distribution might be minimal.

A decision matrix based on these two variables is suggested in Table 1. It suggests a preferred distribution strategy for entering a particular market, based upon the firm's ability to manage uncertainty, and willingness to allow flexibility in its offering to the market. In developed markets, the firm can count on a level of market maturity which makes demand relatively predictable, and a legal and regulatory framework which makes a high-control strategy advantageous. In this situation, efficiency and low-cost are drivers, and the system is designed to maximize certainty, with similar retail formats, standard pack sizes, and automated information gathering in the form of bar codes and similar technologies. The most unpredictable part of the process, the final step of supplying consumers, who live in various locations and who have unpredictable demands, is eliminated; instead, consumers are provided incentives to undertake this function on their own through discounted prices and large product selection at retailers.

Certainty of the mark. environment	Found in...	Demanded consistency	Suggested Distribution strategy
High	Developed countries; many cities in developing countries.	High	Direct control: through direct ownership, or contractual relationships.
Low	In developing countries, especially outside cities, or outside main commercial areas.	Medium	Network: firms perform integration and coordination roles.
		Low	Sell in open market with little need to manage or influence distribution.

Table 1. Matrix for market entry decisions, based on level of certainty in the marketing environment, and the firm's need to control the market offering (Source: the author).

In more uncertain environments, including those found in emerging markets, firms can utilize networks to provide a relatively high level of service, by focusing their efforts at enabling and managing networks of motivated individuals. In this role, firms act to integrate and coordinate, such as identifying target communities with common, clearly defined needs (fresh water, availability of construction supplies), which can be reached by aggregated marketing functions, in order to save costs; providing training programs for network members, to raise understanding of product usage and benefits; and if the infrastructure allows it, implementing software based systems that allow network participants to monitor their own performance.

Finally, for a product with few opportunities for differentiation, or a market that is already capable of using and servicing a particular product, a distribution strategy with little investment can be justified.

METHODOLOGY

In order to illustrate the framework, an actual case of a network of entrepreneurial traders supplying an emerging market was analyzed. The selected case, Vientiane, the capital city of Laos, has a population of approximately one million people, including local residents; foreign residents working in various embassies, NGOs, and other international organizations based in the capital; and tourists. As a lesser developed country, Laos has little domestic manufacturing capability. However, Vientiane lies only approximately twenty kilometers from Thailand, a developed consumer products market where a number of multinational companies have manufacturing operations. An informal network of entrepreneurial border traders has emerged who purchase consumer products from the nearby Thai border city of Nong Khai, transport those products across the Mekong River (border between the two countries at this particular point), and resell them to retailers in Vientiane.

In addition to this informal network, the same multinationals have set up authorized distributors to sell to the Lao market.

Structured interviews were employed as the primary method of data collection, a form of inquiry that allows detailed and holistic analysis, especially applicable in subject areas or settings which have received little previous attention (Miles and Humberman, 1994). Interviews were conducted with a number of parties involved in the informal network, including the entrepreneurs themselves, supplying shops on the Thai side, retailers on the Laos side, as well as authorized distributors who also supply the market.

RESULTS AND CONCLUSIONS

A number of barriers exist between the wide range of consumer products available in Nong Khai, and the market in Vientiane. Poor infrastructure, limited transportation options, and border checkpoint regulations mean travelers must endure relatively long travel times, and must change travel modes several times. These communication and transportation barriers prevent suppliers in Nong Khai and customers in Vientiane from having complete information about each other. Entrepreneurs turn this into an opportunity by calling on a range of individual and social advantages. Many of the individuals in this study came from families who had been performing this activity for several years, learning their jobs from fathers, mothers and friends. They worked in a community where each was familiar with other traders, and other regular participants such as transportation providers and shop owners. These linkages helped build trust and minimize hassles. Many of the entrepreneurial traders spoke of purchasing products on behalf of others, so they could take a day off, or using transportation providers who they had worked with for several years, so it was unnecessary to supervise them.

The findings in the study indicate that the network actually supplies products at a higher price than authorized distributors. The network's value comes from providing a number of complementary, non-price benefits. Entrepreneurs in the informal network are often the first to introduce new products into the market. They react quickly to marketing campaigns offered in Thailand, making promoted products immediately available to consumers in Vientiane. The entrepreneurs can supply a given product to a retailer in Vientiane within a day, and on any day

of the week, while authorized distributors typically make deliveries twice per week. This allows retailers to carry less stock from distributors, and “top up” when stocks run low; inventory levels are optimized without fear of lost sales. Authorized distributors acknowledged this service benefit, and in fact considered it beneficial to the formal channel: distributors supply customers at service levels that are profitable; any additional service level adds expense with little additional profit, and is best left to the network. Given that the network is more expensive, authorized distributors can determine exactly the level of service that they want to provide.

Ultimately, in this case, it is the combination of the formal distribution channel and the informal network that creates the most value: customers are served more quickly; retailers are able to control their inventory more precisely with less need to build additional safety stock to meet peak demand; and the network provides goods in flavors, fragrances, and pack sizes that are demanded by certain customers in quantities too small to be profitable for authorized distributors. As demand for a particular product grows, the authorized channel adds the product to its portfolio.

These results suggest that networks, at least under certain conditions, create value for a number of market participants. This adds, potentially, another strategic option for firms operating in uncertain, emerging markets, allowing these firms to precisely determine the service level that they are willing to provide directly, augmented by encouraging and coordinating informal networks of entrepreneurs. This decision making process is based upon two variables: the overall uncertainty in the environment, and the firm’s need to control the final offering to the consumer. Further research should test this framework in a variety of cases of emerging and developed markets, and improve on the precision of the decision making process.

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SECTION 5

LOGISTICS PLANNING AND CONTROL MODELS

A STUDY OF LOGISTICS SYSTEM FOR EXPORTING NATURAL RUBBER FROM THAILAND TO CHINA

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ABSTRACT

Thailand has followed Asean-China Free Trade Agreement since 2005 in which tariff rates will be totally eliminated by 2010. Many raw materials, components, products and services are now needed for manufacturing and consumption in China. Thailand as one of Asean members should use the FTA regulation for benefits of exporting materials or products to China. Logistics is one factor that could lead to competitive advantages. A question is how we could explore and propose logistics system for exporting products to China in order to achieve competitive advantages. Natural rubber is one of top five products exporting to China. It was selected as a sample to explore the logistics system.

The research methodology is to gather primary data by semi-structured interview in order to understand outbound logistics from rubber manufacturers to China ports and their logistics costs. Three parties were interviewed that were rubber manufacturers, logistics service providers and supporting units such as marine ports, railway and customs houses.

The outbound logistics can be classified into two groups related to rubber plant area and the manufacturer locations that are mostly spread around south of Thailand. The upper-south of Thailand, natural rubber is sent to Laem Chabang or Bangkok ports by train, coastal shipping line or truck. The lower-south of Thailand, shipment is done by train or truck to Songkhla port, Padang Baesar border or Sadao border. Due to limitation of train and coastal shipping line, 87.77% of the total export rubber products used truck as inland transportation. The other 2.97% and 9.26% were transported by coastal shipping line and rail consecutively. The analysis of the findings was pointed out that infrastructure and regulation to support mass transportation in terms of railway and inland water line is not efficiency. As a result, Thailand who is exporting primary agricultural based products that are low price and high weight would not be able to achieve competitive advantages due to high transportation cost. Thailand policy maker would therefore have to concentrate on the development of mass transportation, logistics service provider and natural rubber value chain.

INTRODUCTION

Thailand has followed Asean-China Free Trade Agreement since 2005 in which tariff rates will be totally eliminated by 2010. Many raw materials, components, products and services are now needed for manufacturing and consumption in China. Thailand as one of Asean members should use the FTA regulation for benefits of exporting products to China. Logistics is one factor that could lead to competitive advantages. A question is how we could explore and propose logistics system for exporting products to China in order to achieve competitive advantages.

RESEARCH METHODOLOGY

To explore the logistics system, our next question is which product that we should select to be a good representative of products exported from Thailand to China. According to Thailand customs record, natural rubber is one of top five products exported to China and Thailand has increasingly exported natural rubber to China since 2003. Moreover, China is now the biggest natural rubber customer of Thailand. We then selected natural rubber as a product sample to trace its outbound logistics system to China.

To collect data, we constructed semi-structured interview that is a fairly open framework which allow for focused and conversational to obtain specific quantitative and qualitative information from the sample. From literature review, it was found that there are mainly 3 parties related to the outbound logistics that are rubber manufacturers, logistics service providers and supporting units. We then selected 7 manufacturers from top twenty rubber manufacturers to interview in order to understand their logistics system starting from order receiving to shipping. Logistics service providers have also been interviews. The logistics service providers interviewed are shipping companies, freight forwarders, customs brokers and carriers that serve the rubber manufacturers. Supporting units interviewed are railway, inland ports, international ports, customs houses and transportation ministry. The questions that we would like to explore are following. Firstly, how current situation of outbound logistics activity is taken. Our second purpose is to identify the outbound logistics costs.

THE CURRENT OUTBOUND LOGISTICS

Rubber plant area and rubber manufacturers are mostly located in south of Thailand. The outbound logistics can be classified into two groups related to rubber plant area and the manufacturer locations that are mostly spread around south of Thailand. The upper south of Thailand, Surat Thani can be said as a logistics hub because there are rail container yard and internal costal ports. Intermodal transportation could be conducted. The rubber manufacturers selected to ship their products to China by Laem Chabang port (LCB) or Bangkok port (BKK port). Inland transportation from Surat Thani to the two ports can be done by train , gulf of Thailand coastal vessel and truck. From LCB or BKK ports, natural rubber will finally be shipped to China via HongKong port. Mostly, Thailand natural rubber is shipped to Shanghai and QingDao ports.

Natural rubber from the lower south of Thailand can be exported via Songkhla port, Padang Besar border and Sadao border. For Songkhla port, truck transportation is only inland mode that can access to the port. The capacity of Songkhla port can only be available for feeder vessels. The feeder vessel will then tranship natural rubber to a mother vessel at Singapore port. However, natural rubber mostly transits Padang Besar border and Sadao border to Penang port. To get Padang Besar border, trucks and trains are alternatives. On the other hand, only trucks can access Sadao border. Figure 1 shows natural rubber outbound routes.



Figure 1 natural rubber outbound routes

According to Rubber Research Institute of Thailand record on table 1, Padang Besar border has the highest volume of natural rubber exported. It is about 34.8% of total natural rubber exported on 7 year averaged and it is followed by Songkhla port, Sadao border, and Bangkok port respectively. It can be seen that natural rubber volume at Songkhla port has been decreasing since 2004. On the other hand, the exported volume at Sadao border has been gradually increasing. Eventually, the volume at Sadao border is higher than that of Songkhla port. There are some reasons that we will explain on the discussion part. Chiang San port is a port that serves Mekong river transportation network. The natural rubber volume has been increasing since it was opened in 2003. However, it is not a significant volume comparing to the other gateways. The reasons are location of natural rubber that is spread around south of Thailand and accessibility to the port can only be done by trucks. Cranes to handle containers are not available yet.

On table 2, the exported volume of 2005 has been analyzed to identify the proportion of inland transportation modes. It can be seen that 87.77% of all natural rubber exported used trucks to access the gateways. The other 2.97% and 9.26% were transported by coastal shipping and train consecutively. From our interview, most of rubber manufacturers much wanted to use trains to ship their products to the gateways. The Thailand train service cannot sufficiently serve to customers. The main problem is that the train service cannot promise the train schedule to customers. On time delivery can hardly been met. Therefore, the volume of rail freight is only 9.26%. Only 2.97% of the total volume used coastal shipping because the Thailand coastal shipping operators did not have enough capacity in terms of vessel. Moreover, terminal charged cost for transshipment to LCB port was charged at the same rate as ocean transportation.

Table 1 Natural rubber volume at main Thailand gateways

(Unit : Ton)

Year	Bangkok Port	Songkhla Port	Laem Chabang Port	Padang Besar Border	Sadao Border	Betong Border	Chiang San Port	Others	Total
2000	272,766	446,289	141,559	740,473	203,455	32,466	-	329,145	2,166,153
2001	166,061	429,250	64,157	709,651	251,861	27,982	-	393,117	2,042,079
2002	429,990	408,223	60,182	770,804	303,385	35,326	-	346,506	2,354,416
2003	454,087	509,091	69,365	851,766	338,307	38,274	2,682	309,878	2,573,450
2004	340,454	387,141	145,304	946,427	359,234	41,018	25,534	391,984	2,637,096
2005	320,694	317,401	138,164	935,163	475,203	35,174	38,902	371,697	2,632,398
2006	334,840	307,140	163,852	1,026,619	449,726	38,950	24,056	426,490	2,771,673
% Average	13.5	16.3	4.6	34.8	13.9	1.5	0.5	15.0	100

*Rubber Research Institute of Thailand (<http://www.rubberthai.com/>)

Table 2 the proportion of inland transportation modes on natural rubber volume

Mode	BKK port	Songkhla port	LCB port	Padang Besar	Sadao	Chiang San port	Others	Total (Ton)	Percentage (%)
Truck	199,777	317,401	8,222	864,129	475,203	38,902	406,871	2,310,505	87.77
Vessel	0	0	78,121	0	0	0	0	78,121	2.97
Train	120,917	0	51,821	71,034	0	0	0	243,772	9.26
Total (Ton)	320,694	317,401	138,164	935,163	475,203	38,902	406,871	2,632,398	100

As fuel prices have been dramatically increasing, using truck transportation directly leads to high transportation costs and high consumption of fuel for Thailand. A study of Economic and Social Commission for Asia and the Pacific (ESCAP) shows that trucks, trains and vessels can carry products 25, 85.5 and 217.6 tons-kilometer per liter. We then compared the transportation costs of 3 inland modes transporting from Surat Thani to LCB port. The diesel price used to calculate is 24 Baht per liter. The transportation costs show on table 3.

Table 3 Transportation costs from Surat Thani to Laem Chabang port

Mode	Distance (kilometre)	Fuel consumption (liter)	Cost (Baht)
truck	827	4,570,465.12	109,691,162.90
train	802	1,295,994.	31,103,867.51
ship	491	311,757.92	7,482,190.15

LOGISTICS COSTS

Logistics cost of exporting natural rubber has been analyzed relating to transportation routes. Due to limitation of data, the logistics cost collected cannot be included all logistics activities. The logistics cost that have been collected is consisted of customs charges, transportation cost and packaging cost. The logistics costs were collected from the semi-structured interview. On table 4, it shows the

logistics cost from origin to gateways of Thailand. Then, the transit costs mainly from Sadao and Padang Besar borders to Penang port are provided.

Table 4 Logistics costs of exporting natural rubber

Thailand						Transit				China		Total cost Baht/TEU	Total lead time (day)
From	To	Mode	Time (hr.)	inland Cost (Baht/TEU)	Freight cost to China	Port	Mode	Time (day)	Freight cost Baht/TEU	Mode	Time (day)		
Surat Thani	BKK port	trailer	10	25,300	9,000	HK	vessel	5		vessel	7	34,300	12
Surat Thani	BKK port	truck	10	26,133	9,000	HK	vessel	5		vessel	7	35,133	12
Surat Thani	BKK port	train	18	25,950	9,000	HK	vessel	5		vessel	7	34,950	12
Surat Thani	LCB port	trailer	12	25,300	9,000	HK	vessel	5		vessel	7	34,300	12
Surat Thani	LCB port	truck	12	26,133	9,000	HK	vessel	5		vessel	7	35,133	12
Surat Thani	LCB port	train	24	25,950	9,000	HK	vessel	5		vessel	7	34,950	13
Surat Thani	LCB port	vessel	24	26,133	9,000	HK	vessel	5		vessel	7	35,133	13
Surat Thani	Padang	train	9	14,800		Penang	train	3	15,480	vessel	14	30,280	18
Nakornsri	BKK port	trailer	12	33,410	9,000	HK	vessel	5		vessel	7	42,410	12
Nakornsri	BKK port	truck	12	30,154	9,000	HK	vessel	5		vessel	7	39,154	12
Nakornsri	BKK port	train	24	28,300	9,000	HK	vessel	5		vessel	7	37,300	13
Nakornsri	LCB port	trailer	15	33,410	9,000	HK	vessel	5		vessel	7	42,410	12
Nakornsri	LCB port	truck	15	30,154	9,000	HK	vessel	5		vessel	7	39,154	12
Nakornsri	LCB port	train	30	28,300	9,000	HK	vessel	5		vessel	7	37,300	14
Nakornsri	Padang	train	6	14,800		Penang	train	3	15,480	vessel	14	30,280	18
Songkhla	Padang	trailer	2	16,800		Penang	train	3	9,950	vessel	14	26,750	17
Songkhla	Songkhla	trailer	2	17,200	14,400	HK/SG	vessel	5 and 2		vessel	3 and 8	31,600	8 and 11
Songkhla	Padang	train	2	17,100		Penang	train	3	9,950	vessel	14	27,050	17
Songkhla	Sadao	trailer	2	16,800		Penang	trailer	3	17,200	vessel	14	34,000	17

The outbound logistics cost is not highly different when we compare within the origin of natural rubber location. For Surat Thani province, the cheapest outbound logistics cost is to export natural rubber to Padang Besar border and Penang port by train. On the other hand, it takes 18 days to get China port. Using the other routes, total shipment time can be reduced by 6 days. This could also impact on total logistics costs that the rubber manufacturers would need to consider.

For shipping natural rubber from Nakorsrithammarat, using train to Padang Besar border is the cheapest route, but it is the longest shipment time. For Songkhla province, the shortest shipment time is to use Songkhla port because it takes only 8 – 11 days. However, its cost is higher than using Padang Besar border as a gateway to Penang port.

DISCUSSION

From our interview, there are two points needed to clarify. Firstly, the proportion of inland transportation mode that is mainly using truck or trailer. The other point is decreasing of the volume exported at Songkhla port even it can provide the shortest shipment time. On the other hand, the natural rubber volume exported at Padang Besar border has been dramatically increasing.

For the first point, there is very high demand to use train as inland mode. The problem of unpopularity of using train are from many causes that are inefficiency of

existing locomotive and wagons, not having enough locomotive and wagon, long waiting time for each station due to single rail track along south of Thailand and giving first priority to passenger trains. Those causes lead to having unstable freight rail schedule and not enough capacity for rail freight. Thailand railway has 212 locomotives, but 149 could properly work. 90 locomotives are assigned for passenger trains. Freight locomotive is 59 and it is not enough for demand freight. If a locomotive for passenger trains was broken, a locomotive for freight trains would replace. Moreover, the capacity of locomotive can carry only 25 wagons at a time. The wagon is also not enough to meet demand. Single rail track directly leads to unstable lead time as trains have to wait and give a way for other trains to pass.

It is steadily increasing need for coastal shipping. However, terminal charged at LCB port on coastal shipping was high comparing to that of rail freight. If LCB port which is a state enterprise could change the regulation, more cargo would come to coastal shipping.

The Second point, the decreasing of exported volume at Songkhla port was caused by many factors. Firstly, there is cargo exported very much higher than cargo imported. It then leads to import of empty containers to provide freight transport. The freight cost at Songkhla port is higher than that of Penang port. Not only higher cost, rubber manufacturers would have to wait for days to obtain empty containers. Secondly, Songkhla port does not have cranes to load and unload containers. Feeder vessels visiting the port must have their own crane on the vessels to operate the load and unload activity. Then, not many feeder vessels can come to the port. Figure 1 shows Songkhla port.

According to competitive advantages, logistics cost reduction must be done. Natural rubber area and manufacturing plants are mostly spread around south of Thailand. It is very long distance from upper south to BKK port or LCB port. Using truck transportation leads to higher transportation cost comparing to rail freight cost. The findings do not only represent natural rubber logistics system. They represent other agricultural products their origin is south of Thailand as well. The next section will propose ways to reduce logistics cost.



Figure 1 Songkhla dock

CONCLUSION AND SUGGESTION

Mostly, Thailand exports agricultural products and natural rubber is one of them. The outbound logistics studied can represent logistics system of non-perishable agricultural products that their location is south of Thailand. The logistics system can be divided into two parts that are upper south and lower south. Inefficiency of

mass transportation modes is critical. The inland transportation cost to BKK port and LCB port is mostly done by truck. It could lead to higher transportation cost, traffic jam on main roads to the ports, maintenance road cost for Thai government and high consumption of fuel.

To propose ways to improve and reduce logistics cost, policy makers should concentrate on the following suggestions. Firstly, locomotives and wagons must be procured to meet rail freight demand. Thailand railway should set a project on dual rail track construction. The project could start on some areas that have highly traffic such as from Chumpon to Prachuabkirikan and Chachengsao to Laemchabang. Mindset of Thailand railway should concentrate more rail freight. The railway needs to reengineer its business process as well. It was found that only having more locomotives, wagons and dual track cannot solve on time performance problem (Sajjasophon, 2008). In addition to these, Thai government has given millions of rubber plant to grow in north and north-east of Thailand. About 5 years, huge natural rubber will be produced in that area. Needs for train are even larger as those area do not have inland water transportation. Only truck transportation is available there.

Secondly, laws and regulations on marine shipping should be modified to promote coastal shipping. The reduction of terminal charged on coastal shipping must be done. Thailand ministry of transportation should change regulation on port contract term from 5 years to 15 – 20 years. Moreover, all equipments at the port will be belonged to Thailand when the contract is finished. Songkhla port has a 5 year contract with the ministry. It is difficult for Songkhla port operator to invest cranes or other equipments as the investment cost cannot return within 5 years. As a result, Songkhla port has not been improved. No crane is available. More budgets from water transportation department should be provided to maintain sea depth to support shipping port.

Thirdly, Thai government should pay more concentration on building human capacity on logistics and supply chain management. From our findings, all the players on natural rubber supply chain do not have idea about benefits of supply chain management. No collaboration along the chain has been found. Logistics cost is also not identified.

Fourthly, Thailand exports over 90% of natural rubber production. The natural rubber price depends on world demand. It can be seen that natural rubber price has been increasing because of huge demand from China. This could be very risky if China wants to have its own plant in Vietnam or Lao. Thai government should support more budgets for adding more value on natural rubber chain. It can reduce risk on natural rubber pricing and it can be sustainable solution for natural rubber production.

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THE FUNDAMENTALS OF INTEGRATED TAILORED LOGISTICS

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ABSTRACT

The paper articulates a mass customised framework, in the form of a route map, by which different tailored logistics solutions may be delivered. The aim is to provide a number of guiding principles for fully considering the integrative role of the transport function in logistics supply chains. The approach here is to formulate a framework based on a number of outputs from a three year research project. The research was a combination of conceptual and case based research. The research involved a number of industrial partners from the steel, food and construction sectors. The framework takes into account; transport flexibility types, vertical / horizontal collaboration, B2B e-business architectures and contingency based approach to logistics provision. The framework may act as a strategic route map by which members of the logistics network develop a tailored logistics strategy.

INTRODUCTION

Transport is a key function in the supply chain as it acts as a physical link between customers and suppliers, enabling the flow of materials and resource. Furthermore, with the advent of third party logistics providers (3PLs) and even 4PLs, carriers provide more than just physical transport links. Such carriers provide an overall service including value add activities, inventory control and warehouse management.

Despite the trend of increasing offerings of value add activities the procurement and relationship management of carriers is very much based on traditional price based and adversarial lines. There is therefore the premise by shippers that transport will respond to short term demand changes and, in particular, be willing to accommodate uncertainties (Boughton, 2003). This commoditisation of transport, where shippers exploit their purchasing power, results in carriers offering flexibility as a competitive advantage. But such an approach yields a reactive strategy in which a portfolio of activities and service opportunities are made available without due regard of infrastructure, capability and competency. This "one size fits all" strategy leads to increased costs and, more detrimentally, confused and disappointed customers, leading to a loss in business.

Tailoring whole supply chains to specific customer requirements has been advocated by, amongst others, Fisher (1997), Naylor et al. (1999) and Christopher and Towill (2002). The underlying premise is that different product types, with very different demand characteristics and physical attributes require quite different operational capabilities. Attributes such as product life-cycle, delivery window, market variance, will yield supply chains that, at one extreme are extremely efficient, usually standard products with known demand, while for more fashion orientated products whose demand is difficult to forecast then more responsive, agile supply chains are required. Supply chains that try to satisfy all marketing priorities are vulnerable to developing standard or 'average' offerings

to their customers that lead to increased costs and poor customer service when specific customisation is required.

Rather than look at the whole supply chain, both Fincke and Goffard (1993) and Fuller et al. (1993) argue that logistics processes should be tailored to specific market priorities, each having distinct goals, priorities, measures and capabilities. While such tailored approaches have been advocated much of the underlying research has a manufacturing operations context and focuses upon the fixed assets. Although the models advocated speak of logistics, the inherent transport operations have been neglected. Mason and Lalwani (in press) define conceptually the idea mass customised distribution, which considers transport more explicitly, but there is a need to translate this into practical steps to achieve this.

This paper aims to fill the transport gap in tailored supply chain strategy development. The paper takes the outputs from a nine-person years research project and develops a management guide for what needs to be considered in developing tailored logistics solutions. The guide provides a framework of five underlying principles that require due consideration prior to embarking on a strategic supply chain re-engineering programme.

METHOD

The approach here is to formulate a framework based on a number of previous research outputs. The research programme was a combination of conceptual and case based research. The research involved a number of industrial partners from the steel, food and construction sectors. Our methodological stance may be categorised according to the research frame described by Burgess et al (2006).

Our research has a systems conceptual context that treats the supply chain as an interconnection of processes and hence supply chains may be classified as an all-embracing management framework. Hence, our framework is very much a combination of intra- and inter-organizational relationships, logistics, process improvement orientation, information systems and business results and outcomes.

The research is grounded in the logistics and operations management disciplines. It is based on a multiple research strategy, and hence may be used for discovery, description, mapping, relationship building, theory validation and theory extension / refinement. It is grounded in psychological / sociological theory, specifically inter-organizational networks and general systems theory. Although not addressed in the previous research there is potential for extending the framework to incorporate economics, and in particular transaction cost economics, theory.

THE FRAMEWORK

A number of generic methods exist to enable repeatable problem-solving practice (Kettinger et al. 1997). The general structure of these methods and their rationale are very similar. Our framework is based on the Watson (1994) business systems engineering adage of understand, document, simplify and optimise (UDSO). The framework is as shown in Figure 1 and is applicable when

considering the fundamental principles highlighted in the figure and that we describe later.

The initial stage (Where are we now?) relates to understanding and documenting current practices and market environment, and is undertaken via a comprehensive supply chain diagnostic (see for example, Naim et al, 2002). Based on the pillars of management change (Kettinger et al., 1997), people, technology, management and structure, this first stage determines the extent to which the current business' logistics align with market requirements and stakeholder capabilities.

The diagnostic identifies problems and opportunities with the current practices and suggests the simplest tailored logistics designs necessary in order to ensure efficient but effective service and product delivery. This takes into account the pillars of change and aligned measures of performance.

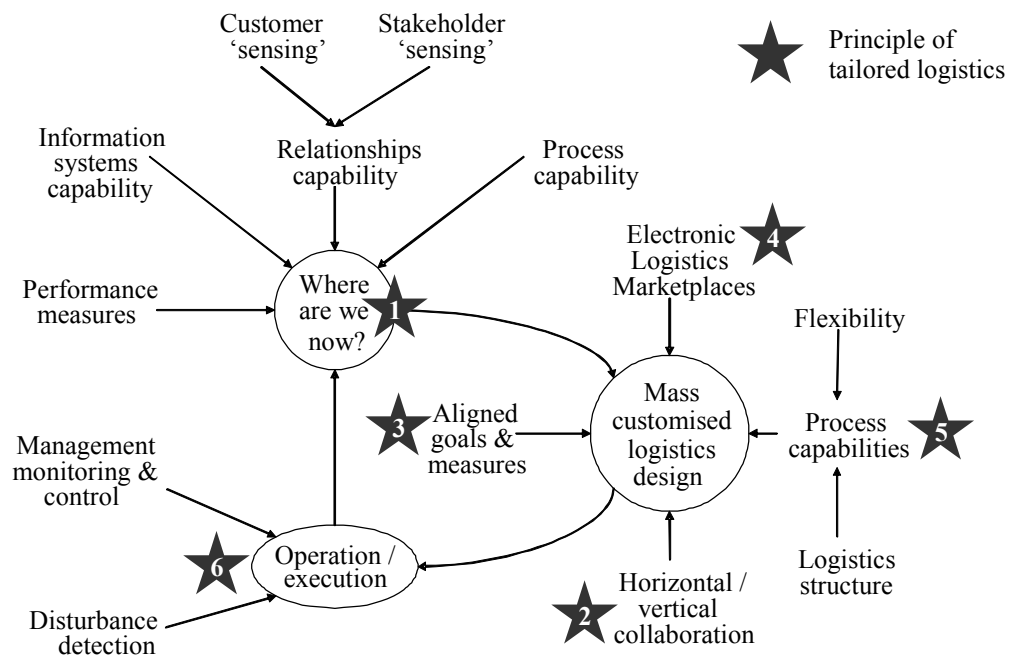


Figure 1: Routemap to integrated tailored logistics

The design stage also includes the development of appropriate information systems, in the form of electronic logistics marketplaces, which allow monitoring and control of any final implementation. It is also important to consider relationships within the logistics system, both vertically and horizontally. While the design stage also includes the development of flexibility capabilities against any external or internal disturbances, these will be for foreseen events. During operation and execution of the logistics design early detection of events that are 'out of the norm' is required to enable responsive corrective actions. The monitoring of the logistics also ensures that continuous improvement, and hence optimisation, of process, technology and relationships is enabled.

Based on the above framework, our research has identified 6 principles that support the introduction of tailored logistics. Each of these is now discussed in more detail.

PRINCIPLE #1: DEFINING THE RIGHT SUPPLY CHAIN TYPE

As already indicated in the introduction, recent developments in strategy indicate that supply chains have to be tailored according to specific competitive priorities based on market place requirements. Hence a business must find a 'feasible logistics space'.

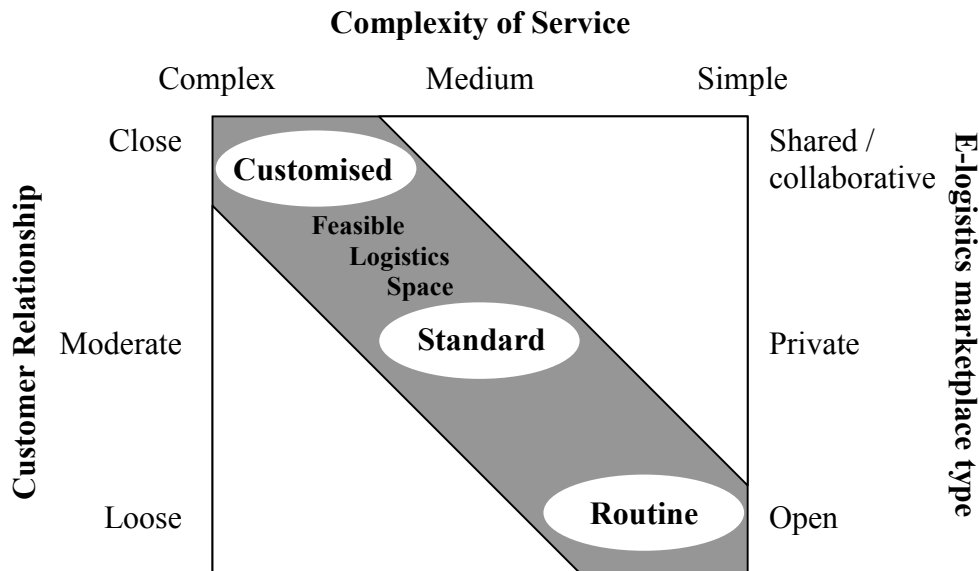


Figure 2: Identifying logistics strategy (based on Bask, 2001, and Wang and Naim, 2007)

Bask (2001), based on the research of Fisher (1997), suggests that logistics operations should also be tailored to match the demands of the supply chain they are contained within, providing flexibility in certain circumstances and efficient solutions in others. Bask (2001) further proposes a framework for logistics provision as shown in Figure 2, which explores the correlation between the complexity of the logistics service provision and the type of relationship required to support it. Within any one business, it is likely that certain clusters will require (and be willing to pay for) a customised service while others will only need a standard or routine service. The efficient management of these diverse logistics requirements reflects the principles behind mass customised distribution (Mason and Lalwani, in press).

PRINCIPLE #2: GO BEYOND THE DYAD

Tripartite logistics is the three way relationship between the logistics provider (the carrier), the contracting party (the shipper) and a third party, to or from which the contracting party wishes to serve (the consignee). Previous supply chain research has considered the dyad, between the shipper and consignee, as the unit of supply chain analysis, despite the suggestion of Beier (1989) that the triad should be the minimum. The logistics triad is inherently more complicated than the basic dyadic partnership. Instead of one dyadic relationship it is made up of three dyadic relationships as well as a triadic relationship shared by all three members of the triad. Although logistics relations need to be contingent to their environment, our research has explored whether, in many cases, an extended aligned partnership across the logistics triad can overcome inherent weak links and support the development of sustained performance improvement.

Previous research relating to the logistics triad has tended to be survey orientated (such as Larsen and Gammelgaard, 2002) with little focus on how a focus on the triad can improve performance.

Based on Principle #1, we need to define what is the relationship type required among the triad members to ensure we are in the 'feasible logistics space'. Figure 1 considers collaboration levels, based on Bask (2001). Once this has been determined, it is then possible to align goals and measures. Mason et al (2007b), through a case study from the steel industry show that by due consideration of the triad, aligned goals and measures can be achieved, leading to enhanced operational performance in terms of on time in full criteria and increased service levels to the end customer.

Focussing on an individual triad effectively considers just vertical collaboration. However, it may be appropriate to consider horizontal collaboration as well, either with competitors or complementors. Narus and Anderson (1996) consider this approach within distribution channels to be effective in providing customer service. From a transport perspective, Mason et al. (2007a) show how combining vertical and horizontal collaboration within transport operations can deliver improved supply chain performance.

PRINCIPLE #3: MEASURE THE RIGHT THINGS

Effective management of the divergence of logistics processes is vital to the success of companies' business operations. The use of performance measurement (PM) systems is a key element in achieving this. However, previous research has tended to concentrate on the 'comprehensiveness' or 'goodness' of performance measure development, trying to incorporate all dimensions of PM with a one-size-fit-all approach. There has only been limited consideration (Kallio et al., 2000) of a scenario where a business manages multiple supply chains with differing objectives through a single PM system.

Based on action research Wang et al. (in press) examine some of the contingent performance measurement issues in retail logistics. The research particularly focuses on retail store operations where the case company had a range of store formats (convenience, high street, supermarket) with differing logistical requirements. It was found that one-size-fits-all performance measures had hidden the real performance of store delivery and had driven the wrong behaviour. The research developed a generic method for PM reengineering and a weighting score system to reflect the different importance of measures in a customised logistics scenario.

With due consideration of representative measures of total customer value, Wang et al (in press) define generic top level metrics that have to be specifically tailored depending on where in the 'feasible space' the logistics process resides, namely;

- Quality – removing variability from the logistics process, particularly in terms of uncertainty in delivery times.
- Service – delivering the correct products at the planned time.
- Cost – influencing the cost of delivery from DCs to stores.
- Lead time – controlling the time taken to make a delivery to the store.

PRINCIPLE #4: DEFINE THE ELECTRONICS INFRASTRUCTURE

In order to support the move to tailored logistics, it is important that an appropriate IT infrastructure is implemented to provide efficiency within the information flow and enable effective performance measurement (Principle #3). Electronic Logistics Marketplaces (ELMs) are one such approach to achieving this. These are defined as electronic hubs using Web-based systems that link shippers and carriers together for the purpose of collaboration or trading.

Through our research, we have identified four main types of ELM in use today (Wang et al., 2007):

- Open System – Accessible by any shipper or carrier and frequently used to offer spot-hire loads and backloading opportunities. Prices are normally determined by an auction.
- Private Marketplace – Created by a single shipper for communication with their hauliers only. They remain responsible for the operation and characteristics. Prices are determined through tendering rather than an auction.
- Shared Marketplace – Similar to private marketplaces, but here the opportunity exists for information to pass between marketplaces. While shippers would not be able to see other shipper's information, carriers may be able to see their loads from various shippers in one location.
- Collaborative Marketplace – Established by a consortium of businesses to identify similarities in transport flows. The marketplace acts as a central hub to control all of these networks in order to provide an optimum solution.

The last three of these types can be classified as closed systems as they are only available for invited members. The architectures can also be matched against the types of logistics service identified in Bask (2001) and is shown on Figure 2.

Closed marketplaces are particularly relevant within the context of tailored logistics. Because they are based around information sharing (as opposed to cost minimisation with open systems), they are conducive to increasing the level of collaboration within the logistics triad (Principle #2). Closed ELMs often have a broader functionality than other transport technology solutions. They enable the planning of loads, tracking and tracing during execution and reporting facilities after delivery (Wang et al., 2007). Underpinning these activities is high levels of communication between triad members, enabled through the Internet.

While most ELMs are controlled by one member of the triad, it is possible for the ELM to be completely independent. This is the role of a fourth party logistics provider (4PL). By introducing a 4PL, there may be a disruptive influence to collaboration levels within the triad (Principle #2). An additional party is added to the communication chain, potentially affecting vertical collaboration within the triad (Mason and Lalwani, 2007; Boughton, 2007).

PRINCIPLE #5: BUILDING IN APPROPRIATE LEVELS OF FLEXIBILITY

The final principle relating to the design of a tailored logistics system relates to the process of transporting products. Determining flexibility requirements needs due consideration of where your business resides in the feasible logistics space (see Principle #1). There is an underlying premise in the supply chain that logistics providers will respond to changes in demand and be willing to accommodate uncertainties. But this reactive use of flexibility often leads to

increased costs and reduced customer service levels. Given that mass customisation is defined as “the ability to provide individually designed... services to every customer through high process agility, flexibility and integration” [ref?] and “the use of flexible processes and organisational structures to produce varied and often individually customised products and services at the low cost of a standardised, mass-production system” [ref?] it is interesting to note that little research has been undertaken on the role of transport flexibility in the supply chain.

Based on a synthesis of the available manufacturing flexibility literature, Naim et al. (2007) develop a framework for identifying the main forms of transport flexibility. External flexibility types are similar to those proposed by Slack (1989) in the context of manufacturing. However, access flexibility is added to reflect the geographical nature of transport operations. Nine internal flexibility types are proposed, based around the transport mode, vehicle, distribution network, routing capabilities and communication. Again, inspiration is drawn from manufacturing, but with concepts translated into the freight transport domain.

PRINCIPLE #6: ROBUST DATA CAPTURE AND RETRIEVAL SYSTEMS

This requires both solid electronic infrastructure (see Principle #4), the willingness among parties in the supply network to release information (see Principle #2) and appropriate measures of performance (see Principle #3).

There is a need to look at how collaboration and information sharing can be used for risk mitigation in a supply chain/network. Supply chains face risks from disturbances which cause negative consequences in terms of cost, service, quality and time. These could be in the form of supplier machine breakdowns or increase in delivery lead times, from application of inappropriate replenishment algorithms or from disruptive events in the environment. Thus we seek to develop an approach to disturbance management based on the principle of early detection of disturbances. The additional reaction time gained is expected to improve the quality of risk mitigation. It is premised that an active collaboration between the supply chain members, as information is shared between them, will form the basis for this detection (Shukla & Naim, 2007)

CONCLUSIONS

The framework developed addresses the little researched area of the role of transport in the context of tailored logistics. The framework indicates that supply chain management requires a multifaceted approach to tailored logistics, taking due attention of process, technology and relationships. The research has investigated tailored logistics from a transport and 3PL perspective. The framework builds on the logistics triad as the *minimum* unit of analysis when auditing, designing, implementing and operating complex networks.

While the research has been limited to testing elements of a conceptual framework to a small number of case studies, this has been in depth but requires further research to fully generalise and enhance. The framework developed may act as a strategic route map by which members of the logistics triad, and further along the whole logistics network, may develop a tailored logistics strategy.

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DESIGNING SUPPLY CHAIN NETWORK USING MAX-MIN ANT SYSTEM

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ABSTRACT

Designing supply chain network is involved in determining the choice of available facilities (such as plants and warehouses) to be opened and in planning the transportation routes between parties (from suppliers via plants and warehouses to customers) in order to meet customers' demand with minimum cost. The problem is usually constrained by the finite capacity limitation on each suppliers, plants and warehouses. This paper proposes a nature inspired algorithm called Max-Min Ant System (MMAS) that used for minimising total costs associated within a supply chain network including material cost, manufacturing cost, holding cost and transportation cost. The proposed algorithm was tested using three sizes of benchmarking dataset of logistic chain network, which is typical of those faced by most global manufacturing companies. The computational experiments were conducted to compare the efficiency of the proposed methods with Genetic algorithms and Ant System in terms of the total costs obtained from each problem size.

Keywords: Supply Chain, Ant System, Max-Min Ant System, Genetic Algorithm, Linear Programming.

INTRODUCTION

The importance of supply chain and logistics management has been widely recognised. Effective management of the supply chain can reduce costs and lead times and improve responsiveness to changing customer demands. logistics may be defined as the art of bringing the right amount of the right products to the right places at the right time with minimising costs related within and between all parties and usually refers to supply chain problems. Typical supply chain commonly involves a network of suppliers, plants, warehouses and customers (see Figure 1).

Typical problem arising in the chain network is involved in determining the choice of available facilities (such as plants and warehouses) to be opened and in designing the transportation routing between parties (from suppliers via plants and warehouses to customers) in order to meet customers' demand with minimum cost. The problem is usually constrained by the finite capacity limitation on each supplier, plant and warehouse. The design tasks are to satisfy customers' demand and to minimise total costs related to raw materials, production, holding, transportation between stages and fixed operation costs by simultaneously considering resource and capacity limitations.

Supply chain network designing (SCND) problem has been previously tackled using various methods. Gunnarsson et al. (2004) have applied a conventional optimisation technique called integer linear programming (ILP) to solve the SCND

problem. The ILP approach was relatively well developed and attributed to the military services early in World War II. Based on the full enumerative search within this approach, the optimal solutions are always guaranteed. However, the application of this method might need exponential computational time in the worst case. This becomes an impractical approach especially for solving a very large size problem. Therefore, alternative approaches that can guide the search process to find acceptable solutions within a reasonable amount of computational time are more practical and desirable. Syarif et al. (2002) have applied spanning tree-based Genetic Algorithm approach to minimise the total transportation costs arisen within the supply chain network. However, costs related to material, manufacturing and holding activities were neglected in their model.

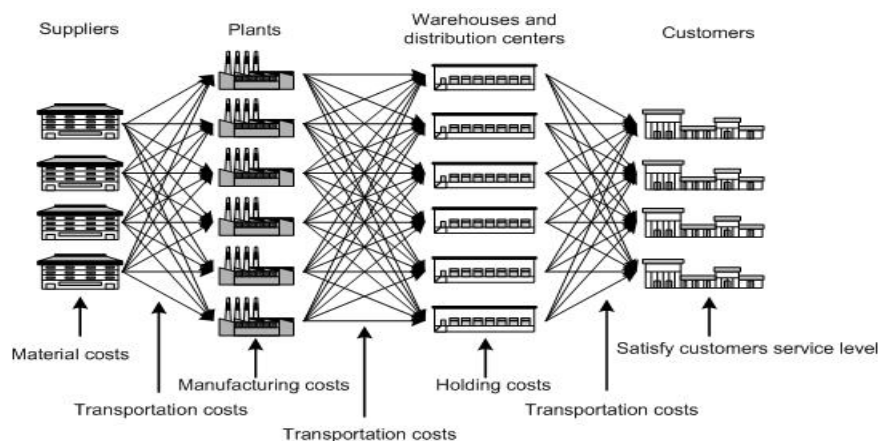


Figure 1. Typical supply chain network.

The objectives of this work were to: i) present a mathematical model of supply chain network designing (SCND) problem including costs of transportation between parties, material, manufacturing, holding and fixed operation costs; ii) propose the Max-Min Ant System (MMAS) to solve the SCND problem; and iii) compare the results obtained from MMAS with other algorithms using three sizes of benchmarking datasets.

The remaining sections in this paper are organised as follows. The next section presents the problem statements and mathematical model of the supply chain network designing (SCND) problem. Then, Max-Min Ant System for the SCND problem and its pseudo code are described. This followed by the sections of numerical experiments and conclusions.

PROBLEM STATEMENTS AND FORMULATIONS

The supply chain network designing problem is to minimise the total costs associated to materials, manufacturing, holding, transportation between parties and fixed operation cost related to the available facilities (such as plants and warehouses) to be opened by simultaneously considering resource and capacity limitations in order to meet given customers' demand. The mathematical model and its notations for designing supply chain network (Pongcharoen et al., 2007) considered in this work are as follows.

Indices:

- i denotes supplier i^{th} in the set of suppliers (I)
- j denotes plant j^{th} in the set of plants (J)

k denotes warehouse k^{th} in the set of DC (K)

l denotes customer l^{th} in the set of customers (L)

Parameters:

a_{ij} is transportation cost per unit of raw material flow from supplier i^{th} to plant j^{th} .

b_{jk} is carrying cost per unit of finished goods moved from plant j^{th} to warehouse k^{th} .

c_{kl} is moving cost per unit of goods deliver from warehouse k^{th} to customer l^{th} .

S_i is the upper limit of supplier i^{th} can supply.

P_j is the production capacity of plant j^{th} .

W_k is the storage limit of warehouse k^{th} .

C_l is the demand of customer l^{th} .

f_j is the fixed cost for operating at plant j^{th} .

f_k is the fixed cost for operating at warehouse k^{th} .

Decision variables:

x_{ij} is the amount of raw material transferred from supplier i^{th} to plant j^{th} .

y_{jk} is the amount of finished goods moved from plant j^{th} to warehouse k^{th} .

z_{kl} is the amount of finished goods delivered from warehouse k^{th} to customer l^{th} .

$t_j = 1$ if production takes place at plant j^{th} , otherwise 0

$t_k = 1$ if warehouse k^{th} is used, otherwise 0

$$\text{Minimise } \sum_{i=1}^I \sum_{j=1}^J (a_{ij} + r_i) x_{ij} + \sum_{j=1}^J \sum_{k=1}^K (b_{jk} + m_j) y_{jk} + \sum_{k=1}^K \sum_{l=1}^L (c_{kl} + h_k) z_{kl} + \sum_{j=1}^J f_j t_j + \sum_{k=1}^K f_k t_k \quad (1)$$

$$\sum_{j=1}^J x_{ij} \leq S_i, \quad \forall i, j \quad (2)$$

$$\sum_{k=1}^K y_{jk} \leq P_j, \quad \forall j, k \quad (3)$$

$$\sum_{l=1}^L z_{kl} \leq W_k, \quad \forall k, l \quad (4)$$

$$\sum_{k=1}^K z_{kl} = C_l, \quad \forall k, l \quad (5)$$

$$\sum_{i=1}^I x_{ij} \leq P_j t_j, \quad \forall i, j \quad (6)$$

$$\sum_{j=1}^J y_{jk} \leq W_k t_k, \quad \forall j, k \quad (7)$$

$$\sum_{i=1}^I \sum_{j=1}^J x_{ij} = \sum_{j=1}^J \sum_{k=1}^K y_{jk} = \sum_{k=1}^K \sum_{l=1}^L z_{kl} = \sum_{l=1}^L C_l, \quad \forall i, j, k \quad (8)$$

$$x_{ij}, y_{jk}, z_{kl} \geq 0, \quad \forall i, j, k, l \quad (9)$$

$$t_j, t_k = \{0, 1\}, \quad \forall j, k \quad (10)$$

Constraint (2) (3) (4) and (5) represent the capacity limitations of the suppliers, plants, warehouse/distribution centres and customers, respectively. Constraint (6) ensures that raw materials are delivered to only operating plants; likewise, constraint (7) for only operating warehouses. Constraint (8) ensures that the same amount of items is transported in each stage and also meets customers' demand. In the case of unbalanced supply and demand, a dummy supplier or customer may be introduced. Constraint (9) ensures that transportation variables are greater or equal to zero whilst binary decision variables are specified in the last constraint.

MAX-MIN ANT SYSTEM FOR DESIGNING SUPPLY CHAIN NETWORK

Nature has always been a source of inspiration. Various types of nature-inspired algorithms have been developed during the last few decades. These algorithms

sometimes called metaheuristics iteratively conduct stochastic search process adopted from natural intelligence. They can be categorised into three groups (Engin and Doyen, 2004): physically-based inspiration such as Simulated Annealing (Kirkpatrick et al., 1983); socially-based inspiration for instance Taboo Search (Glover, 1986); and biologically-based inspiration e.g. Neural Network (Haykin, 1999), Genetic Algorithms (Gen and Cheng, 1997, Goldberg, 1989), Shuffled Frog Leaping (Eusuff and Lansey, 2003), Particle Swarm Optimisation (Kennedy and Eberhart, 2001), Ant Colony Optimisation (Dorigo and Stutzle, 2004) and Artificial Immune System (Hart and Timmis, 2005). These algorithms have been applied to solve a variety of real-world applications and optimisation problems (Chaudhry and Luo, 2005, Dorigo and Blum, 2005, Hart and Timmis, 2005).

Ant Colony Optimisation (ACO) is biologically-based inspiration method that initially imitates collaborative artificial ants for finding the shortest path between the nest and the source of food. ACO methods include Ant System (AS), Elitist AS; Rank-based AS; Ant Colony System and Max-Min AS (MMAS). AS is the first algorithm and has been extensively improved in the series. All the main procedures within the AS and its extensions are generally similar [see Dorigo and Stutzle (2004) for more details]. These methods are being continually proposed and exploited to solve a wide range of optimisation problems in diverse fields (Dorigo and Blum, 2005).

In this work, the Max-Min Ant System (MMAS) proposed by Stutzle and Hoos (1997) was adopted for designing the supply chain network problem. Like other ant systems, the MMAS consists of two main phases: the ants' solution construction and the pheromone update. Ants iteratively construct their tour stage by stage based on the amount of pheromone deposited on the route taken by the ants. After iterations of moving, the amount of pheromone on the route undertaken by ants will be decreased according to the pheromone evaporation rate. On the other hand, the route taken by ants has more pheromone value assisting to bias the search.

The Max-Min Ant System (MMAS) was derived from the Ant System (AS) according to the following modifications: i) only either the iteration-best ant or the best-so-far ant is allowed to deposit pheromone; ii) the possible range of pheromone trail values is controlled by the upper and lower pheromone limits (τ_{\max} and τ_{\min}); iii) the pheromone trails are initialised to the upper pheromone trail limit with a small pheromone evaporation rate (ρ); and iv) when the system approaches stagnation or the generated tour has been unimproved for a certain number of consecutive iterations, pheromone trails are then reinitialised (Stutzle and Hoos, 2000). The pseudo code of the MMAS for solving the supply chain network designing problem is provided in Figure 2.

EXPERIMENTAL RESULTS AND DISCUSSIONS

In this present work, three-sizes of the benchmarking SCND problems characterised in Table 1 were considered. The large problem, for example, involved eight suppliers, sixteen plants, sixteen warehouses and eight retailers. To solve the problem using Mixed Integer Linear Programming (MILP), it required 512 integer and 32 binary variables based on 625 constraints. The best solutions for these benchmarking problems were initially identified by LP method using a

software package. Due to the limited (trial) version of the software package used, only total costs for small and medium size problems were found at 87,500 and 187,800 Baht, respectively. These results were then used for benchmarking the performance of the proposed method described in the previous section.

Pseudo code of Max-Min Ant System (MMAS) for designing logistic network

```

Initialise the value of MMAS parameters including no. of ants ( $A_{max}$ ) and iterations ( $I_{max}$ ), pheromone weight ( $\alpha$ ), heuristic information weight ( $\beta$ ) and pheromone evaporation weight ( $\rho$ )
Initialise pheromone values for each stages: supplier node  $i$  and plant node  $j$  ( $\tau_{ij}$ ), plant node  $j$  and warehouse node  $k$  ( $\tau_{jk}$ ) and warehouse node  $k$  and customer node  $l$  ( $\tau_{kl}$ )
Set current iteration ( $I$ ) = 1
Do
  Set current ant ( $A$ ) = 1
  Do
    Repeat
      Randomly select a starting supplier node ( $i$ )
      Update candidate list of plant nodes ( $J$ )
      Calculate the moving probability ( $P_{ij}^A$ ) from node  $i$  to node  $j$  ( $j \in J$ )
      Choose the best plant from the list with highest probability
      Update candidate list of warehouse nodes ( $K$ )
      Calculate the moving probability ( $P_{jk}^A$ ) from node  $j$  to node  $k$  ( $k \in K$ )
      Choose the best warehouse from the list with highest probability
      Update candidate list of customer nodes ( $L$ )
      Calculate the moving probability ( $P_{kl}^A$ ) from node  $k$  to node  $l$  ( $l \in L$ )
      Choose the best customer from the list with highest probability
    Until all customers' demand is satisfied
    Calculate total costs related to the desired chain network
    Update local pheromone trail based on each ants
     $A = A + 1$ 
  While  $A \leq A_{max}$ 
  Calculate the upper and lower pheromone limits ( $\tau_{max}$  and  $\tau_{min}$ )
  Update global pheromone trail based on the best ant
   $I = I + 1$ 
While  $I \leq I_{max}$ 

```

Figure 2. Pseudo code of MMAS for design supply chain network.

Table 1. Characteristics of the benchmarking problems.

Characteristics	Problem sizes		
	Small	Medium	Large
Number of suppliers	4	8	8
Number of plants	6	10	16
Number of warehouses	6	10	16
Number of retailers	4	8	8
Total number of integer variables	84	260	512
Total number of binary variables	12	20	32
Number of constraints	129	337	625

A two-step sequential experiment was adopted in this work. The first experiment was designed to investigate the appropriate setting of MMAS parameters including number of ants and iterations ($A \cdot I$), pheromone weight (α), heuristic information weight (β), and pheromone evaporation weight (ρ). Since each parameter was considered at two levels (see Table 2), the half fractional factorial design (2^{k-1}) (Montgomery, 2001) was adopted in this experiment. It should be noted that the combination of numbers of ants (candidate solutions) and iterations ($A \cdot I$) determine the amount of candidate solutions generated, which are directly implied the amount of search in the solution space. The higher values of these parameters mean that there is more chance of getting good solutions but this requires longer computational time. The combination of these factors was fixed to 1,000 candidate solutions in order to fairly compare the obtained

results with other algorithms. The setting values for other factors were based on the suggestions in literature (Dorigo and Stutzle, 2004, Pongcharoen et al., 2007, Sujaree and Pongcharoen, 2008).

Table 2. Experimental factors and its level.

Factors	Levels (coded)	
	Low (-)	High (+)
Number of ants and iterations ($A*I$)	50/20	20/50
Pheromone weight (α)	0.5	2.5
Heuristic information weight (β)	1.0	4.5
Pheromone evaporation weight (ρ)	0.2	0.9

The experiment was repeated five times using different random seed numbers, which could be a potential nuisance factor. The computational results obtained from 40 ($2^{4-1} \times 5$) runs shown in Table 3 were analysed using a general linear form of analysis of variance (ANOVA). A factor with $P \leq 0.05$ is statistically significant with 95% confidence level.

Table 3. ANOVA on the results obtained from AS using small problem.

Source	DF	Problem Sizes					
		Small		Medium		Large	
		F	P	F	P	F	P
$A*I$	1	0.14	0.712	0.42	0.520	0.59	0.448
α	1	3.04	0.091	0.03	0.860	0.00	0.965
β	1	82.71	0.000	129.26	0.000	234.87	0.000
ρ	1	0.15	0.698	0.42	0.530	2.23	0.146
seed	4	1.41	0.255	0.11	0.980	0.40	0.805
Error	31						
Total	39						

From Table 3, it can be seen that only single factor called heuristic information weight (β) was statistically significant on all problem sizes with 95% confidence interval. The remaining factors including numbers of ants and iterations ($A*I$), heuristic information weight (β), and pheromone evaporation weight (ρ) in the range considered were not statistically significant with 95% level of confidence. It should be noted that the potential nuisance factor (random seed) was also not significant. The main effect plots shown in Figure 2 suggested that the appropriate setting of all MMAS parameters ($A*I$, α , β and ρ) should be 20*50, 2.5, 5 and 0.9, respectively.

The last experiment was aimed to compare the experimental results obtained from Max-Min Ant System (MMAS) with those using Linear Programming (LP), Genetic Algorithms (GA) and simple Ant System (AS) reported by Sujaree and Pongcharoen (2008). The setting of MMAS parameters in this sequential experiment was recommended by the analysis of variance on the computational results from the previous experiment. It should be noted that the total amount of search for each methods conducted in the computational runs was fixed at 1,000 candidate solutions generated in order to make a reasonable comparison.

The summary of the solutions obtained from LP, GA, AS and MMAS is shown in Table 4. It can be seen that for small problem, both AS and MMAS were able to find the optimal solution with the total costs of 87,500 Baht whilst GA produced best-so-far solution with total costs of 88,150 Baht or 0.74% deviation from the optimal solution. For medium problem, both AS and MMAS once more produced

best-so-far solutions or 4.57% higher than the optimal solution (187,800 Baht) followed by the best-so-far GA result which was higher than the optimum by 5.96%. Since the numbers of 512 variables and 625 constraints required for solving the large problem exceeded the limitation of the LP software package for student version used, the optimal solution could not be provided. For large problem, the best-so-far result obtained from MMAS was better than those using GA and AS.

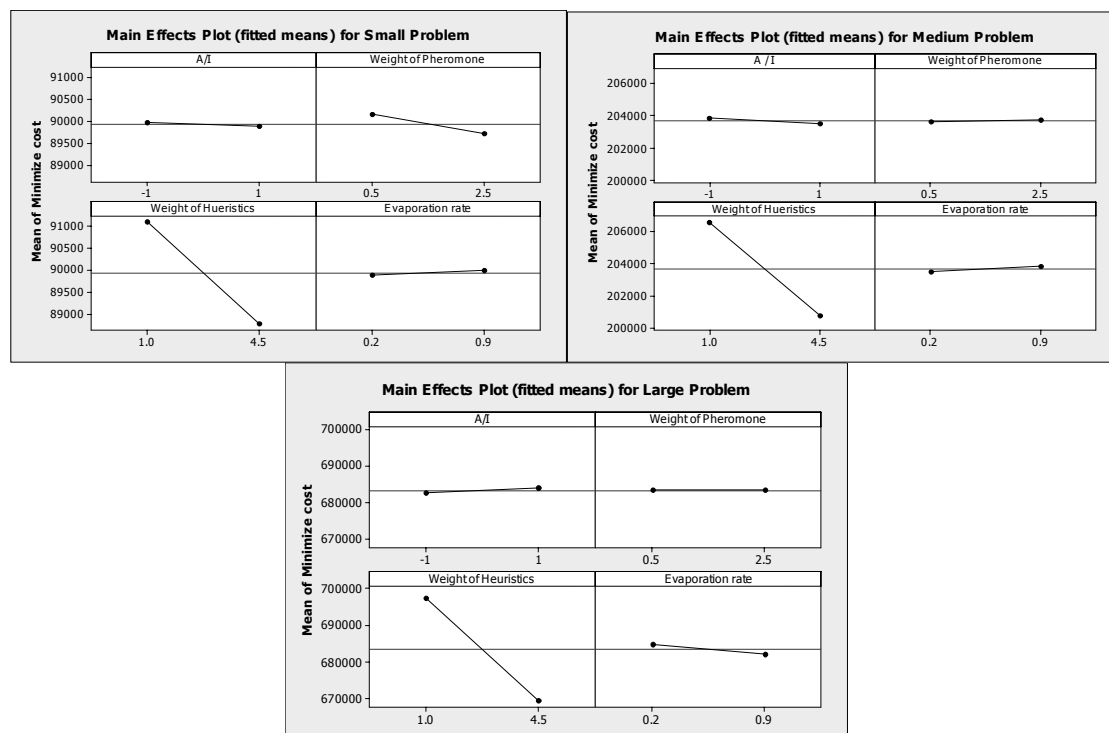


Figure 2. Main effect plots of the MMAS parameters.

Table 4. Summary of the results obtained from four methods.

Problem size	Best-so-far solutions (% error)			
	LP	GA	AS	MMAS
Small	87,500	88,150 (0.74%)	87,500 (0.00%)	87,500 (0.00%)
Medium	187,800	199,000 (5.96%)	196,400 (4.57%)	196,400 (4.57%)
Large	N/A	674,300	660,400	659,900

CONCLUSIONS

This paper proposes a biologically-inspired algorithm called Max-Min Ant System (MMAS) used for minimising total costs associated within a supply chain network including material cost, manufacturing cost, holding cost and transportation cost. The proposed algorithm was tested using three sizes of benchmarking dataset of logistic chain network, which are typical of those faced by most global manufacturing companies. Two-step sequential computational experiment was adopted in this work. Since the performance of an algorithm depends on its parameters' setting, the first experiment was based on half fractional factorial design aiming to investigate the appropriate setting of MMAS parameters, which was then used in the second experiment intending to compare the performance of the proposed method with other algorithms including Genetic Algorithm and

Ant System. It was also found that MMAS produced results with lower costs than those obtained from other methods especially for the large size problem.

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AN INVENTORY RATIONING METHOD IN A M-STORE REGIONAL SUPPLY CHAIN OPERATING UNDER THE ORDER-UP-TO LEVEL SYSTEM

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ABSTRACT

This research studies the inventory rationing problem in a general two-stage supply chain. The supply chain has a central warehouse supplying a single type of product to several retailers. The end-user demand is independent and normally distributed. It operates under the order-up-to level inventory replenishment system. The warehouse inventory is replenished in every fixed-interval from a source outside the concerned supply chain, but the retailer inventory could be replenished daily. The system has N truck. Each truck can make a round trip to one retailer for each period. Based on the current inventory status, the planner must make two decisions in each period (which retailer to replenish and what is the replenishment quantity) so as to minimize the lost sales in long-run. In case of insufficient warehouse inventory to fulfil all projected retailer demands, an inventory rationing rule must be applied. The current research aims to propose an inventory rationing rule for this particular setting. The proposed rationing rule tries to minimize the expected total cost in the period that the allocation takes effect and ignore all costs in all subsequent periods. Its performance is then tested against some existing rationing rules. Numerical experiments show that the proposed rule outperforms the existing rationing rules.

INTRODUCTION

Figure 1 illustrates the concerned supply chain, which is modelled from a small frozen-food supply chain in Bangkok, Thailand. A regional warehouse receives periodical inventory replenishments from factories, which are controlled by a national unit (Head Office). The national unit utilizes a nationwide planning system to determine the shipping quantity and time. Absolutely, they are based on inventory in the national chain, sales history, and sales forecasts for each region. Selectively, the fixed-cycle (e.g. weekly, monthly) inventory replenishment with predetermined order-up-to levels (R,S system) is adopted. The regional warehouse then operates a limited number of trucks that transfer products to M regional stores. The stocking points are therefore $M+1$ and the product transfer within stores or back to the regional warehouse is not allowed. Each store experiences an uncertain customer demand and a lost sale occurs when customer demand is not satisfied. Due to the management policy, the primary goal is to minimize the lost sales within the region in the long run. The replenishment policy must therefore position the inventory to meet customer demand. Also at the same time holding back the inventory, so as to be able to respond quickly when the demand at a store rises. Consequently if a situation occurs when the available stock at the warehouse exceeds the regional demand then the decision is trivial because each store will be overstocked. However if demand exceeds supply the inventory rationing decision is vital, as system performance is affected.

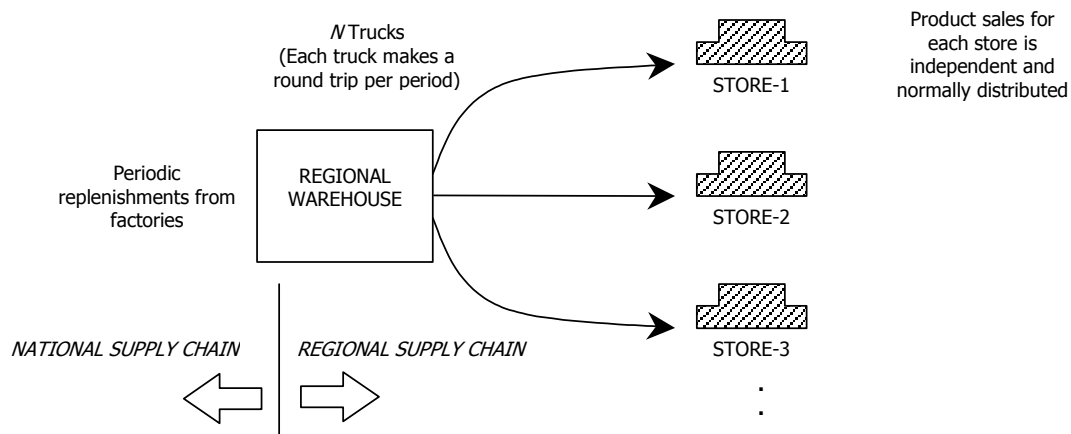


Figure 1. The N-Truck M-Store Regional Supply Chain Replenishment Model

To simplify the analysis without loss of generality, the following conditions are made:

- (i) a single type of products is selected
- (ii) the end-user demand is independent, stationary and normally distributed
- (iii) the number of truck N is less than the number of stores M ($N < M$)
- (iv) storage capacities at any stocking points and on the truck are sufficient
- (v) inventory replenishments occur at the start of each period and are available in that period.

The main research focus of this paper is to determine the replenishment quantity needed, so as to minimize future losses in sales.

LITERATURE REVIEW

The early work on the inventory rationing problem can be credited to Veinott (1965). He first analyzed the critical-level inventory rationing rule using multiple demand classes, zero lead time, and backordering policy. A similar model based on lost sales showed that a base stock policy has to remain optimal and the optimal rationing policy could be specified by a set of control limits under certain conditions: Topkis (1968). This result was also further emphasised by Kaplan (1969).

A two-echelon divergent supply chain was first considered by Eppen and Schrage (1981). They derived an approximately optimal inventory rationing rule, (equally stockout-probability allocation rule) for a particular setting. Federgruen and Zipkin (1984) discounted some assumptions in Eppen and Schrage (1981). The stock rationing was obtained by solving a myopic allocation rule. This aimed to minimize the expected costs in the period that the allocation actually took effect, ignoring the costs in all subsequent periods. Zipkin (1984) proposed a dynamic program that allocated stock from a main inventory from a single depot to many demand points. His model was concerned with normally distributed demands in relation to the backlogging of unfulfilled demand. Jackson (1988) also studied a

stock allocation in a two-echelon distribution system. He showed significant effects of risk pooling between replenishments in a single-cycle model, where the initial stock level was given. McGavin et al. (1993) also considered allocation policies in a single replenishment cycle with given initial stock. Various ways were examined to exploit the effect of risk pooling between replenishments. A similar model with a different cost structure; including the costs of shipments between central depot and local warehouses; was analyzed by GÜllü and Erkip (1996).

So far, an extensive review on this issue was undertaken by Diks et al. (1996). The authors reviewed many inventory rationing methods, for instance: Fair Share (FS); Appropriate Share (AS); Consistent Appropriate Share (CAS); Priority; and various other rationing rules. The CAS rule was also studied in De Kok (1990) for a two-echelon divergent model with a stockless depot and the fill rate criterion. The similar models which allow the depot to maintain stock were analyzed by Seidel and De Kok (1990) and Verrijdt and De Kok (1996). The adaptation of the CAS policy to a one-depot/multi-retailer inventory system was presented in Diks and De Kok (1996).

A more complex system named Supply Chain Operations Planning Problem (SCOP) was studied by De kok and Fransoo (2003). The SCOP aimed to coordinate the release of materials and resources such that supply chain costs were minimized under in comparison to customer demands. The author proposed the Synchronized Base Stock (SBS) policy and comparing it against a LP-based planning system. The SBS outperformed the LP-based system, using a more sophisticated linear-allocation inventory rationing rule. This rule coincides with one derived by Van der Heijden (1997), named the Balanced Stocking (BS) rationing. Van der Heijden (1997) further concluded that the BS was accurate and more robust than the CAS rationing rule.

Recently, a model with several demand classes that was first studied by Veinott (1965) was still being investigated by many researchers: Melchioris et al (2000); Melchioris (2003); Deshpande et al (2003); Ayanso et al (2006). The extension of the inventory rationing issue covering the production was conducted by: Lee and Hong (2003); Huang and Iravani; Ha (1997a, b, 2000); De Véricourt et al (2002); and Axsäter et al (2004).

The literature review reveals that while several papers consider the divergent supply chain, especially the two-stage supply chain with one upstream and multiple downstream members. These are primarily focused on the inventory and distribution costs, which typically include inventory holding, inventory ordering, shipment, and stock-out costs. The problem studied here differs, in that the inventory holding and distribution costs are not significant. The main focus of this paper is on the lost sales cost, which affects the replenishment problem. Further more, all previous studies on the inventory rationing problem never considered the effect of any vehicle constraints. This vehicle constraint is a significant concern as it affects the inventory replenishment system. Hence, some of the stores cannot be replenished simultaneously due to a lack of trucks. Thus, benefits of rationing some items of stock to these stores need further investigation.

PROBLEM DESCRIPTION

The following notations have been used to describe the main decision problem at the regional warehouse.

Notation:

j	store index ($j = 1, 2, 3, \dots, M$)
n	truck index ($n = 1, 2, 3, \dots, N$)
t	time period index ($t = 1, 2, 3, \dots, T$)
I_t	ending inventory at the regional warehouse in period t
$V_{j,t}$	ending inventory at store j in period t
A_t	shipment quantity arriving at the regional warehouse in period t
μ_j	mean end-user demand for the product at store j
σ_j	standard deviation of end-user demand for the product at store j
$d_{j,t}$	actual demand or sales at store j in period t
$L_{j,t}$	Lost sales (stock outs) at store j in period t
C_j	Cost of a lost sale (stock out) at store j

Main decision variables at the regional warehouse:

$X_{j,t}$	a binary variable; if store j is supplied in period t , $X_{j,t} = 1$ else $X_{j,t} = 0$
$Q_{j,t}$	replenishment quantity shipped to store j in period t

At the end of each period, the planner learns the inventory status $[I_t, V_{j,t} \mid j > 0]$. The value $d_{j,t}$ is known for the history periods and unknown for the future periods. This can be described by the mean μ_j and standard deviation σ_j . Since the primary goal is to minimize the lost sales within the region, it can be expressed as equation 1.

$$\text{Minimize the total lost sales cost (TC) = MIN } \sum_{j,t} C_j L_{j,t} \quad (1)$$

It is clear from the truck constraint that in any period at most N number of $X_{j,t}$ can be non-zero. Thus, the problem can be verbally described as selecting a set of $X_{j,t}=1$ and $Q_{j,t}>0$ so as to minimize TC given the current state $[I_t, V_{j,t}]$.

INVENTORY CONTROL POLICY

Let S_j and S_w be the pre-designed order-up-to levels at store j and at the warehouse, λ_j and λ_w are safety factors at store j and at the warehouse, μ_w and σ_w are average aggregate demand and standard deviation across all downstream members, FI is the fixed interval of the inventory replenishment at the warehouse, and TL is the order processing time and transportation lead time from the outside source. The numbers S_j and S_w can be derived as follows: (see De Kok and Fransoo 2003).

$$S_j = M\mu_j + \lambda_j \sqrt{M} \sigma_j \quad \text{where } \lambda_j \geq 1 \quad (2)$$

$$S_w = (FI+TL)\mu_w + \lambda_w \sqrt{FI+TL} \sigma_w \quad \text{where } \lambda_w \geq 1 \quad (3)$$

As mentioned earlier, only N numbers of $X_{j,t}$ can be one at any time. The following method that is based on maximum expected shortage is adopted to determine the variable $X_{j,t}$.

Let $ES_{j,t}$ be the expected shortage cost for store j in period t . $X_{j,t}$ is therefore determined as follows:

$$ES_{j,t} = \int_{V_{j,t-1}}^{\infty} P(y)\{(y-V_{j,t-1})C_j\} dy \quad (4)$$

$$X_{j^*,t} = 1 \mid ES_{j^*,t} = \text{Max}_j \{ES_{j,t}\} \text{ else } X_{j,t} = 0 \quad (5)$$

where $P(y)$ is the normal probability density function. Equations 4 and 5 are recalculated until all trucks are assigned ($\sum_j X_{j,t} = N$ for each period t). Once stores are selected then the replenishment quantity $Q_{j,t}$ must be derived. If the warehouse has insufficient stock, an inventory rationing rule must be imposed.

INVENTORY RATIONING RULES

The frozen-food supply chain uses the Priority rationing rule (PRR). This rule uses a list of stores and rations the available inventory according to its position in the list. When this rule is applied, the product will be transferred to the selected stores, until replenishment levels are reached. The Balanced Stock rationing rule (BSR) proposed by Van der Heijden (2000) operates as follows. When the shortage arises, the inventory at store j is raised to the level $S_j - (p_j)(\text{shortage})$, where p_j is a rationing fraction such that $\sum_j p_j = 1$, calculated as $p_j = (0.5M) + \{(\sigma_j)^2 / 2 \sum_j (\sigma_j)^2\}$.

This paper aims to propose a new inventory rationing rule for this circumstance: the Expected Cost Minimization rationing rule (ECM). It is a myopic allocation rule. It aims to minimize the expected cost in the period that the allocation takes effect and ignore all subsequent periods. The ECM is applied by solving the problem **P** below:

$$\text{The problem P:} \quad \text{Minimize} \quad \sum_j ES_{j,t}^* \quad (6)$$

s.t.

$$ES_{j,t}^* = \int_{V_{j,t-1} + Q_{j,t}}^{\infty} P(y)\{(y-V_{j,t-1} + Q_{j,t})C_j\} dy \quad (7)$$

$$\sum_j Q_{j,t} = I_{t-1} + \sum_{\tau=t, t+M-1} A_{\tau} \quad (8)$$

$$Q_{j,t} \geq 0 \text{ for all } j \quad (9)$$

The objective of Equation 6 is to minimize the overall expected shortage of the entire supply chain. Equation 7 shows a cumulative cost function to estimate the shortage cost. Equation 8 shows that the total projected shipping quantity must be equal to the total projected availability as indicated by the inventory at the regional warehouse for the next M periods. Equation 9 is the non-negative constraint condition.

It is noted that $Q_{j,t}$ is proportionally applied to all products available in period t ($I_{t-1} + A_t$) if it exceeds the sum of current inventory I_{t-1} plus shipment quantity A_t . And only $Q_{j,t}$ in which its corresponding $X_{j,t} = 1$ will be transferred to store j . The remaining products will be kept at the warehouse for future periods.

NUMERICAL EXPERIMENTS

Performance of the ECM was evaluated against the PRR and BSR. The first numerical experiments were conducted based on modified data from the frozen-food supply chain: ($M=6$ and $N=2$). The product type was selected in which its

end-user demand could be assumed to follow normal distributions (in the long term). The parameters at the six stores were set as follows, $\mu_j = \{428, 425, 418, 420, 448, 423\}$, $\sigma_j/\mu_j \approx 0.1$, $C_j = \{6.00, 6.20, 6.50, 6.70, 6.80, 7.00\}$, $\lambda_j = 1 \forall j$, $V_{j,0} = \{450, 450, 475, 475, 500, 500\}$, $FI = 5$, and $TL = 2$. As noted earlier, if the supply of products at the warehouse is unconstrained then the replenishment is trivial. To create a sufficiently constrained problem the base problem used the safety factor $\mu_w = 0.5$. The initial inventory at the warehouse was 4500 ($I_0 = 4500$). The experiment was carried out to cover 20 periods ($T = 20$). The following numbers were recorded for each rule; the total lost sales cost, the total products remaining in the system (REMAIN), and the difference between the total customer demand and the total products entered into the system (DIFF). The experiment was repeated until the 95%-confidence interval/s of the observed average numbers did not exceed their 5% errors. For general purposes, the second test was performed to evaluate the efficiencies of the rationing rules under various parameter settings. The test was conducted with 7 different sets of mean customer demand μ_j , standard deviation σ_j , and cost of a lost sale C_j . They were re-generated within the 50% gap of those used in the base case.

RESULTS

Table 1 below shows the results of the study. The base case is shown on the first row. One-way ANOVA was applied and showed that the rationing rule significantly affected the total lost sales costs at a significant level of 0.05. The multiple comparison test (Duncan Method) was then performed to classify the rationing rules into homogeneous subsets. Their ranks were shown by the numbers in the parentheses. It was seen that the ECM outperformed the other rules being ranked 1st followed by the BSR and PRR rules. Interestingly, the current practice used (case study) was ranked 3rd (worst case). In fact, the PRR rule represented did not account for the benefits of rationing some items of stock, in taking advantage of the transshipment in the subsequent periods. This research study proved that by rationing appropriate future stock allocations was beneficial, demonstrating the need to revise the current practice of the supply chain. The BSR and PRR were ranked poorer than the ECM rule because they sometimes caused the allocation of inconsistent levels of stock to selected stores. This is because; the ECM scale took into account the demand distribution function/s.

	ECM-Rule			BSR-Rule			PRR-Rule		
	TC	DIFF	REMAIN	TC	DIFF	REMAIN	TC	DIFF	REMAIN
Base Case	7472 (1)	794.85	318.28	7691 (2)	+2%*	318.18	7924 (3)	-5%	318.86
1	8936 (1)	927.96	286.14	9159 (2)	-2%	290.56	9413 (3)	-4%	300.33
2	7023 (1)	783.63	304	7227 (2)	+3%	312.64	7427 (3)	-3%	311.91
3	8558 (1)	935.25	301.28	8672 (2)	-3%	302.68	8950 (3)	-3%	305.98
4	6298 (1)	859.93	309.77	6582 (2)	-4%	316.09	6694 (3)	-8%	318.91
5	5245 (1)	591.22	357.22	5317 (2)	-2%	364.23	5497 (3)	-8%	362.46
6	5717 (1)	757.09	332.59	5899 (2)	-3%	333.7	5994 (3)	-7%	331.21
7	4693 (1)	520.09	378.38	4877 (2)	+1%	383.29	4985 (3)	-5%	387.21

* represents the DIFF value in relative to that of the ECM rule.

Table 1. Results (Average Numbers) from the 1st and 2nd Tests.

The DIFF values could be used as an indicator of the insufficiency of the system, because they were all positive. Proving that the rationing rules were needed

because the system was not overstocked. The PRR-DIFFs were all less than ECM-DIFFs. Thus, implying that more products were always supplied to the system when the PRR rule was used instead of the ECM rule. This observation further amplifies the poor performance of the PRR as it acquired more products, returning a higher TC. The positive REMAINS for all rules always showed that there were always products remaining in the system after the 20-day running period, even though the system acquired insufficient product levels. This phenomenon was due to demand uncertainty and could not be eliminated by any rationing rules.

SUMMARY

This investigation studied the inventory rationing problem, embedded in the regional supply chain inventory replenishment problem. Firstly, the concerns raised about the regional supply chain, which operated under the order-up-to level system, were introduced. The system was modified from a small frozen-food supply chain in Bangkok, (Thailand), supplied by a national unit through a nationwide planning system. To simplify the analysis of the order-up-to-level-system, certain control conditions were introduced. The regional warehouse used N trucks, to make a round trip to transfer a single type of product to the stores in its region. When the warehouse had insufficient inventory, a rationing rule must be imposed. In this paper, a new inventory rationing rule was developed. This was based on the logical purpose being compared against the current practice and the BSR rule. Based on the experiments, it could be concluded that the proposed rationing rule was better and more robust than the other rules.

The current research findings can also be attributed to further, future study. The first extension would be to consider the multiple product case, which is certainly a more common scenario in practice. In such a case, the replenishment conflict will become two dimensional since need of stores and products may be in conflict. Another extension is to study the demand correlation between stores. A key assumption in the design of many regional supply chains is that there is a negative correlation between stores. Therefore the net demand for the region will have a more steady state.

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TEMPORAL PATTERN MINING IN LOGISTICS

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ABSTRACT

Modern technologies like RFID, GPS, and wireless networks provide means for an automated tracking of goods, containers, and transportation vehicles. Collecting data about positions and movements of different actors and objects is a prerequisite for an automated analysis of ongoing logistic processes. As extensive information about objects and their relations is available, it is possible to apply data mining techniques in order to identify patterns in the data. In this work, we analyze the requirements for mining patterns in the logistics domain and present an algorithm for mining temporal patterns and prediction rules from complex representations of scenes. An implementation of the mining approach is applied to two test scenarios in order to create and test prediction rules.

INTRODUCTION

In logistics scenarios, there exist many different kinds of objects like transport vehicles (e.g., trucks, ships, or planes), different actors or organizations (e.g., depots, carriers, manufacturers), highways or tracks, transshipment stations, etc. Different events can occur in the dynamic environment like traffic jams, weather events, break downs of transport vehicles, or delivery delays of some goods. It would be very valuable to identify repeating patterns that lead to certain situations in order to predict, for instance, that for the given situation it is likely that rescheduling will be necessary later on. Having this information it would be possible to initiate some counter-actions earlier in order to avoid financial loss or penalty payments. Such a pattern could be, for instance: If the capacity load of depot X is high and transportation vehicles Y on the way to X has a break-down, it is likely that some goods Z have to be transferred to some other depot.

Modern technologies like RFID, GPS, and wireless networks provide means for an automated tracking of goods, containers, and transportation vehicles. Having available data about positions and movements of different objects enables an automated analysis of ongoing logistic processes. If extensive information about objects and their relations is available, it is possible to apply data mining techniques in order to identify patterns in the data. Patterns can be transformed to prediction rules by estimation of causal interdependencies. If it was known that certain situations lead to some future events or situations with some probability, this information could be used to improve the decision making process in logistic scenarios, for instance by avoiding critical situations. The logistics domain features high complexity w.r.t. different objects and relations appearing in scenes on the one hand and demands means for the representation of temporal information on the other hand.

The requirements for learning such patterns are manifold. On the one hand, the complex situations need a sophisticated representation formalism in order to capture the scenes and to represent the patterns. On the other hand, the patterns should be comprehensible and easily applicable to future situations. The requirements are:

- The scene representation has to provide means to represent objects, their properties, as well as interrelations among objects.
- Due to the dynamics, an explicit representation of the temporal dimension is needed. As different relations and events can exist concurrently, it is required that the representation can also deal with such concurrent situations.
- Capturing conceptual information about object's classes and possible interrelations is needed to guide the search for patterns.
- Background knowledge is necessary in order to cover general rules of the domain without demanding the user to provide (redundant) knowledge about each individual object (truck, depot etc.).
- Unsupervised identification of generic frequent patterns, i.e., abstracting from the concrete objects and identifying common patterns.
- Generation of prediction rules to be applied to future situations.
- Pattern matching methods in order to detect patterns (or preconditions of prediction rules).
- Evaluation of created prediction rules.

The paper is structured as follows: Section 2 presents related work, addressing learning in logistics and pattern mining approaches. Our pattern mining approach is described in section 3. In section 4, we give an example scenario and show created patterns before conclusions are drawn in section 5.

RELATED WORK

In logistics scenarios usually a huge amounts of data are involved. Different learning approaches have been used in order to handle this data and to improve the solutions of logistics problems. For instance, neural networks are used to optimize traditional logistics problems like the Travelling Salesman Problem, routing problems, bankruptcy prediction, and dispatching problems (Wilppu, 1999). Another task in logistics is to manage and control a supply chain. With the rising connectivity of the world (airplains, ships) the supply chains spread wide over all continents. Bruzzone and Orsoni describe three different approaches how costs in supply chains could be reduced using techniques from the areas of artificial intelligence, stochastic and mathematics (Bruzzone and Orsoni, 2003). Another approach to handle the complexity of global supply chains is described in (Pontrandolfo et al., 2002). Pontrandolfo et al. use Reinforcement Learning to let different sites learn to work efficiently together. Every site is represented by an agent who acts with semi-Markov decision processes. Traffic route planning problems can also be described with a multi-agent system. Gehrke and Wojtusiak present an approach to react online on influences from the environment (for example weather) (Gehrke and Wojtusiak, 2008a, b). The approach tries to identify the best routes by taking into account the wetness and the speed limits of the roads. Every truck is represented by an

agent and can dynamically react to new events. The (propositional) rule induction system AQ21 has been used to set up prediction rules.

In the recent years, different learning approaches have been presented which satisfy the requirements described above partially. In the field of Inductive Logic Programming (ILP), various approaches have been presented that can deal with relational representations. ILP approaches like FOIL and Progol (Muggleton, 1995; Quinlan, 1990) are supervised and thus do not identify frequent patterns from data as desired. The rule learner WARMR combines ideas from the fields of association rule mining and ILP (Dehaspe and Toivonen, 1999) but does not provide means for explicit representation of the temporal dimension. Different approaches to sequential or temporal pattern mining can be found, e.g., (Agrawal and Srikant, 1995; Höppner, 2003; Mannila et al., 1997). But most of these approaches cannot deal with relational representations as required in our case.

Jacobs and Blockeel apply the ILP association rule learner WARMR in order to mine shell scripts from Unix command shell logs (Jacobs and Blockeel, 2001). Although having a complete different domain, the resulting patterns can represent complex interrelations and temporal relations (sequences). Log files of shells can be seen as a sequence of commands. Frequent patterns from such command sequences can be interpreted as shell scripts. The challenge is to deal with the arguments in commands and use variables in patterns in order to represent that the same argument (e.g., a file name) should be used by a different command. Jacobs and Blockeel use WARMR for the generation of scripts and also present some methods for speedup by splitting up the learning task and using the so called minimal occurrence algorithm. Command sequences are represented by a stub relation with unique identifier, execution time, and command (e.g., `stub(1,2008,'cp')`) and parameter relations (e.g., `parameter(1,1,'file1')` and `parameter(1,2,'file2')`). The learning task is split up by first finding the frequent sequences of commands and then taking the parameter information into account. The minimal occurrence algorithm takes into account the sequential information in the query generation process and can thus prune some of the patterns that cannot be frequent any more. It also utilizes the identifiers at which sequences of the previous step start for the calculation of occurrences of a new sequence (Jacobs and Blockeel, 2001).

Masson and Jacquenet address the mining of frequent logical sequences (Masson and Jacquenet, 2003). They extend the SPIRIT system (Garofalakis et al., 1999) to discover logical sequences and introduce the SPIRIT-LOG algorithms. The major adaptations w.r.t. SPIRIT are done in the generation and pruning functions. Candidate generation is extended to handle logical sequences with variables and in the pruning step an inclusion test between logical sequences (including unification of variables) are developed. SPIRIT-LOG can only create patterns of contiguous predicates, i.e., no gaps are allowed in the sequential patterns. Furthermore, it is not possible to use background knowledge in the form of clauses (cf. (Lee and De Raedt, 2004)).

Lee and De Raedt introduce the logical language SeqLog for the representation of sequential logical data (Lee, 2006; Lee and De Raedt, 2004). The sequence itself is represented as a sequence of logical atoms. Additionally, it is possible to

specify background knowledge as DATALOG style clauses. The mined patterns consist of a sequence of logical atoms. Two adjacent atoms in the pattern can be specified as direct (temporal) neighbors or allow for having other elements between them (denoted by the < symbol). Lee and De Raedt introduce the mining system MineSeqLog which mines the borders of the solution space for an input sequence and a conjunction of monotonic and anti-monotonic constraints on the patterns (Lee and De Raedt, 2004). However, this mining approach cannot mine any patterns with concurrent occurrences of events or activities.

MINING TEMPORAL PATTERNS

The representation of scenes used here is based on Allen’s theory of action and time (Allen, 1984); it is a set of time intervals representing different events and relations between objects in the scene with a temporal validity interval. An example for such a representation is shown in Fig. 1. The temporal dimension is shown on the x axis. The intervals (like “capacity_load(s1, high)”) determine the validity of certain relations or activities. Formally, there exists a start and end time for each interval. As it can be seen in Fig. 1, there are various intervals “active” concurrently.

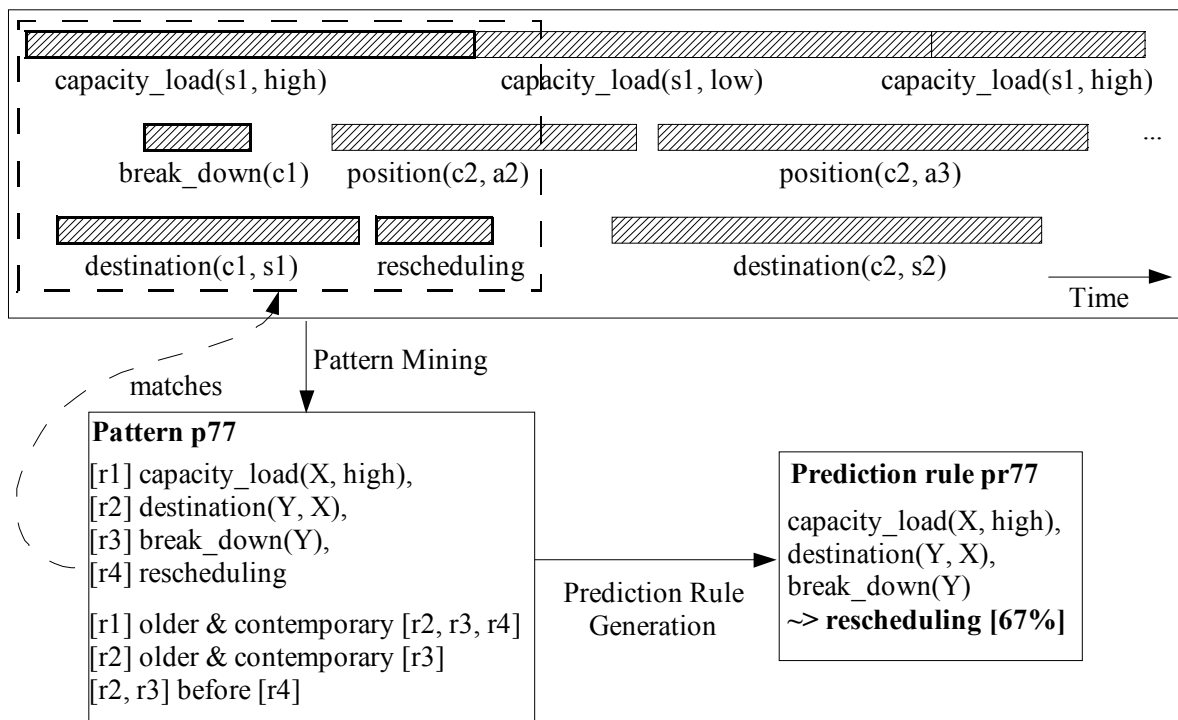


Figure 1: Pattern Mining and Prediction Rule Generation

We define a temporal pattern as a set of predicates with temporal restrictions (interrelations) and concept restrictions. Predicates can represent relations between objects (e.g., “capacity_load(depot1, high)”) or more abstract statements with variables (e.g., “break-down(X)”). The temporal restriction describes temporal constraints between predicate (time interval) pairs using interval relations as they have been introduced by (Allen, 1983) and (Freksa, 1992) (e.g., high capacity load in depot Y happens before break-down of Y). As a third aspect, variables can be restricted to certain concepts (e.g., “X must be an instance of Truck”). A temporal pattern matches to a situation if all variables can

be unified with objects in the situation without violation of the temporal or conceptual constraints.

The mining algorithm itself can be seen as an extension of the well known association rule mining algorithm Apriori (Agrawal and Srikant, 1994), additionally inspired by different approaches to relational as well as sequential association rule mining (Dehaspe and Toivonen, 1999; Höppner, 2003; Lee, 2006). It performs a top-down search through the pattern space starting with the most general pattern. The most general pattern consists of no predicate and thus matches any situation. In different refinement steps the patterns are specialized by five refinement operators:

- Lengthening: Extend the pattern with a predicate.
- Variable unification: Unify two variables X and Y , i.e., $X=Y$.
- Instantiation: Replace a variable by one of the instances of the corresponding concept.
- Temporal refinement: Restrict the set of allowed temporal relations among the predicates.
- Concept refinement: Specialize the concept of one of the variables by replacing it with one of its sub concepts (e.g., from "vehicle" to "truck").

The search is restricted by a support threshold (as it is the case in association rule mining; (Agrawal and Srikant, 1994)). If a pattern does not exceed the support threshold, all its refinements also cannot exceed this threshold. The reason for this is that the refinements are a further restriction and cannot lead to more matches.

For pattern matching, a sliding window is used. A pattern matches at a window position if there exists a variable assignment such that all predicates are matched, and no concept or temporal restriction is violated. It is possible to use different sets of (time) interval relations, e.g., those defined by (Allen, 1983).

In a second step, the generated patterns are transformed into prediction rules. This is done by splitting the pattern into two parts: The precondition and consequence part. For each prediction rule, a confidence value for the rule is computed by counting the situations where the preconditions and consequence occur together. If such a prediction rule is applied to future situations, it is checked if the precondition matches a scene. If this is the case, the consequence part is provided as prediction (with the assigned confidence value). A time interval representation as well as the mining process is illustrated in Fig. 1. Further details about the mining algorithm can be found in (Lattner, 2007).

SCENARIO

The approach presented in the previous section has been applied to the test scenario sketched in Fig. 2. This scenario and the upcoming test scenario have been created manually for illustration purposes. The first part of the input file (left-hand side in Fig. 2) describes the used parameter for learning. The size of the sliding window (for pattern matching) is set to 12, the minimal frequency is 0.2, and the minimal and maximal pattern sizes are 1 and 4, respectively. The maximal refinement level (number of pattern refinement steps) is set to 20. The sliding window size determines what time window is actually taken into account for pattern matching. The pattern sizes restrict how many predicates can be

added to a temporal pattern. The frequency threshold indicates in how many situations a pattern must occur in order to be regarded as "frequent". The predicate templates section in the input file defines the predicates (and the valid concepts of their parameters) which can be used during mining. The predicate template "destination(vehicle, depot)", for instance, defines that the destination relation can exist among vehicles and depots. Concept and instance information is provided for setting up the concept hierarchy (is-a relation among concepts) and the instance-of relations between objects and concepts. In this scene description, there are definitions of the concepts depot, vehicle, location, and tour (all direct sub concepts of object; the formalism also allows deeper concept hierarchies). The objects v1, v2 etc. are instances of the concept "vehicle".

The actual dynamic scene description is shown on the right-hand side of Fig. 2. The set of holds predicates describe which predicates are valid at what times by providing the start and end times for each relation. The first line represents the fact that there has been high capacity load in depot d1 during the time interval from 5 to 20. This is an alternative representation for the time line as illustrated in Fig. 1. The dynamic scene consists of some repeating combinations of predicates.

<pre> %% % Parameters mitempParam(windowSize, 12). mitempParam(minFrequency, 0.2). mitempParam(minPatternSize, 1). mitempParam(maxPatternSize, 4). mitempParam(maxLevel, 20). %% % Predicate templates predicate(high_capacity_load(depot)). predicate(destination(vehicle,depot)). predicate(break_down(vehicle)). predicate(position(vehicle,location)). predicate(rescheduling(tour)). %% % Concept and instance information isA(depot, object). isA(vehicle, object). isA(location, object). isA(tour, object). directInstanceOf(v1, vehicle). directInstanceOf(v2, vehicle). directInstanceOf(v3, vehicle). directInstanceOf(v4, vehicle). directInstanceOf(v5, vehicle). directInstanceOf(a1, location). directInstanceOf(a2, location). directInstanceOf(a3, location). directInstanceOf(d1, depot). directInstanceOf(d2, depot). directInstanceOf(d3, depot). directInstanceOf(t, tour). </pre>	<pre> %% % Dynamic scene (pattern mining) holds(high_capacity_load(d1), 5, 20). holds(destination(v1,d1), 6, 15). holds(break_down(v1), 8, 14). holds(rescheduling(t), 16, 19). holds(position(v2, a1), 10, 20). holds(position(v3, a3), 8, 18). holds(high_capacity_load(d1), 45, 60). holds(destination(v3,d1), 46, 55). holds(break_down(v3), 48, 54). holds(rescheduling(t), 56, 59). holds(position(v5, a1), 50, 60). holds(capacity_load(d3,high), 48, 58). holds(high_capacity_load(d2),85, 100). holds(destination(v5,d2), 86, 95). holds(break_down(v5), 88, 94). holds(rescheduling(t), 96, 99). holds(break_down(v1), 90, 100). holds(position(v1, a2), 88, 98). holds(high_capacity_load(d2),125,140). holds(destination(v2,d2), 126, 135). holds(break_down(v2), 128, 134). holds(rescheduling(t), 136, 139). holds(capacity_load(d1,low),130, 140). holds(position(v3, a2), 128, 138). holds(high_capacity_load(d3),165,180). holds(destination(v4,d3), 166, 175). holds(break_down(v4), 168, 174). holds(rescheduling(t), 176, 179). holds(break_down(v5), 170, 180). holds(position(v2, a3), 168, 178). </pre>
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Figure 2: Pattern mining input

An implementation of the pattern mining approach (MiTemp; implemented in XSB Prolog (Sagonas et al., 2006)) has been applied to the scenario in order to create frequent patterns and prediction rules. Two examples for prediction rules are shown on the left of Fig. 3. The first prediction rule can be read like this: If there is a precondition with a depot A having high capacity load, a vehicle B with destination A, and a breakdown of B, then it is very likely (for this example even a likelihood of 1.0) that a rescheduling will be necessary later on. There is a set of temporal relations among the different predicates stating that `high_capacity_load(A)` must be older and contemporary with `break_down(B)` etc. This prediction rule (no. 1) is then applied to another dynamic scene example shown on the right-hand side of Fig. 3 in order to test if a general rule has been identified which also applied to situations with other vehicles and depots.

<pre> ... ==== Prediction rule 1: [high_capacity_load(A), destination(B,A), break_down(B)] => [rescheduling(t)] temp(tr([olderContemp],[olderContemp], [olderContemp]),tr([olderContemp], [before]),tr([before])) conceptRestr(depot, vehicle, depot, vehicle, tour) Eval: 0.6779 (f: 0.2674, c: 1.0000, j: 0.1497, s: 1.0000, r: 0.6500, p: 1.0000) ==== Prediction rule 2: [high_capacity_load(A), destination(B,A)] => [break_down(B), rescheduling(C)] temp(tr([olderContemp],[olderContemp], [olderContemp]),tr([olderContemp], [before]),tr([before])) conceptRestr(depot, vehicle, depot, vehicle, tour) Eval: 0.6805 (f: 0.2674, c: 0.9524, j: 0.2631, s: 1.0000, r: 0.6000, p: 1.0000) ==== ... Application of prediction rule 1: Precondition matches at: [i(8,27), i(49,66), i(88,107), i(129,147), i(169,187)] Quality => 1.0000 </pre>	<pre> %% % Dynamic scene (testing) holds(high_capacity_load(d6), 4, 21). holds(destination(v6,d6), 5, 16). holds(break_down(v6), 8, 15). holds(rescheduling(t), 17, 20). holds(position(v10, a5), 13, 16). holds(position(v8, a6), 14, 19). holds(high_capacity_load(d6), 43, 62). holds(destination(v8,d6), 44, 56). holds(break_down(v8), 49, 54). holds(rescheduling(t), 57, 60). holds(position(v7, a5), 53, 61). holds(capacity_load(d5,high), 46, 55). holds(high_capacity_load(d4),84, 101). holds(destination(v10,d4), 87, 96). holds(break_down(v10), 88, 95). holds(rescheduling(t), 97, 100). holds(break_down(v6), 88, 98). holds(position(v6, a4), 87, 96). holds(high_capacity_load(d4),123,142). holds(destination(v7,d4), 127, 136). holds(break_down(v7), 129, 135). holds(rescheduling(t), 138, 140). holds(capacity_load(d6,low),129, 135). holds(position(v8, a4), 127, 134). holds(high_capacity_load(d5),163,181). holds(destination(v9,d5), 166, 177). holds(break_down(v9), 169, 175). holds(rescheduling(t), 178, 179). holds(break_down(v10), 174, 183). holds(position(v7, a6), 167, 179). </pre>
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Figure 3: Prediction rules and test scene

Testing the learned prediction rules on the new scene leads to a set of time intervals where the precondition of the prediction rule is actually satisfied, for instance in the time interval from 8-27 (Fig. 3, bottom left). Within this interval all three predicates are found within a sliding window in the scene and thus it is predicted that a rescheduling is likely to follow. In this test scenario, for all five occurrences of the pattern, the prediction rule has correctly identified the upcoming rescheduling event.

CONCLUSION

In this paper, we have proposed an approach to temporal pattern mining in logistics. The motivation for the identification of patterns is to set up (temporal) prediction rules which might identify critical situations before they occur. The domain of logistics demands a high representational expressiveness due to various types of objects, relations, and the dynamic aspects of scenes. The proposed mining approach can identify frequent pattern from a multi-relational and temporal representation of scenes. In the first step of the mining algorithm, frequent patterns are identified. This is done by a generic-to-specific search starting from the most general pattern and applying different refinement operations. The second step splits the patterns in precondition and consequence parts and computes the confidence of the pattern (i.e., the fraction of occurrences where precondition and consequence appear together).

For illustration, the learning approach has been used to learn prediction rules from a training scenario. One of the created prediction rules has been applied to a test scenario showing that a general prediction rule (independent from concrete instances) could be found. Nevertheless, this is only the first step towards an evaluation of the approach in the logistics domain. For future work, it would be interesting to apply the mining approach to some real-world data and to find out, how identified prediction rules perform on unseen situations.

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APPLICATION OF ADAPTIVE NETWORK BASED FUZZY INFERENCE SYSTEM (ANFIS) IN SYSTEM DYNAMICS MODELLING

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ABSTRACT

System Dynamics Modelling (SDM) is a powerful simulation approach for studying and managing complex feedback systems with a focus on policy analysis and design. SDM has been applied to wide range of problems especially in the area of supply chain and inventory management. SDM often requires a collection of mathematical equations to explain the relationship between variables in a system. However, in some cases, it may not be possible to establish an appropriate mathematical representation especially when the system contains soft variables such as human judgement, which are hard to measure with precise numerical data. This paper describes a methodology to integrate Adaptive Network Based Fuzzy Inference System (ANFIS) with SDM to model soft variables. An example of a system dynamics model was developed in order to test the potential of this integrated model. The results show that the integrated methodology gives better results than the classical SDM.

Keywords: System Dynamics Model, ANFIS, Soft variables, Human Judgement

INTRODUCTION

System Dynamics Modelling (SDM) is a powerful simulation approach for studying and managing complex feedback systems with a focus on policy analysis and design. SDM has its root in industrial dynamics introduced by Forrester in the late 1950s (Forrester, 1961, Forrester, 1958). It was originally favoured for industrial modelling to control engineering and management. However, applications of this method have expanded into cognitive and social psychology, organisation theory, economics, and other social science areas. In industrial application, SDM has been applied to a wide range of problems such as supply chain management (Barlas, 1999, Akkeermans, 1999, Wilson, 2002), inventory management (Winch, 1998, Sterman, 1989, Barlas, 1999, Towill, 1982) etc. However, in practise, one of SDM weaknesses is lack of reliability due to errors in model formulation (Coyle, 2000, Doman, 1995, Martin, 2000).

SDM often requires a collection of mathematical equations to explain the relationship between variables in a supply chain system. However, in some cases, it may not be possible to establish an appropriate mathematical representation (Martin, 2000, Coyle, 2000, Doman, 1995) especially when the system contains soft variables such as human judgement, which are hard to measure with precise numerical data. Therefore, in some cases, the SDM may not produce the right results (Coyle, 2000). Figure 1 shows an example of a soft variable.

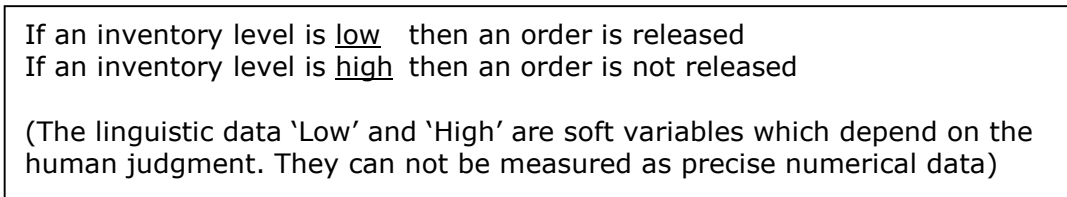


Figure 1: The example of a relation which has soft variables.

This paper describes the methodology to integrate ANFIS as a function approximator to model soft variables in a SDM. In addition, an example of a system dynamics model which includes human judgment was created in order to test the potential of this integrated model.

METHODOLOGY

ANFIS is one of a number of hybrid neuro-fuzzy systems (Nauck, 1997) for function approximation which was created by Jang (Jang, 1993) in 1993. It is a new generation of artificial intelligence which integrates some advantages between fuzzy system and neural networks techniques by combining the parallel computation and learning abilities of neural networks with the knowledge representation and explanation abilities of fuzzy systems. ANFIS can estimate a relation of soft variables in terms of a fuzzy inference system (Figure 2) which can be defined as a process of mapping from given inputs to an output (Negnevitsky, 2002).

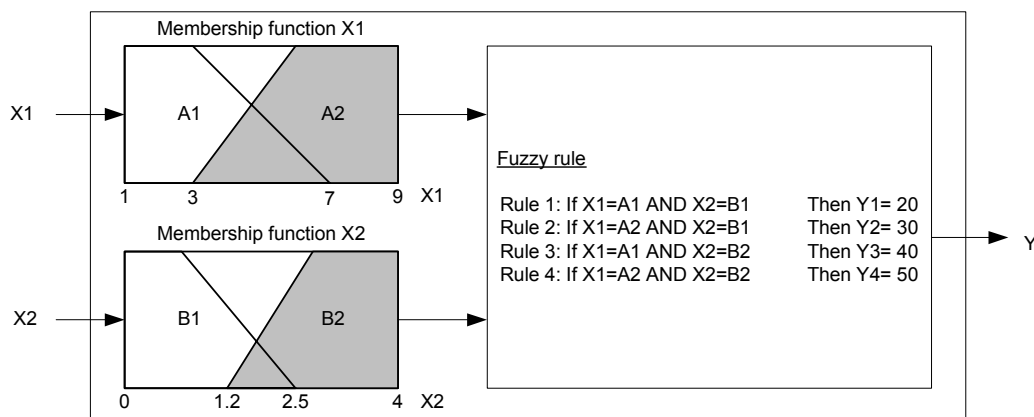


Figure 2: An example of a fuzzy inference system.

In order to create a fuzzy inference system as shown in Figure 2, an appropriate membership function of each input variable and fuzzy rules have to be identified. In a fuzzy inference system, each input variable is assumed as a fuzzy set which is a set with fuzzy boundaries. For example, in Figure 3, X1 composes of two subsets which are A1 and A2. Each point in input space can not be exactly defined into which subset it belongs to. For example, when $X1 = 4$, it belongs to subset A of 0.75 and subset B of 0.4. These degrees depend on a membership function of each subset which is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1. ANFIS can generate a fuzzy inference system by searching appropriate membership functions and fuzzy rules from a given input/output data set (training data) via ANFIS learning process. After identifying appropriate membership functions and fuzzy rules, a

fuzzy inference system consists of three steps for estimating output from given inputs (Figure 3). For example, when input $X1 = 4$ and $X2 = 2$, the output is $Y = 35.98$.

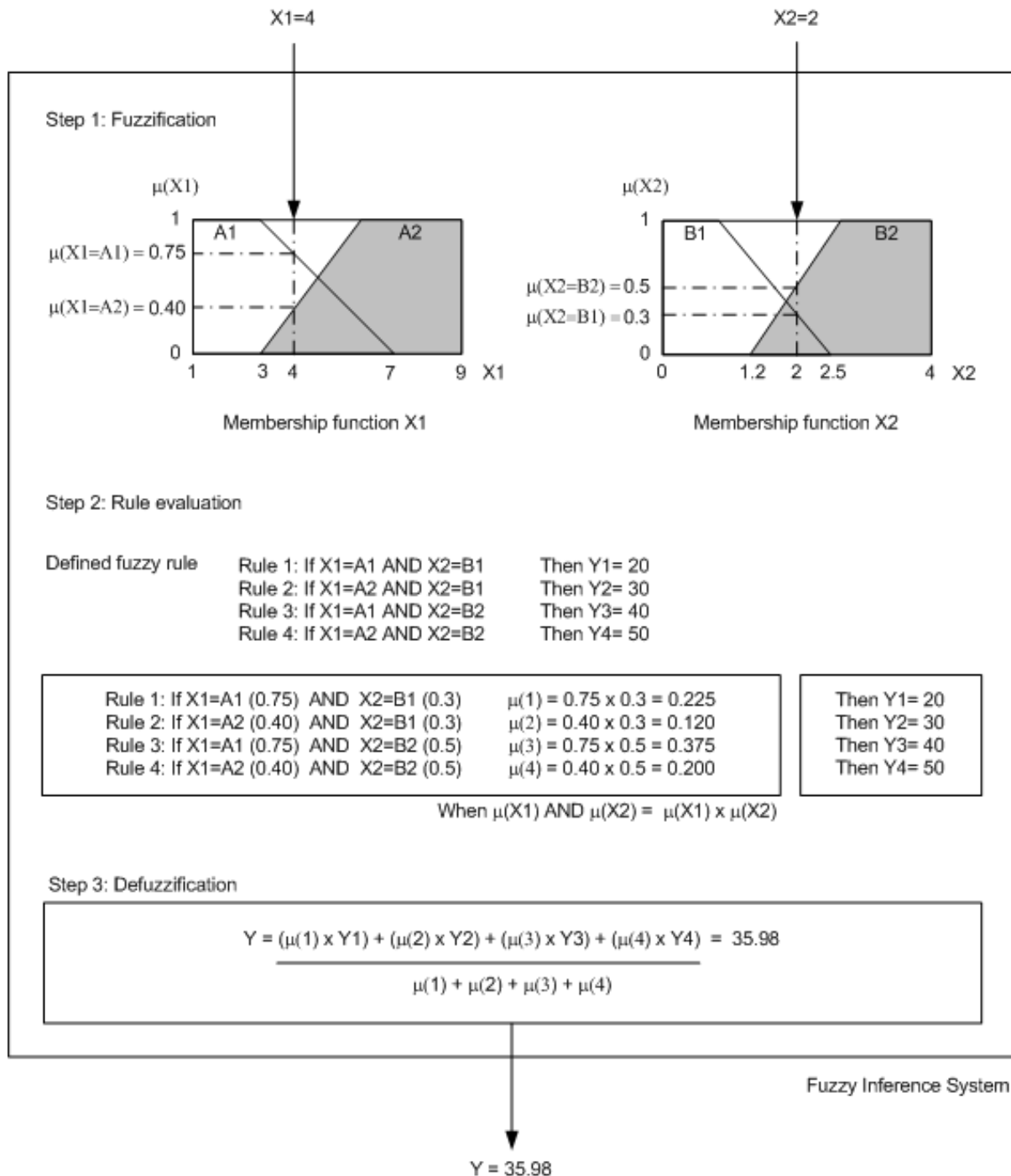


Figure 3: The basic structure of fuzzy inference system created by ANFIS.

The first step, fuzzification, is to take the inputs and determine the degree to which they belong to its subsets via membership functions. For example, input $X1 = 4$ belongs to subset A1 of 0.75 and subset A2 of 0.40. The second step, rule evaluation, is to take the fuzzified inputs, $\mu(X1=A1) = 0.75$, $\mu(X1=A2) = 0.4$, $\mu(X2=B1) = 0.3$ and $\mu(X2=B2) = 0.5$ and apply them to the antecedents of

the defined fuzzy rules. As a result, the conjunctions of the rule antecedents with 'AND' operation are evaluated. For example, the conjunction of the rule antecedent of fuzzy rule 1, $\mu(1)$, is 0.225. The last step in the fuzzy inference system process is defuzzification which quantifies the output Y as a single number using the weighted average equation as shown in Figure 3.

There are two steps to apply an ANFIS for function approximation to model soft variables in a SDM. The first step is to create a fuzzy inference system to explain relation between inputs and output of soft variables. The second step is to change that fuzzy inference system into the form of a mathematical representation which can be used in a SDM.

Step1: Creating a fuzzy inference system by using ANFIS

In order to create a fuzzy inference system, membership functions of input variables and fuzzy rules have to be identified. This research used one of the most popular programming languages – the MATLAB fuzzy logic Toolbox (1998) for creating a fuzzy inference system via ANFIS learning algorithm. There are two basic steps to create a fuzzy inference system (Figure 4) which are 1) setting the architecture of a fuzzy inference system (Initial stage) and 2) generating an optimised fuzzy inference system from a given input/output data set (training data) via ANFIS learning algorithm. Users can learn more about creating a fuzzy inference system based on ANFIS approach by using MATLAB Software from 'Fuzzy logic toolbox: User's guide' (1998).

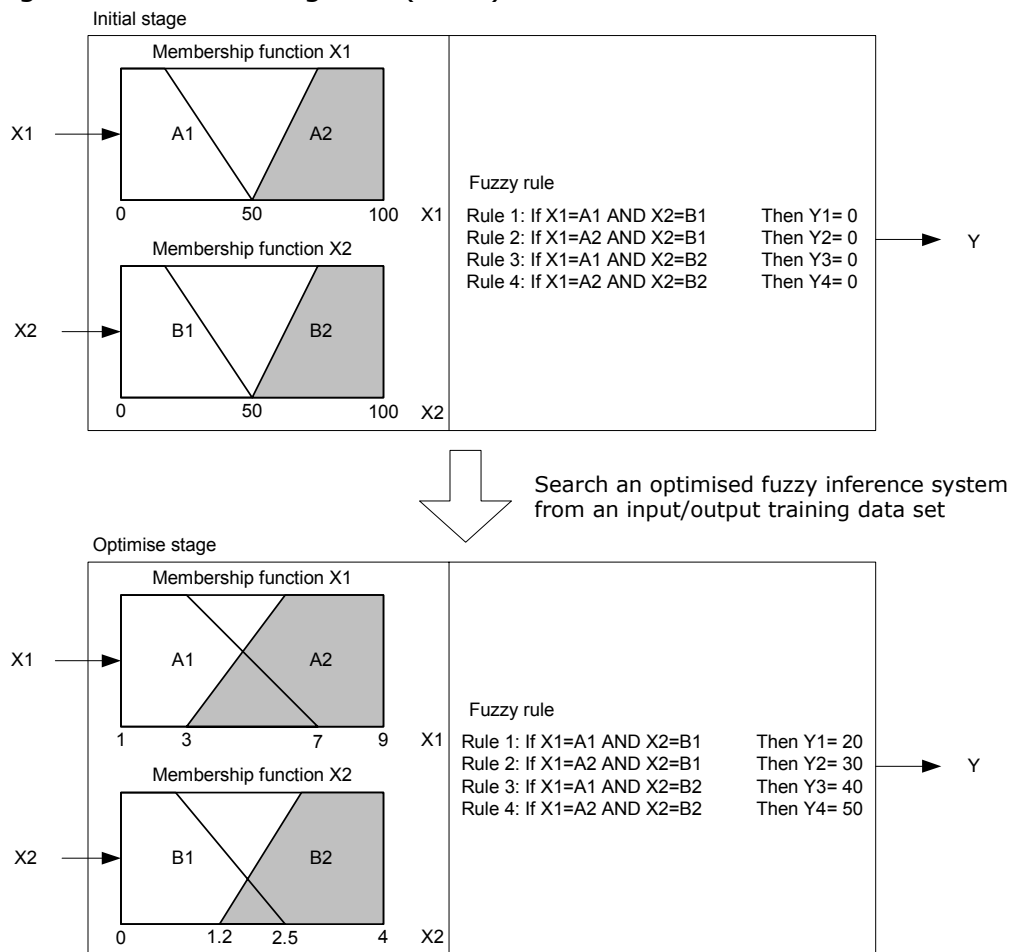


Figure 4: The process to create an optimised fuzzy inference system.

Step 2: Modelling of the fuzzy inference system in a SDM

After an optimised fuzzy inference system is identified by using ANFIS, the next step is to transform this acquired fuzzy inference system into the form of a mathematical representation which can be used in a system dynamics model. There are three steps in a fuzzy inference system process (Figure3) which are fuzzification, rule evaluation and defuzzification. These processes are transformed into mathematical equations which can be modelled in a SDM.

CASE STUDY

A simple system dynamics model including human judgment as shown in Figure 5 was developed to test the potential of implementing an ANFIS in a system dynamics model. This example is aimed to model the number of products in an inventory after removing defects. 'Inventory' in the model is an inventory level which is dependent on the number of products that are inspected by a human ('Inspection rate') and the number of defects ('Defect rate'). The model formulation is shown in Figure 5.

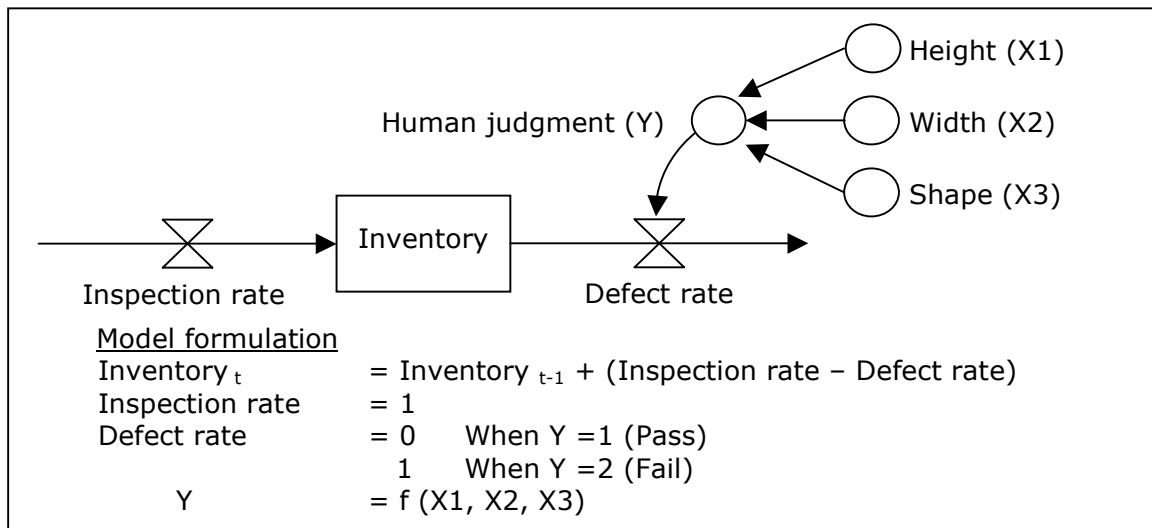


Figure 5: A simple system dynamics model include human decision.

This case study assumes that 'Inspection rate' is 1 unit / time while 'Defect rate' is dependent on human judgment. The example of the product is shown in Figure 6. It includes four commonly found variants of the product: an acceptable product, and three typical rejects relating to the upper surface.

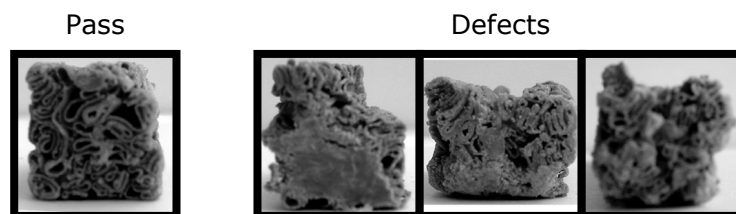


Figure 6: Typical product.

An expert human uses subjective judgment (Figure 7) based on three parameters to detect defects. These are height (X1), width (X2) and shape (X3). Figure 7 shows rules that are used to classify the product. A linguistic data

'Unacceptable' is a soft variable which is dependent on the human judgment. In order to test the potential of implementing ANFIS in a system dynamics model to increase the accuracy to model soft variables, two system dynamics were developed. In the first model, soft variables were modelled by using a classical approach in system dynamics model. Alternatively, in the second model, soft variables were modelled by using the ANFIS approach. This model presented an integrated simulation model between system dynamics and ANFIS. In order to compare performance of the two system dynamics models, two types of error were determined: errors in estimating the soft variable of model ('Y') and errors in modelling output of model ('Inventory').

	If 'Height' is unacceptable	then Output = Fail
Or	If 'Width' is unacceptable	then Output = Fail
Or	If 'Shape' is unacceptable	then Output = Fail
Else	Output = Pass	

Figure 7: Rules that are used to classify the product.

RESULT

Classical SDM approach

SDM provides 'If-Then function' or 'classic logic' to model human judgment. After interviewing an expert, the human judgment to detect defects for this product can be modelled in terms of classic logic as presented in Figure 8.

	If Height < 18 mm. or Height > 19 mm.	then Human decision = Fail (2)
Or	If Width < 18 mm. or Width > 19 mm.	then Human decision = Fail (2)
Or	Shape > 4 mm.	then Human decision = Fail (2)
Else	Human decision = Pass (1)	

Figure 8: Model human judgment by using a classical approach.

Classic logic was applied to this application using a simple range of allowable cross-sections (Height and Width) and surface texture dimensions (Shape) of the product. The difficulty was in incorporating the complex criteria used in human judgment into a simple classic logic decision making system. The use of rigid rules rather than application of a weighting to the various parameters therefore resulted in classic logic only being an approximation of the expert-human classification.

Integrated simulation model

In the second model, the ANFIS approach was applied to model soft variables in a system dynamics model. There are three inputs in this relation which are height (X1), width (X2) and shape (X3). The output is human judgment (Y) which Y = 1 means 'Pass' while Y = 2 means 'Fail'. 160 input/output data was collected as training data to search an optimised fuzzy inference system. The ANFIS uses a hybrid learning algorithm that combines the least-squares estimator and the gradient descent method to generate an optimised fuzzy

inference system. Then this fuzzy inference system is changed into the form of a mathematical representation which can be used in the proposed simulation model. These equations will be used to identify the variable 'Y' in a system dynamics model.

Simulation error

In order to compare the accuracy of the pure system dynamics model and the integrated simulation model, 80 testing data were created, using a different set of human judgments (Y) and measured parameter (X1, X2, and X3) data. Two types of error were determined: errors in estimating a soft variable of model (Y) and errors in modelling output of model (Inventory).

• *Error in estimating a soft variable of model (Y)*

Error in estimating the human judgment (Y) which is a soft variable was determined by comparing the percent error (%error) as shown in Equation 1.

$$\%error = \left(\frac{N_E \times 100}{N} \right) \tag{1}$$

Where N_E = The number of incorrect estimation
 N = The number of testing data

Table 1 shows the '%error' of the pure system dynamics model and the integrated simulation model between system dynamics model and ANFIS. The errors are 16.25% and 1.25% respectively. The results show that implementing ANFIS in a system dynamics model can increase accuracy for estimating a soft variable 'Y'.

Model	Simulation		%error
	The number of testing data	The number of incorrect estimation	
A classical SDM	80	13	16.25%
An integrated simulation model	80	1	1.25%

Table 1: Estimation for soft variables of model.

• *Error in modelling output of model (Inventory)*

In order to compare accuracy for estimating a model output (Inventory) between the pure system dynamics model and the integrated simulation, the actual level of inventory at time = 80 is collected. The error in this case can be measured by using an equation as shown in Equation 2.

$$Error(\%) = \frac{|A - S|}{A} \times 100 \tag{2}$$

Where A = Actual data
 S = Simulation result

Model	Inventory (Y) at t = 80		Error (%)
	Actual data	Simulation result	
A classical SDM	20	7	65%
An integrated simulation model	20	21	5%

Table 2: Estimating output for the model.

Table 2 shows the error for modelling 'Inventory' which is the model output of a pure system dynamics model and the integrated simulation model between system dynamics model and ANFIS. At time = 80, the actual number of products in the inventory should be 20 units. However, the results of the classical SDM and integrated simulation model are 7 units (the error is 65%) and 21 units (the error is 5%) respectively. The results show that the integrated simulation model between SDM and ANFIS gives a more reliable result.

CONCLUSION

The errors of variable estimation affect the reliability of behaviour of SDM. The results show that ANFIS can significantly increase accuracy for estimating soft variables in a SDM (Table 1). Consequently, the output for the model is more reliable (Table 2). Therefore, ANFIS may be a better approach to model a fuzzy condition relation, such as human judgment in a supply chain environment. Using this method, the error of estimation for a soft variable was decreased and the overall behaviour of the SDM was more reliable than using a classical SDM.

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THE CLUSTERING OF PRODUCTS TO IMPROVE FORECAST ACCURACY

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SUMMARY

Several methods of clustering (or classifying) product components in the electronics industry were examined, with a view to improving methods of forecasting demand. Raw demand data were converted to time series and examined for trends/patterns. Several exponential smoothing forecasting methods and measures of forecasting efficiency were used. The products were ranked according to their efficiency for each forecast method for each cluster; certain patterns were found, indicating when the forecasting approaches used are useful ones.

KEYWORDS: Forecast, accuracy, clustering, exponential smoothing, efficiency

INTRODUCTION

Supply chains are diverse in nature, ranging from high value, made to order items, to low value, commodity items; this complicates demand forecasting. This research examines the effect of how similarities among product items enable one better to forecast demand for them as a group. Clustering is the grouping together of items according to a criterion or criteria of similarity. The resulting product classification can then aid in the design of focused supply chains: in which "simplicity, repetition, experience and homogeneity of tasks breed competence" (Skinner, 1974). This has been treated in the literature, e.g., (Childerhouse et al, 2002), (Caniato et al, 2005). This paper addresses four research questions:

1. How accurate are exponential smoothing methods when forecasting short term demand? Which method is best?
2. Does the choice of efficiency measure affect forecast accuracy?
3. Does the choice of time step affect forecast accuracy?
4. Does the clustering of products when forecasting affect forecast accuracy?

In conjunction with an industrial partner, Company A, who provided Point of Sale (POS) data for 57 products over a 2 year period, a detailed analysis was carried out to examine if there was any improvement in forecast accuracy when clustering of products was applied.

LITERATURE REVIEW

Model based studies have shown that forecast sharing can improve supply chain performance (Thonemann, 2002), (Frohlich and Westbrook, 2001). (Lee et al, 2000) have shown that manufacturers can obtain reduced inventory and costs by sharing information. (Lee et al, 1997) show that demand variability can be amplified upstream when accurate forecasts are not shared with suppliers. The value of information sharing can also be significantly influenced by the demand

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patterns (Zhao et al, 2002): where demand is predictable, sharing of information does not lead to large performance improvements, but the opposite is true when demand is unpredictable. In many supply chains, the most important action that can now be taken to improve the efficiency and effectiveness of the logistics process is to improve the quality of the demand forecasts (MIT, 2003).

Clustering has rich history in diverse areas such as biology, psychology, psychiatry, archaeology, geology, geography and marketing (Jain et al., 1999). Fisher & Rajaram (2000) adopted a cluster-based methodology for accurate testing of fashion merchandise. The merchandising testing process clusters stores based on the similarity of the sales mix, which is highly variable. This approach performs significantly better than alternative methods used in retail practice, based on standard statistical approaches or on clustering by store descriptor variables. The impact on cost of the superior performance was enough to double a retailer's profits. Zotteri et al. (2005) propose a forecasting process that introduces new aggregation dimensions based on a clustering methodology that can improve forecasting accuracy when compared with traditional approaches. The clustering approach groups demand data for customers according to their degree of similarity rather than on the basis of other features such as region, or size of the location. The researchers deduce that if it is possible to group together customers who show similar demand patterns over time, it is then possible to forecast demand only for the most representative customer in the cluster to gain an evaluation for the overall cluster's demand, thus increasing information efficiency. However, it remains unclear as to when this approach is most effective. Caniato et al. (2005) try to resolve this issue by applying the aforementioned clustering approach to effectively forecast irregular demand and balance the trade-off between accuracy and cost. Their research implies that while the clustering approach benefits forecasting accuracy when variability is due to structural (e.g. seasonality) and/or managerial (e.g. promotions) causes, it actually deteriorates for random (e.g. unpredictable) variability. Kalchschmidt et al. (2006) then analysed customers in three different cases and capitalised on their heterogeneity by clustering them according to their demand patterns, in order to develop the most effective forecasting approach for that cluster. They concluded that forecasting performance can significantly improve through application of this technique. Expanding on the work of Childerhouse et al. (2002), Phelan and McGarraghy (2006) applied clustering techniques to product components in the telecommunications industry and found that clustering according to certain criteria could aid in forecasting in some circumstances, while other clustering criteria were less useful. They examined clustering criteria such as volume per unit time, cost, sales, position in lifecycle and product specific criteria when examining time series data.

EXPERIMENTAL DESIGN

TIME HORIZONS AND FORECAST ACCURACY

One of the fundamental principles of forecasting, as highlighted in texts by Armstrong (1985); Armstrong (2001); and Makridakis et al. (1998) is that there is a negative relationship between the forecasting horizon or time step (TS) and forecast accuracy. A firm's one month ahead forecasts are likely to be more accurate than its one year ahead forecasts. This fundamental relationship in forecasting is supported by empirical evidence from the M-Competition

(Makridakis et al., 1982), the M-2 Competition (Makridakis et al., 1993) and the M-3 Competition (Makridakis & Hibon, 2000). The forecasting horizon also corresponds to the delivery lead time of the supply channel. This is important because little attention has been paid to lead time effects on forecast accuracy. Given the characteristic of long lead times in an industry such as electronics, it is vital that organisations are aware that long lead times increase the forecast horizon, thus reducing forecast accuracy (Andries & Gelders, 1995).

FORECASTING METHOD SELECTION

A set of forecasting methods was chosen for this research building on the work of Phelan and McGarraghy (2006). Simple exponential smoothing (SES) was used because it is one of the most commonly used forecasting techniques (Makridakis et al., 1998). Adaptive-response-rate single exponential smoothing (ARR) was included because it allows for changes in the pattern of the data (Makridakis et al., 1998). Holt's linear exponential smoothing (HOLT) was included because of its ability to accommodate a linear trend in the data (Holt, 1957). Croston's simple exponential smoothing (Croston, 1972) (CTN) was included because of its ability to handle intermittent data. These four methods are limited to stationary, intermittent & linear demand which may result in reduced accuracy (Gardner, 1985). No provision was made for seasonality due to the short life cycle of the products.

EFFICIENCY MEASURE SELECTION

Both the mean of the squared errors (MSE) and mean absolute error (MAE) are scale dependent measures. MSE was selected because of: its utility when comparing different methods on the same set of data (Hyndman & Koehler, 2005); and its mathematical simplicity (Makridakis et al., 1998). MAE on the other hand was selected because of its interpretability for managerial decision making (Makridakis et al., 1998). However, Armstrong & Collopy (1992) highlight their poor reliability and validity. For instance MSE should not be used when making comparisons across data sets that have different scales.

The mean absolute percentage error (MAPE), a measure based on percentage error, was used because: it is the most commonly used measure (Mentzer & Kahn, 1995); it is scale independent, i.e. it can be used to compare forecast performance across different data sets (Hyndman & Koehler, 2005); and it is a reasonably reliable and valid measure (Armstrong & Collopy, 1992). However, there has also been criticism of use of the MAPE as it places a heavier penalty on positive errors than on negative errors (Hyndman & Koehler, 2005) and favours low forecasts (Armstrong, 2001).

Theil's U-statistic, a relative measure, was used because: it considers both the disproportionate cost of large errors and provides a relative basis for comparison with naïve methods (Makridakis, et al., 1998); and it is relatively easy to interpret (Ahlburg, 1992; Hyndman & Koehler, 2005).

CLUSTERING CRITERIA SELECTION

There were a number of factors that influenced the selection of the clustering criteria that were used. Childerhouse et al. (2002) provided general clustering criteria such as volume, sales, cost and position in lifecycle. Phelan and McGarraghy (2006) provided further research in this area and examined product

specific clustering criteria. For this research the clusters were restricted by the “richness” of the Point of Sale (POS) data on offer. It was essential that the data could be decomposed into appropriate cluster bands that were of practical relevance to Company A to support decision making. This condition limited the choice of company specific clusters available.

Volume per unit time (Volume cluster) was selected because the data sets were volumes demanded over time, or POS data. It was very relevant to Company A because of strategic importance associated with the classification of SKU’s depending on the volume of demand. Also, the volume demand was effectively used for clustering in research by Childerhouse et al. (2002), Zotteri et al. (2005), Caniato et al. (2005) and Kalchschmidt et al. (2006).

Cost was selected because of the capability of the data and also its strategic importance to Company A in that the forecast accuracy of higher cost products is given higher priority.

Company A uses innovative design principles of postponement to avoid excessive inventory. Product postponement is used extensively. The firm designs the product so that it can delay its customisation, often by using standardised components. Three further company specific clusters were selected because of their strategic importance to Company A’s postponement policies and the nature of the data.

CLUSTER ANALYSIS

The items were clustered according to a common characteristic or clustering criterion. The clusters were then analysed as a group to determine which forecasting method was the most accurate when each of the efficiency measures were applied, for each of the four time steps. Every forecasting method was then assigned a score (S) depending on its performance for each of the efficiency measures, where each had an equal weighting. The scores for each method were calculated by summing the number of times a method was the optimum one relative to the other three for each efficiency measure (n_{MSE} , n_{MAE} , n_{MAPE} and $n_{TheilsU}$), which was then divided by the number of products in each cluster (n_{pc}) times 4 (to account for the number of efficiency measures).

$$S = \frac{[n_{MSE} + n_{MAE} + n_{MAPE} + n_{TheilsU}]}{n_{pc} \times 4}$$

This process facilitated the researchers’ determination of the ‘most accurate’ forecasting method for each cluster for each time step, when those four efficiency measures were used. When two methods were recommended for one cluster, i.e., the cluster analysis could not establish an optimal method as each method scored the same, second place rankings were considered and a new score was calculated and the necessary adjustments were made.

EVALUATION AND COMPARISON

The actual efficiency of the forecasts was computed via four measures, namely MSE, MAE, MAPE and Theil’s U statistic. The results were averaged across 57 time series to give an overall result. The relative performance of each forecast was computed via a rank performance system whereby each forecast was ranked in ascending order from 1 to n , where n is the number of forecasts to be ranked,

for every efficiency measure. These scores were then averaged to give the forecasts their average rank performance. The absolute accuracy of the various methods is not as important as how well these methods perform relative to some benchmark (Makridakis & Hibon, 2000).

RELATIVE ACCURACY OF FORECASTING METHODS

SES was shown to be very robust under a variety of conditions such as varying time step, efficiency measure and cluster as advocated by Gardner (1985).

Although a large proportion of the data sets were found to have trends, HOLT was consistently the worst performing method on average for all efficiency measures. As HOLT is appropriate for forecasting demand with linear trends, it is highly likely that the trends in the data in this research were curvilinear; and methods such as Gardner and McKenzie's (1985) damped additive trend, Pegels' (1969) multiplicative trend, and Taylor's (2003) damped multiplicative trend may have been more suited.

CTN performed well for intermittent demand when it was compared to SES in research conducted by Willemain et al. (1994) and Chatfield & Hayya (2007). However, CTN average rank performance here was behind that of SES and ARR, even when only intermittent data sets were considered for analysis. This relatively poor performance may be somewhat explained by the initialisation parameters set for CTN. CTN only initialised when there were three or more zero values in a data set. In hindsight, perhaps an intermittent pattern in a data set should be defined when a certain percentage of the data set is a zero, instead of a predefined number of values which can be easily absorbed by a large data set.

FORECAST ACCURACY AND CHOICE OF EFFICIENCY MEASURE

A similar positive trend was experienced by Armstrong & Collopy (1992) when they examined the reliability of error measures across time step. They used RMSE, MdAPE, MAPE, GMRAE, MdRAE and Percent Better as opposed to the MSE, MAE, MAPE and Theil U that were used in this research; and the time steps they used were quarterly vs. annually. The reliability of all the measures increased as the time step was increased in both studies, with the exception of the MAPE in Armstrong & Collopy (1992). Overall, the reliability findings in this research serve to strengthen those found by Armstrong & Collopy (1992), as the positive trend here was established using different measures across independent data sets.

FORECAST ACCURACY AND TIME STEP INVOLVED

The findings that the average MSE of SES, HOLT and ARR increased as the time step increased was analogous to those in the M-Competitions (Makridakis et al., 1982). However, the forecasting horizons used in the M-Competitions started at one month and increased on a monthly basis with a sequence of 1, 2, 3, 4, 5, 6, 8, 12, 15, and 18. This differed to the time step sequential increase used in this research of 3 days, 7 days, 14 days and 28 days. Nonetheless, a positive trend was experienced in both cases. However, the finding that the average MAPE decreased as the time step increased was contrary to those of Makridakis et al., (1982) where the MAPE increased as the time step increased.

The accuracy of the various exponential smoothing methods depends on the length of the forecasting horizon or time step involved. This finding is echoed in

the M-Competition (Makridakis et al., 1982), the M-2 Competition (Makridakis et al., 1993) and the M-3 Competition (Makridakis & Hibon, 2000).

FORECAST ACCURACY AND CLUSTERING DEMAND ITEMS

When forecasting demand, the clustering of products with similar characteristics such as demand patterns, cost and company specific product mix can improve accuracy. These findings support those of Fisher and Rajaram (2000), Zotteri et al. (2005), Caniato et al. (2005) and Kalchschmidt et al. (2006) regarding clustering and improved forecasting performance. However previous studies only used demand patterns when clustering.

CONCLUSIONS

We express our conclusions by revisiting our four research questions:

How accurate are exponential smoothing methods when forecasting short term demand? And which method is best?

Overall, SES was the best for the 3 day time step while ARR was the best for the 28 day time step. ARR relative performance improved as the time step increased, as did SES (though SES did not improve to the same extent). While many of the data sets contained trends, HOLT performed poorly. This may indicate that there were relatively few linear trends and that other methods tailored to pick up curvilinear trends such as damped or exponential may have been more accurate. Also, CTN performed relatively well on intermittent data sets; however, it did not outperform SES.

- The accuracy of a forecasting method can depend on how well the model fits with patterns in the data.
- The actual efficiency of the forecast method increased in utility to the forecaster when it was compared with the other methods in order to determine which one performed best.
- Relative accuracy is more important than absolute accuracy when comparing forecasts.
- This conclusion is similar to the contention of Makridakis et al. (2000).

Does the choice of efficiency measure affect forecast accuracy?

The reliability and construct validity of the measures were examined by calculating the average Spearman correlations and pairwise Spearman correlations for the measures, and this analysis found large variations depending on what measures are used.

- The choice of an efficiency measure can affect conclusions about the relative accuracy of forecasting methods.
- This conclusion is similar to that of Armstrong & Collopy (1992).

Does the choice of time step affect forecast accuracy?

Overall, actual efficiency of SES, HOLT and ARR decreased as time step increased for all measures. CTN efficiency increased but this was attributed to bias in the experiment design.

- The accuracy of a forecasting method depends on the time step involved.
- This conclusion is analogous to that reached in the M-Competition (Makridakis et al., 1982), the M-2 Competition (Makridakis et al., 1993) and the M-3 Competition (Makridakis & Hibon, 2000).

Does the clustering of products for forecasting affect forecast accuracy?

Overall, the clustering methodology indirectly improved forecast accuracy relative to the single methods. Specifically, the clustering of products enables forecasters to select the optimum method, efficiency measure and time step, each of which directly impacts forecast accuracy. The performance of each cluster varied dramatically across the different time step durations; hence, the study was inconclusive in determining the single best cluster.

The selection of forecasting method, time step and measure of efficiency can all have an effect on forecast accuracy. A clustering methodology can aid in the selection of forecasting method, time step, and efficiency measure, and thus improve forecast accuracy. Practically, the clustering concept provides forecasters with a method to determine the most appropriate forecasting procedures for a particular situation, and thus it aids in the implementation of the demand management process.

There are a number of limitations to this research:

- The number of forecasting methods examined in the experiment was limited to four exponential smoothing methods
- The number of efficiency measures examined was limited to four
- The number of clusters examined was limited to five: Volume, Cost and three product specific clusters
- The experiment examined four different time steps: 3, 7, 14 & 28 days
- The number of time series examined was limited to 57
- The selection of the sample of 57 time series was a non-random process and thus the findings are not generalisable to the population

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COUPLING OF ERP-SYSTEMS WITH SIMULATION TOOLS: A FLEXIBLE COMMUNICATION CONCEPT SUPPORTING DECISION MAKING IN LOGISTICS PLANNING AND CONTROL

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ABSTRACT

The logistics planning and control process is affected by the co-existence of various decision making approaches. Typically, these approaches are based on computerised systems for supporting decision making in planning and execution of logistics activities. Focusing on this kind of integrative planning the paper reverts to a flexible communication concept based on the web service technology which couples standard simulation software with ERP-systems. On this, architecture and processes of an interconnected ERP simulation environment are described. This approach provides a possible solution for operations in heterogeneous and distributed IT-environments, and makes a contribution to the designing of decision support systems (DSS) for production and logistics planning activities. The set-up of a first prototype is introduced visualising the practical implications.

INTRODUCTION

Today's enterprise resource planning systems (ERP-systems) are highly integrated systems stemming from their corporate structure. They ensure the observance and control of resources and provide the transactional tracking of information from any part of a company and its supply chain [1]. In order to fulfil these functions, most ERP-systems offer a range of methods and parameterisations of common processes to choose from (e.g., best practice solutions, specific branch solutions).

Considering the amount of methods for reference processes and data models, there is a high variance of planning procedures within a company. This can result in a gap between the requirements of a company and the system features. Parameter variations of, for example, operation times, set-up times or machine availability can lead to situations in which the ERP planning cannot manage the high amount of changed model items. Additionally, external variables, such as fluctuations in customer demand volume and change requests, affect the supply chain as well. These parameters are typically extracted from the process flow in the form of average values, most likely to be done by the owner of the process, based on historical data and experience. The combined application of standard methods and static and imprecise parameterisation tends to result in a risk of overspending of valuable resources [2].

As introduced, ERP-systems are integrated online transaction processing systems (OLTP-systems). Primarily, the objective is to automate transaction processes, and accordingly to increase efficiency in processing operating data. At the same time, companies need to increase individual and organisational decision making effectiveness [3].

In this context, various types of decision support systems (DSS) focusing on this objective can be specified. Some DSS alternatives use simulation methods in order to support decision making for planning and controlling purposes, leading to additional value. In particular, discrete event driven simulation can help decision makers to evaluate how performance is affected if the system is modified [4]. Simulation is described as a well-established, useful, descriptive and mathematics-based method for extracting knowledge from complex decision making situations [5]. Moreover, the combination of simulation methods with optimisation methods in an iterative way is seen as a promising field of study [6, 7].

Combining ERP-systems as the information distributors, with standard simulation software for extracting knowledge forming the major components of a DSS, arises from the need for data with higher excellence and seems a worthwhile endeavour [8]. This method enables on-demand situation analysis without depending on individual and difficult to exchange software modules. In the following approach, a DSS architecture is developed by coupling ERP-systems with a simulation environment. DSS architecture and DSS workflow structure are explained by means of an application study including a first prototype.

Common events of enterprise processes, like production planning and scheduling, are often affected by fast changing information. To maximise its benefit, the DSS data base, extracted from the ERP-system and used by the simulation tool, has to be up-to-date. To manually offset this necessity incurs high costs in money and in time of maintaining. For the automation of updating the DSS data base, two kinds of methods can be used.

On the one hand, custom-built DSS components from particular companies can be integrated into the environment of the ERP-system. These ERP extensions are usually based on highly specialised, inaccessible program code for maintaining and updating. This kind of integration offers the DSS direct access to the data base. Additionally, the user gains benefit in usability as an effect of the, in common cases unchanged, user interface. Overall, a highly integrated and specialised user-friendly DSS component, tied to a particular company is provided.

On the other hand, the market offers different standard simulation tools, which include interfaces for data exchange. Using these interfaces provides for more flexibility in coupling different ERP-system to the simulation and an easy adoption towards new requirements. Insertion of standard simulation tools commonly produces user interfaces of various kinds. Compared with the custom-built ERP extensions, this solution is less user-friendly but opens up a wide range for access of current data while being less bound to a particular company.

Combining the advantages of both approaches, the developed prototype is based on open standards for the communication and the user interface. An adaptable DSS is designed, coupling amenable standard simulation tools and ERP-systems.

RELATION TO EXISTING WORK

In the context of this paper, DSS, simulation techniques and specific IT technologies form the relevant research background. Referring to the initial work of Alter [9] on decision support systems and further refined by Power [10] different categories of DSS can be classified. Important categories which are also relevant for the purpose of this paper are:

- Communications-Driven DSS: support participatory decision making and dispersed team work emphasising communication and collaboration processes and techniques.
- Data-Driven DSS: are based on computerised systems helping decision makers using very large databases of business data.
- Document-Driven DSS: developed for decision makers to gather, retrieve, classify and analyse non-structured documents.
- Knowledge-Driven DSS: are based on specific problem solving expertise using business rules and knowledge bases.
- Model-Driven DSS: are built on heuristics and optimisation models and can be characterised as not usually data intensive.
- Web-Based and inter-organisational DSS: are implemented using Web technologies and support decision making in the entire supply chain

The presented concept supporting decision making in logistics planning and control has communication-driven, data-driven, model-driven and web-based characteristics. Communication-driven characteristics result from the interconnection of different ERP-systems to the DSS. Data-driven aspects result from transferring and processing ERP data to the DSS and from the feedback loop transfer from the DSS to the ERP-system.

With respect to the embedded simulation model the DSS can also be described as *model-driven*. Simulation techniques enable decision makers to have access to a representation of the decision making situation as it runs through different scenarios. Running the models offer the opportunity to observe how the process is likely to operate. In this context, visual interactive models (VIM) [11], as a part of DSS, can be seen as a promising area.

The research community of data warehousing thoroughly investigated concepts of coupling to OLTP systems (see for instance [12]). Data warehouses are an approach to support online analytical processing (OLAP). OLAP systems provide data analysis by means of statistical methods. A decoupling from OLTP systems is essential for OLAP, since huge amounts of data have to be interpreted. In this respect, these systems are similar to simulation tools. The main difference is the way in which the data is extrapolated. OLAP aggregates data to key figures, whereas simulation takes decisions and considers their consequences. Coupling between OLTP and OLAP is known as ETL: extracting, transforming and loading. However, the main focus of research work in this field considers direct access to the OLTP databases and extraction of data from there, while this paper discusses indirect access over the application level.

To ensure that the coupling of ERP-systems with standard simulation software can be fulfilled, the web service technology is used for the realisation of the interconnections [13, 14]. The presentation of the user information is taken over by a modern and flexible asynchronous JavaScript and XML (AJAX)-based web framework. The application of modern information technologies and software design concepts allows for an open and highly integrative DSS approach.

APPROACH

This paper refers to the research project “Modelling of Business Networks” [15] and documents the results of coupling ERP-systems with standard simulation software, focusing on the logistics planning and control process. This enables a design and realisation of a software tool focusing on business management reasons, ensuring that the outcome fit the business needs. The combination of these techniques – delivering live data from the ERP and simulating the output – is discussed in the literature as the so-called “digital factory” [16].

As Figure 1 below shows, the basic architecture consists of three software components: ERP, control centre and simulation. In our prototype the components are represented by the SAP R/3 ERP-system [17], the ZK framework [18] as the web-based tool for the control centre and Plant Simulation as the discrete event driven standard simulation tool [19].

The components are linked by two different XML-based communication technologies [20]. ERP and the control centre are connected by web service technology. This technique offers an approach independent from programming language to enable communication inside heterogeneous system environments using the XML-based simple object access protocol (SOAP).

The second communication interface is realised between the control centre and the simulation tool. In order to simplify the communication between these components, the concept used is based on a simple XML document. As a consequence, web service technology is often not supported by standard simulation tools. This approach then increases the chance of coupling these tools with the control centre.

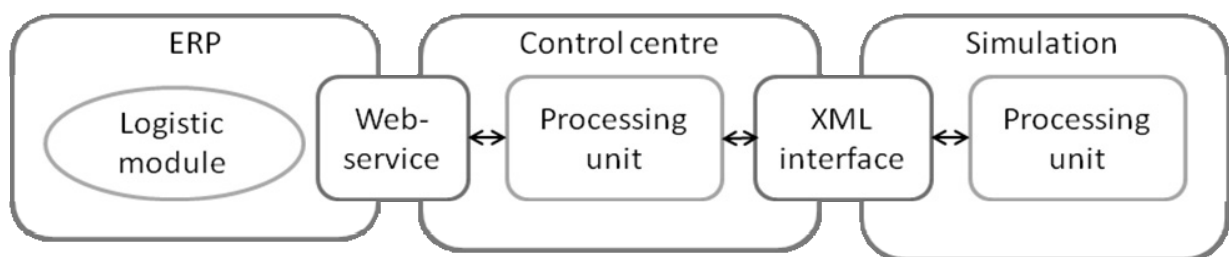


Figure 1: basic architecture

Arranged between the familiar software components, the ERP-system and the simulation tool, the control centre manages the communication flow between the individual components. The processing logic used for extracting data from an XML file is embedded between the software parts as processing unit. The applied web-based technology for the control centre enables the execution of the DSS by

every client with an installed web browser, and is, as a fact of using AJAX technology, indistinguishable from normal desktop solutions, whose design can be adapted to the used ERP-system.

The illustrated basic communication concept is realised as a prototype and represents the DSS. As an addition to these functions, the communication concept offers the possibility to expand the involved ERP-systems as shown in Figure 2. Thus, for instance, a combined simulation of a complete supply chain is possible.

This procedure, which couples different partners with different ERP-systems, needs to implement a role-based concept for the control centre with multiple views. This also offers the option to protect classified data.

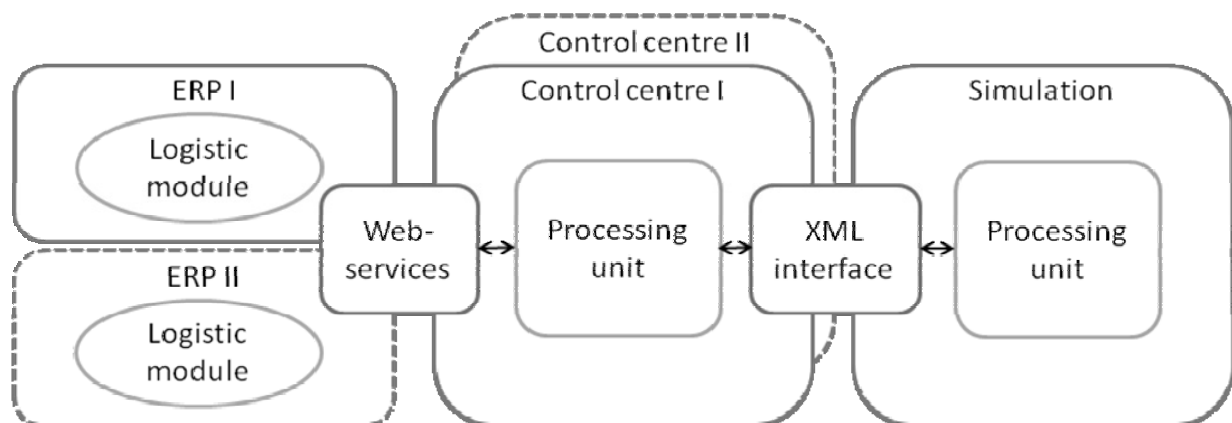


Figure 2: extended architecture

Control centre I could be a sophisticated planning view, represented by detailed information, and extended by the option of taking influence on the behaviour of the system by evaluating the actual data and adjusting influencing parameters.

Control centre II could be a simple view for salespeople providing the simulation outcome at a higher aggregation level. The users have no further options to either influence the data or get access to the detailed information. Other facets could be about testing and controlling a production line or information for customer about changed completion date. If needed, the number of views can easily be extended.

CONCLUSIONS AND FUTURE RESEARCH

The simulation replicates real time situations by processing the data it receives from the ERP-system. This enables the user to test the potential outcome. In the context of logistics planning and control, the coupling of ERP-systems and simulation tools is a promising combination in terms of more efficient planning. For example, the simulation allows testing of alternative scenarios (worst case, best case, most likely) based on current data supplied by the ERP-system(s). This consideration of uncertainty is expected to improve forecast accuracy. Other potentials are cost reductions achieved through better capacity utilisation and reductions of changeover costs, to name but two.

This approach shows also that coupling any web service capable ERP-system to standard simulation software is not only a possibility, but even a competitive alternative compared to specialised simulation software bound to ERP-systems. In comparison, the presented architecture is easy to handle regarding connectivity and extensibility. Another important fact is the increase in transparency for the involved supply chain partners; this may also be one of the main obstacles in case of lack of trust between the partners. Further risks are posed by general limitations of simulation techniques, security problems, investment needs and running costs.

From the authors' perspective, challenges for future research activities are extensions of the existing approach towards the integration of further ERP environments. Regarding the multitude of different systems, this is also an essential matter for practical solutions. The web service architecture furthermore enables distributed planning and simulation. The planning functions of ERP could be used for partial decisions based on local data and the simulation system for overall global decision support. With respect to changes in organisational structures and processes affecting the mapped supply chain, the dynamic model adaptation of the simulation model is also identified as a fruitful research field.

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SOLVING BUS CREW SCHEDULING PROBLEM: A CONSTRAINT-BASED APPROACH

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ABSTRACT

This paper aims to solve a bus crew scheduling problem. The problem is normally constrained by several complex operational constraints such as crew preferences, crew satisfaction, work-shift, etc. These constraints are considered fully in the proposed model. A constrained local search is applied to solve this problem with an objective to minimize the total operating cost. The algorithm is tested with the real data set from three bus lines of a bus company in Bangkok with around 120 crews. The computational results show that around 20 percent of the existing crews can be reduced. The operating costs can be decreased significantly while a higher level of crew satisfaction can be achieved.

Keywords: Bus crew scheduling, Constrained local search

INTRODUCTION

Bus crew scheduling involves an assignment of a number of staff to different scheduled bus services. The problem is normally constrained by a number of operational and practical constraints. Based on an example of a bus line operation in Bangkok, the bus and crew scheduling are carried out separately few months prior to its operations. Prior to bus crew scheduling, job timeslots for each bus line on each day are normally determined as shown in Figure 1.

Morning shift			Afternoon shift			Night shift		
No.	Start	End	No.	Start	End	No.	Start	End
1	03:25	11:25	1	12:10	20:10	1	18:30	02:30
2	03:40	11:40	2	12:20	20:20	2	19:30	03:30
3	04:00	12:00	3	12:30	20:30	.		
.			.			.		
.			.			.		
<i>N</i>	05:25	13:25		14:10	22:10			

Fig. 1: Example of job timeslots

In Fig. 1, there are three shifts for job timeslots: morning, afternoon, and night shifts. Note that different shifts may be assigned with different sign-in/sign-off times for the crews. In this Bangkok example, each crew will have to work for around eight standard working hours per day. The crews can then be assigned

different patterns of the shifts over a week or several weeks as illustrated in Fig. 2.

Code	Name	Lot	Job timeslot		Break (B)	Fri	Sat	Sun	.	Fri
			Start	End		1	2	3	.	29
425102	Crew 1	1	03:25	11:25	Sun	11	8	B	.	18
432099	Crew 2	2	03:40	11:40	Sat	12	B	6	.	1
439224	Crew 3	3	04:00	12:00	Fri	B	10	7	.	2
.										
N										

Fig. 2: Example of shift allocation for crews

After the crew shift schedule is determined, the bus schedule can be defined separately as show in Figure 3 (Vanitchakornpong et al. 2008). Given the bus service schedule, the crew schedules can then be created accordingly.

No.	Job	Line	Bus Code	Service Type
1	04:25 - 05:00	4	4-44089	Air conditioned
2	04:10 - 05:40	134	4-80227	Normal
3	04:20 - 05:20	4	4-40451	Normal
4	04:25 - 05:35	205	4-44086	Air conditioned
.				
N				

Fig. 3: Scheduled jobs

In this paper, we focus on developing a flexible algorithm for the crew scheduling problem (CSP). The objective is to minimize the total operating costs while satisfying several operational constraints. The paper is organized as follows: the next section reviews the literature on bus crew scheduling problem, and the formulation of CSP is described afterwards. The following two sections address the solution algorithm for CSP and present the test results from the case study of the Bangkok bus company. The conclusions and possible further research issues are discussed in the last section.

LITERATURE REVIEW

CSP has been a challenging optimization problem over decades. Several transit crew scheduling systems were developed during 1970 – 1980, such as TRACS, RUCUS, and OPTIBUS (Wren and Rousseau, 1993). These systems employed heuristic methods to solve the CPS and have been adopted in several countries, such as England, Australia, and Hong Kong. The significant reductions in crew operating costs were reported by the transit companies.

Beasley and Cao (1996) proposed a solution algorithm based on the tree search structure to solve CSP. In their algorithm, the subgradient method based on the Lagrangean relaxation is used to increase the efficiency of the lower bound. This algorithm was tested with a general CSP with around 50-500 crew jobs. Peters *et al.* (2007) developed a hybrid GRASP and Branch-and-price method to solve a bus crew scheduling problem in India. Santos and Mateus (2007) proposed another hybrid algorithm to solve a bus crew scheduling

problem in Brazil. They applied column generation method together with GRASP and genetic algorithm to solve the problem.

The application of artificial intelligence systems was also applied to solve CSP. Ftulis *et al.* (1998) applied the expert system to crew scheduling problems. Operational constraints were formulated as the expert-rules to search for the solution and to efficiently reduce the area of potential search space. Shibghatullah *et al.* (2006) proposed an agent-oriented system to solve dynamic CSP. The dynamic scenario addressed varying traffic conditions and the availability of the crews in case that they do not follow the assigned timetables.

The bus and crew scheduling problems may be integrated and solved simultaneously. However, the advantage of the integrated approach depends largely on characteristics of the problem and current operational procedure of bus companies. Freling *et al.* (2003) compared the sequential and integrated bus and crew scheduling models (VCSP). Valouxis and Housos (2002) applied a quick shift heuristic (QS) together with column generation (CG) to solve the VCSP with a case study in Greece. Mesquita and Paias (2007) developed the algorithm to tackle VCSP benchmark proposed by Huisman *et al.* (2005). Rodrigues *et al.* (2006) combined the integer linear program (ILP) and heuristics to solve the VCSP from a case study in Brazil.

From the application point of view, our proposed crew scheduling algorithm is relatively similar to the previous works mentioned earlier in which the algorithms were developed to the large size CSP. However, each of these algorithms was constructed to suit with different conditions of the case studies. Therefore, the main contribution of this paper is the development of model and algorithm to solve CSP with a specific bus operational pattern in Bangkok; in particular, we consider soft constraints which involve crew's duty preference, skilled lines, and duty spread-over. A constrained local search approach is employed to optimize the crew schedules.

PROBLEM FORMULATION

Many crew scheduling approaches solve crew pairing and crew rostering sequentially to reduce the complexity of the problem. However, crew pairing and rostering in this paper are considered simultaneously. The main reason is that crew re-scheduling process can be easily maintained when the actual operations deviate from the planned schedules. The CSP is formulated as a set partitioning-type model as shown in Fig. 4.

Timetable trips			L1		L2	
			K11	K12	K21	K22
			c1	c2	c3	c4
L1	K11	8:00	1	0	0	0
L2	K21	8:15	0	0	1	0
L1	K12	8:30	0	1	0	0
L2	K22	8:35	0	0	0	1
L1	K13	9:00	1	0	0	0

Fig. 4: Set partitioning model

Fig. 4, there are five jobs for this timetable trips with two different service lines: *L1* and *L2*. For instance, bus *K11* departs the depot at 8:00 and bus *K12* departs at 8:30. *c1*, *c2*, *c3* and *c4* represent crew members. *c1* and *c2* are dedicated to

$L1$, and $c3$ and $c4$ for $L2$. $c1$ prefers to work with $K11$ for some personal reason. To facilitate the discussion, the following notations are used:

$L = \{1, \dots, l\}$: set of bus lines

$W = \{1, \dots, w\}$: set of jobs

$W'_l = \{1, \dots, w_l\}$: set of jobs for line l

$M = \{1, \dots, m\}$: set of crews (drivers)

$M'_l = \{1, \dots, m_l\}$: set of crews for line l

$O_i = \{1, \dots, o_i\}$: set of assigned jobs for crew i in ascending order

m : the number of crews i

Q_i : maximum jobs for crew i

c_{ij} : duty operating cost for crew i serving job j

$x_{ij} = 1$ if crew i serve job j ; 0 otherwise

$n_i = 1$ if crew i is chosen, i.e. $\sum_{j \in W} x_{ij} > 0$; 0 otherwise

e_{ij} : starting time of crew i serving job j

t_{ij} : working time of crew i serving job j

s_l : the number of crews serving line l

$\{a_i, b_i\}$: crew i start job at time a and finish job at time b

Hard constraints

In our case study, there is a crew pair (driver and toll collector) taking on a single bus. However, we only consider the assignment of bus drivers. The toll collector can be manually pre-assigned to each driver to reduce the size of the problem and to satisfy personal relationship of crew pairs. The hard constraints in the model are:

$$h_p = \max\left(0, \sum_{j \in W} \left| \sum_{i \in M} x_{ij} - 1 \right| \right) \quad (1)$$

Constraint (1) states that job j is exactly served by one crew. h_p is the hard violation for this partitioning constraints.

$$h_e = \sum_{i \in M} \left[\max\left(0, \sum_{j \in O_i} [(e_{i,j-1} + t_{i,j-1}) - e_{ij}]\right) \right] \quad (2)$$

Constraint (2) ensures that crew can only carry out the next job after completing the previous job.

$$h_a = \sum_{i \in M} \left[\max\left(0, \sum_{j \in O_i} (a_i - e_{ij})\right) \right] \quad (3)$$

Constraint (3) ensures that crew executes job after the starting time (a) of pre-specified job timeslots.

$$h_b = \sum_{i \in M} \left[\max\left(0, \sum_{j \in O_i} (e_{ij} - b_i)\right) \right] \quad (4)$$

Constraint (4) ensures that crew cannot start working after the ending time (b) of pre-specified job timeslots.

$$h_q = \sum_{i \in M} \left[\max \left(0, \sum_{j \in W} x_{ij} - Q_i \right) \right] \quad (5)$$

Constraint (5) ensures that jobs for crew must not exceed the maximum jobs.

Soft constraints

Soft constraints represent objective functions of the problem. The soft violation, v is used to assess the quality of the planned schedules.

$$v_n = \sum_{i \in M} (\max(0, n_i)) \quad (6)$$

Equation (6) is the violation for crew (bus driver) cost of the planned schedules.

$$v_c = \max \left(0, \sum_{j \in W} \sum_{i \in M} c_{ij} x_{ij} \right) \quad (7)$$

Equation (7) is the violation for the duty operating cost.

$$v_v = \max \left(0, \sum_{j \in W} \sum_{i \in M} v_{ij} x_{ij} \right) \quad (8)$$

Equation (8) is the violation for the priority bus assignment; v_{ij} is a violation penalty for priority bus if crew i is assigned to job j

$$v_p = \max \left(0, \sum_{j \in W} \sum_{i \in M} p_{ij} x_{ij} \right) \quad (9)$$

Equation (9) is the violation for the priority line assignment; p_{ij} is a violation penalty for priority line if crew i is assigned to job j

$$v_b = \sum_{i \in M} [\max(0, t_{io} - b_i)] \quad (10)$$

Equation (10) is the violation for over time cost that exceeds the standard working hours, e.g. 8 hours a day.

$$v_a = \max \left(0, \sum_{i \in M} |(avg - k_i)| \right) \quad (11)$$

Equation (11) is the violation for duty spread-over in which working hours (or jobs) should equally be assigned to each crew; avg is the average working hours

of crews, i.e. $avg = \left(\sum_{i \in M} b_i - a_i \right) / m$, and k_i is the actual working hours of crew i

From (1) to (5), the hard constraint violation can be defined as $H = h_p + h_e + h_a + h_b + h_q$, as well as the soft violation, $S = v_n + v_c + v_v + v_p + v_b + v_a$ (Eq. (6) – (11)). Therefore, the total constraint violation is $V = H + S$.

SOLUTION METHODS

In this paper, we apply the constrained local search to solve the bus crew scheduling problem as follows:

Sequencing feasible jobs

Since crew and bus scheduling is independent, and is planned sequentially, we can pre-assign the starting time of crew jobs in ascending order, i.e. $e'_{j-1} < e'_j$; $\forall j \in W$ where e'_j is the starting time of job j

Constrained local search

A constrained local search (CLS) was first proposed by Indra-Payoong, *et al.* (2005) and was applied to solve a number of complex transport and logistics problems. Recently, Vanitchakornpong, *et al.* (2008) have applied CLS for solving bus fleet scheduling problem. The procedure of CLS can be summarized into three steps:

- *Step 1: Constraint selection.* After the initial assignment for all variables in the model, the number of columns (represent crews) are randomly selected in accordance with the violated constraints (columns, $H > 0$) are given the priority.
- *Step 2: Variable selection.* The algorithm selects the row (represent crew jobs) that its value equal to 1 (i.e. a crew is assigned to job). Then, this algorithm performs a trial flip with other variables in the same row as illustrated in Fig. 5.

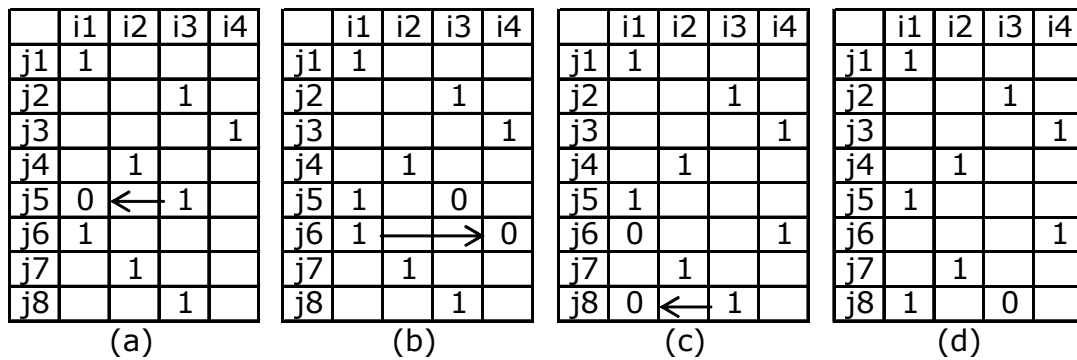


Fig. 5: Trial flip operations

Fig. 5 (a) shows the trial flip process, the crew $i3$ is randomly selected. After that, in the same row ($j5$), crew $i1$ is randomly chosen as a trial flip pair. Fig. 5 (b, c, d) show the similar trial flip process for different jobs.

- *Step 3: Move acceptance.* CLS chooses the best V amongst the flipped variables in every single iteration, and assigns the best V to the current solution.

COMPUTATIONAL EXPERIMENTS

We assess the proposed model and algorithm for the CSP based on the data from the Bangkok bus company (BMTA). The soft constraints in the model can be categorized as: i) pre-specified constraint, ii) crew preference, and iii) schedule cost, as shown in Table 1.

No.	Soft constraints	Violation
Pre-specified		
A-1	Crew pair	0
A-2	#Break	0
A-3	Break day	0
A-4	Shift type	0
A-5	Sign-in/Sign-off time	0
Crew preference		
B-1	Priority bus	5
B-2	Priority line (4 levels)	0,5,15,30
B-3	Duty spreadover	1
Schedule cost		
C-1	#Crew	500
C-2	Duty operating cost (DOC)/min	1.05
C-3	Overtime (OT)/min	5

Table 1: Soft violation scheme

From Table 1, the soft constraints in the pre-specified type will not definitely be violated. This is simply because crew pair, #break, break day, shift type, and sign-in/sign-off time are pre-assigned and not included as decision variables in the model. This represents the actual operational practice and limits the size of the search space. The soft constraints for crew preference include the priority bus, priority line, and duty spread-over. The violation for the priority line is determined as four levels: 0, 5, 15, and 30 respectively, i.e. the zero violation represents the highest crew preference. The violation schemes for crew preference depend on the policy of each bus company.

The constraint violations for the schedule cost include crew cost, duty operating cost (DOC), and overtime cost, which can be specified directly from the operational costs spent. We illustrate the efficiency of the optimized crew schedules in terms of the key performance indices (KPI) as shown in Table 2. BMTA can test on different soft violation schemes in order to evaluate the efficiency of the schedules.

Scheduling Plan	KPI
Crews	25
Line (s)	1
Trips	72
Preference	
> Priority bus	330
> Priority line	0
> Duty spreadover	1548
Operations	
> Idle time (hh:mm)	110:00
> Actual time (hh:mm)	66:55
> Extra time (hh:mm)	0:10
Cost (Baht)	
> Duty	11,057.29
> Overtime	10.42

Table 2: Crew scheduling KPI

We also compare the results obtained from the proposed model with the current schedules which are defined manually by the experts in the filed. For an arbitrarily chosen case, the existing 120 crews are dedicated to the three bus lines as shown in Table 3. A computerized schedule with a single line scenario can cut off 36 (30%) unnecessary crews. Note also that even 10% of crews is included additional as redundancy crew, the reduction in terms of the crew number is still significant.

To evaluate the performance of the proposed algorithm and to analyze crew schedules with multi-skilled line scenarios (2-Line and 3-Line), we further test on the same data set as shown in Table 3. A value in the parenthesis indicates the standard deviation of the results from 10 different runs. The computational run-time is also given in the Table (in seconds).

Scenario	Trips	#Crew	Preference			Cost		Time (sec)
			1	2	3	OT	DOC	
Current		120						
Single Line	253	84	1235 (86)	0 (0)	4836 (67.76)	957 (13.46)	38,024 (160.52)	19.218
2-Line	253	84	1255 (44)	840 (8.57)	4904 (50.53)	618 (13.63)	38,305 (132.31)	29.781
3-Line	253	82	1255 (52)	2490 (20.26)	3922 (34.76)	577 (11.33)	37,726 (105.38)	39.421
	Saving (%)	2.38				39.72	0.78	

Table 3: Multi-skilled policy (test for 10 runs)

The results in Table 3 show that there is a slightly improvement in terms of crews and the operating costs (OT and DOC). This is because the number of crew jobs is minimized and fixed as priori during the bus scheduling process. Therefore, the rotation of the crews for multiple lines may not be necessary.

CONCLUSIONS

This paper applied CLS approach to bus crew scheduling problem. The additional soft constraints including bus priority, skilled lines, and duty spread-over, which are unavoidable in real world are fully considered. The computational experiments based on the BMTA data showed that the number of crews and the operating costs can be saved significantly by the computerized crew schedules with a fast computational run-time. However, like other heuristics, CLS cannot guarantee the optimality of the solution found. Note that the optimized crew schedules may not directly reflect the company policy on its actual operations. Thus, it is necessary that the schedule should be tested with several soft violation schemes so as to select the most appropriate crew schedule.

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SECTION 6

INVENTORY MANAGEMENT

MANAGING THE INVENTORY SYSTEM IN A HOSPITAL SUPPLY CHAIN

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ABSTRACT

The paper presents a case study of applying logistics and supply chain management in service sector. One of the biggest state-owned hospitals in Thailand is selected. We begin the study with business process analysis (BPA) focusing on information system and inventory management. It is found that there is a problem in managing medicine stock system. The problem occurs at the medicine storeroom in each hospital ward, medicine central warehouse and the hospital purchasing department.

At present, the pharmacy at each ward's medicine storeroom uses their own experiences to set the reorder point for replenishing the medicine stock. Again, at the central medicine warehouse, the warehouse supervisor uses the "MSale" value, which is weighted average using all history data, to set the reorder point for each medicine. The results show that the patients' real demand is not used for stock replenishment at each ward including the medicine central warehouse. Furthermore, the MSale cannot reflect the end demand and this reorder point is inaccurate. Here we propose a new inventory system to calculate the MSale value. Also the linkage between the medicine storeroom and the central warehouse for reflecting patients end demand through information technology will be presented.

Keywords: logistics and supply chain, inventory management, health sector

INTRODUCTION

Logistics management has become a competitive tool for enhancing system efficiency and customer satisfactions in many businesses and industries in Thailand. However it is mostly interpreted and applied in the environment of transportation and exports. In author's previous work, we have adapted logistics concepts together with supply chain management in industries such as textile, rubber and SMEs. It is found that implementing logistics in the order fulfillment process results in lead time reduction and higher customer satisfactions.

Thailand, one of the speedy growing manufacturing countries, also has good reputations in service industry. Having a number of high standard hospitals, we aim to become a medical hub in the region. In this study an attempt was made to apply logistics concept to this sector. First of all, we recognize some similarities between industrial sector and service sector. In the industry supply chain, we see the core system as input, process and output. Then material flow and information flow are analysed. Likewise, we attempt to identify the input, process and output in the hospital supply chain. However, unlike the production process in industry, there are a number of chains crossing one another in a hospital. We then need to select one essential chain to study in depth. One of the

significant input material flows in the hospital is medicine. It circulates across functions in hospital. Also, the information of this flow also needs to be distributed among functions in the chain.

The study takes place in one of the biggest state-owned hospitals. To understand the current situations in the chain, an interviewing phase is necessary. The purpose of this step is to gather information from an individual who possesses expertise considered important to both order process mapping and technology analytical effort. The primary data gain in this research come from an in-depth semi-structured interview in the medicine storeroom in each hospital ward, medicine central warehouse and the hospital purchasing department. Then, to explicitly illustrate the flow of this supply chain, it is necessary to demonstrate the current situation of business process. This is called the AS-IS model business process mapping. This model describes information exchange and decision making in all processes in supply chain. The business process model consists of material and product flow (Physical Flows) and information for material management (Information Flows). The business process mapping tool used in this study is the Integration Definition (IDEF0) methodology (Feldmann, 1995). It was initially intended for the use in systems engineering. The IDEF methodology provides a disciplined way of graphically describing the detailed structure of processes and how they relate to one another. Then the problems can be found and the proposed system is recommended.

LITERATURE REVIEW

Healthcare enterprises involve complex processes that span diverse groups and organizations (Anyanwu et al, 2003). Anyanwu et al (2003) states that the processes involve clinical and administrative tasks, large volumes of data and large numbers of patients and personnel. The tasks in the enterprises are supported by a variety of software applications and information systems. The idea is supported by DeScioli (2005). He studies in depth in hospital supply chain. He is convinced that a hospital needs to implement more than one supply chain policy in order to achieve its objective of maximizing patient care while avoiding prohibitive costs. Litvak and Long (2000) also proposes an idea of systemwide analysis for healthcare business. He indicates that to achieve maximal cost effectiveness in healthcare, we must understand the complete dynamics of patient interaction with all components of the delivery system and their mutual interdependencies. Also, a report from FPMA (2007) believes that key business processes are usually supported by a series of essential system and technology infrastructures. Also inventory and safety stocks are a key factor in healthcare supply chain disruption.

Among those papers convincing the complexity in healthcare supply chain, Jansen-Vullers and Reijers (2005) believe that business process redesign is frequently applied to optimize business processes. Solutions can be found by using Coloured Petri net which is another approached based on redesign heuristic. In their paper, case study in a mental healthcare institute has been considered by using CPN to model and simulate business process. However, they conclude that result from CPN model is too complex and is hard for the end-user to understand. Beyond the business process modeling, Litvak and Long (2000) points out that in healthcare industry, one should consider decision making area. They identify the difficulties in technically measure the cost and quality consequences of most healthcare management decisions. DeScioli (2005) gives an example of apply s, Q inventory policy to fit product and supply chain policy

implemented within the hospital. He finally concludes that “one-size-fits-all” strategies are inappropriate in a hospital a supply chain enhancement.

From the literature in supply chain healthcare businesses, we found that applying business process analysis in hospital supply chain is promising. A modeling approach is needed. Also, area for technical decision making must be explored. A management decision support system should be developed. Here in this paper, we then propose a way to explore hospital supply chain by business process modeling using IDEF0. Then a problem is found at a decision making area – inventory. A new policy for inventory management for this case study is proposed.

FINDINGS

Current system

First of all, to understand logistics flow of medicine in the hospital, interviews are conducted. The questions are to investigate how medicine are flown and managed. The study found that medicine and its information are flown across three major functions in the hospital. Theses are medicine storeroom in each ward, medicine central warehouse and the purchasing department.

When medicines are delivered by suppliers, it is sent to the central warehouse. The warehouse checks against purchasing order and store these medicines in its storeroom. Then the warehouse distributed medicines to each ward storeroom according to the requests. Figure 1 shows medicine distribution system in the hospital.

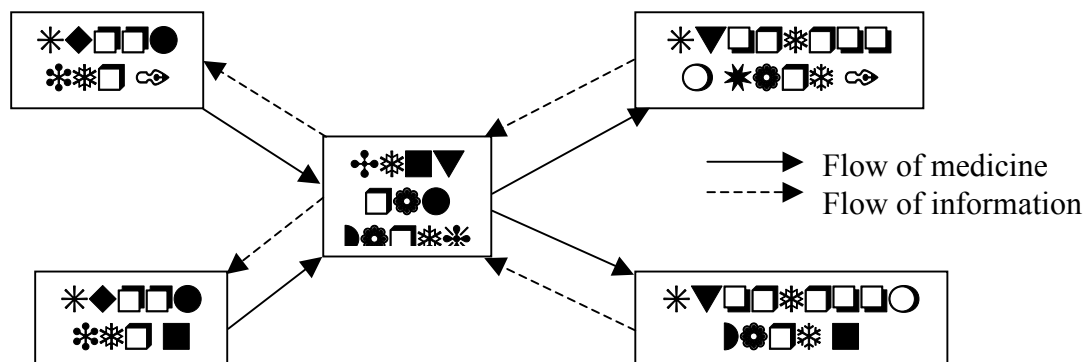


Figure 1: Medicine distribution system in the hospital.

The medicine requisition from each ward to central warehouse is defined by each storeroom’s pharmacist. The pharmacist defines the quantity of each medicine type to replenish the stock in each ward by their own experience. This depends upon level of stock left in each storeroom and other conditions such as seasonal diseases, emergency request, new government regulations, etc. The pharmacist places this demand order to the warehouse everyday at 9 am. The warehouse collects all this requests and supplies this amount to each ward daily without knowing the stock level in each storeroom. The warehouse also uses this amount placed by the pharmacists to calculate the reorder point level in the central warehouse. The weighted demand average using all historical data is set as “Msale” value. The Msale is updated each month. When stock is less than 70% of this MSale, the warehouse will place a request to the purchasing department to replenish the stock up to 100-150% of the value.

Business process analysis

The current system is then modeled by IDEF0. The IDEF0 (Integration Definition for Function Modeling) is a method designed to model the decisions, actions, and activities of an organization or system. The "box and arrow" graphics of an IDEF0 diagram show the function as a box and the interfaces to or from the function as arrows entering or leaving the box. To express functions, boxes operate simultaneously with other boxes, with the interface arrows "constraining" when and how operations are triggered and controlled (Feldmann, 1995).

The objective of using IDEF0 in this study is to illustrate the flow of material and information of the medicine supply chain. Figure 2 shows the relationship of activities of medicine supply chain in the hospital.

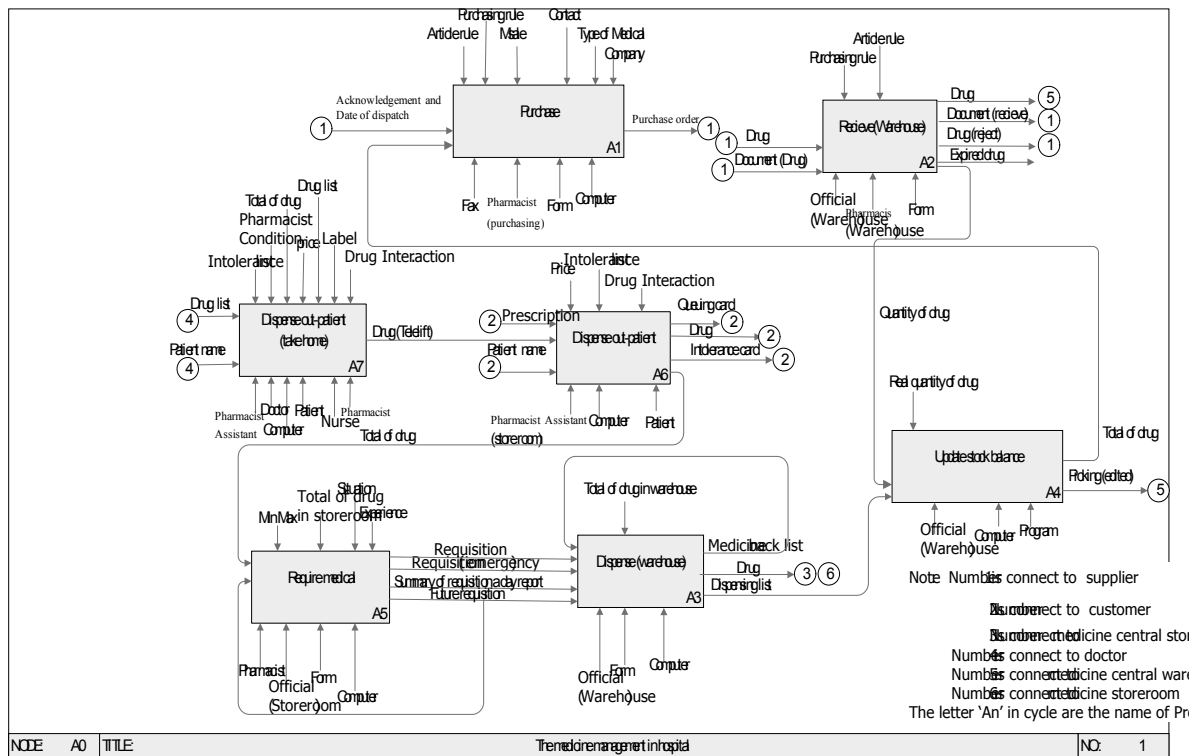


Figure 2: IDEF0 of medicine supply chain in the hospital

From the figure above, in A5 activity, the amount of medicine requested come from the amount of patient uses. However the level of requisition placed to the warehouse is controlled by minimum and maximum level set by pharmacist in each storeroom. This is then sent to the central warehouse daily. The central warehouse in A3 receives the amount requests and updates stock record in A4 by consider amount of total medicine in the warehouse and amount requested together with amount receive from supplier in A2.

From the IDEF0 above, it can be seen that the information flow in this medicine supply chain is obviously one-way communication. It is evidenced that the only information that the warehouse receives is the request form from each ward. The central warehouse has no chance to see the patients' end demand and each ward's stock level. As a result, the stock updating information is not the supply chain stock in the whole system. It is merely the stock in the central warehouse. This results in mislead calculation of the stock reorder point. This again affects the accurate order amount supply to patients' demand.

where N is number of days the warehouse would like to stock for and y_0 is on-hand inventory. Note that N should be less than the medicine’s shelf-life, otherwise; medicine will be wasted.

Type II: Demand has no trend but high variability.

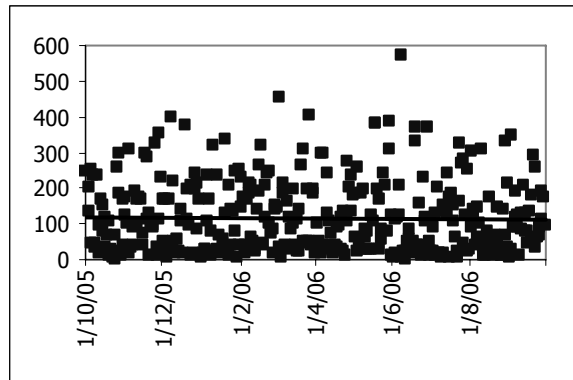


Figure 4: Type II demand.

In this case the demand variability is quit high. The reorder point r should depend on not only lead-time and mean demand but variance of demand as well. Thus, r can be found from

$$\Pr(D_L \leq r) \leq 1 - \alpha$$

where $1 - \alpha$ is a service-level and D_L is total demand during lead-time with mean $\mu(L+1)$ and standard deviation $\sigma\sqrt{L+1}$. The order quantity Q can be found from

$$Q = \text{Max} \left\{ \left\lceil \frac{\mu N + S - y_0}{\text{units per box}} \right\rceil, \text{min. order} \right\} - r.$$

Type III: Demand has trend with high variability.

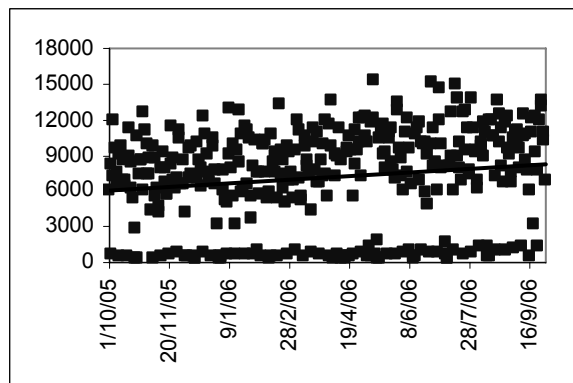


Figure 5: Omeprazole demand.

The solid line in Figure 5 is the trend of type III demand. In fact Type III demand can be either increased or decreased. In this case we use the linear regression method to approximate future demand say $f(x)$ which is in the form of $ax + b$. The reorder point r can be found from the following equation:

$$\Pr(D_L \leq r) \leq 1 - \alpha$$

where D_L is future demand during lead-time with mean $\sum_{i=M}^{M+L} f(x_i)$ and variance $(L+1)\text{MSE}$ obtained from linear regression result.

$$\Pr(D_N + \sum_{i=M}^{M+N} f(x_i) \leq Y) \leq 1 - \alpha$$

and the order quantity Q can be obtained from

$$Q = \text{Max} \left\{ \left\lceil \frac{Y + S - y_o}{\text{units per box}} \right\rceil, \text{min. order} \right\} - r .$$

NUMERICAL RESULTS

In the following we compare our proposed to the current policy in the medical central warehouse. Let $M = 45$, $L = 10$ days. We consider Tuberculin as a representation of the demand of Type I, Dormicum and Losec for Type II and Omeprazole and Pariet for Type III.

Policy	No of Orders	Total Quan.	Average Inventory	Percentage
Current	7	480	45	
Proposed	3	105	25	44.44%

Table 1: Type I demand results.

	Policy	No. of Orders	Avg. Inventory	Percentage.	Safety Stock
DORM	Current	5	12685		45 days
	Proposed	5	8739	31.11%	90 days
		6	7419	41.51%	75 days
		7	6694	47.23%	70 days
		8	6122.11	51.74%	60 days
		11	4933.616	61.11%	45 days
LOSC	Current	11	4207		45 days
	Proposed	9	3660	13.00%	60 days
		10	3381	19.63%	55 days
		11	3205	23.82%	52 days
		12	2933	30.28%	50 days
		14	2720.126	35.34%	45 days

Table 2: Type II demand results.

	Policy	No. of Orders	Avg. Inventory	Percentage.
OMPZ	Current	25	113532	
	Proposed	24	102459	9.75%
		26	94112	17.11%
		28	91219	19.65%
PARI	Current	18	5293	
	Proposed	18	4409	16.70%
		19	4184	20.95%
		20	3955	25.28%

Table 3: Type III demand results.

From Table 1, our policy reduces 44.44% of the inventory on average with 3 times orders for Tuberculin, Type I demand. Safety Stock in Table 2 is the value of N determined by the warehouse. If the number of orders is fixed, then our policy

yields the higher value of N with the lower average inventory. For the same value of N, our policy indicates that the warehouse is overstocked. As a result, average inventory can be reduced by 61.11% and 35.34% for Dormicum and Losec respectively. The results of Omeprazole and Pariet are shown in **Error! Reference source not found.** The demand of Omprazole is quite large and the price of Pariet is very high, the central warehouse has trouble with the area of stocking these two items. As a result we suggest that the safety stock for these two items in should be only for 30 days. Our policy yields the similar number of orderings as using the current policy. In addition, the results show that the average inventory can be reduced from 9.75% to 25.51%.

DISCUSSIONS AND CONCLUSION

In this paper, we apply the concept of supply chain and logistics management in service industry- hospital. The missing link in the chain is found between each ward's storeroom and the central warehouse. The IDEF0 model evidences the problem in calculating the MSale. The MSale value comes from the medicine requisition form from the pharmacist in each ward, rather than patients' end demand. The reorder point is then based on moving average value. The pattern of real demand is not taken into account. We then propose a new policy for managing inventory in the medical central warehouse and perform a case study in this case. We compare the current policy with our proposed policy. We analyze 1-year demand data and found that there are three types of demand: no trend with small variability, no trend with large variability, and trend with variability. In our policy we proposed three different methods to calculate reorder points and order quantity corresponding to each type of demand. Our results indicate that the proposed policy can reduce the average inventory for all types of demand varied from 9.75% to 61.11%. However, our findings come with limitations. In our formula we assume that the lead-time is deterministic. It would be interesting to consider the stochastic lead-time with bounded. Moreover, more data is needed to make any further conclusions.

Furthermore, in this paper we only propose a solution to deal with the MSale value. This is particularly to solve the inventory problem found from the business process analysis. The IDEF0 model also illustrates the problem of information system. The linkage of information flow between the storeroom in each ward and the central warehouse will be developed in our further research. This is to link the stock database between these two focal points. This will enable the central warehouse to see the stock at each ward. Then the forecasting model for reorder point inventory will become more accurate.

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AN INTEGRATED THREE-ECHELON SUPPLY CHAIN INVENTORY MODEL WITH COMPENSATION POLICY FOR DETERIORATING ITEMS

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ABSTRACT

This paper develops a mathematical inventory model of deterioration item to take into account a vertical integration for three-echelon supply chain (one supplier, one distributor, and one retailer) through strategic alliance to share cost. The mathematical model describes how an integrated approach to decision making can achieve a global optimum as compared to individual models (independent model, supplier's perspective model and retailer's perspective model). The objective of this model is to minimize the joint total relevant cost and to devise a compensation policy for the integrated inventory model. A simple but efficient heuristic technique is used to derive the optimal solution. A numerical example, sensitivity analysis, and the effects of the compensation policy on the optimal results are presented to validate the results of the proposed integrated model.

Key Words – Inventory, deterioration, integration, three-echelon, compensation

INTRODUCTION

This paper considers the product deterioration and the coordination of three-echelon supply chain simultaneously. To take into account a vertical integration of supply chain by applying Lee and Moon's method [19], we propose an integrated model for an on-going deteriorating item with compensation policy. This study proposes an integrated analysis and strategy to achieve coordination among supply chain partners. An illustrative example and sensitivity analysis are given to validate the inventory model. The numerical example shows that the integrated approach taking account of the supplier, the distributor and the retailer results in a cheaper system. The model has potential application in a multi-echelon supply chain inventory system.

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LITERATURE REVIEW

Several researchers have shown that in integrated models one partner's gain may result in the other partner's loss. To entice cooperation, the net benefit should be shared by both parties in an equitable fashion. Eum *et al.* [1] proposed a new allocation policy considering buyers' demand using neural network theory. Lee and Moon [2] extended Goyal [3]'s method and proposed a compensation policy that shares the benefits and the losses according to a ratio acceptable to both parties. To the best of our knowledge, the research considering product deterioration and three-echelon supply chain coordination simultaneously has not been solved.

MODELING of individual parties

We consider the supply chain inventory system consisting of a supplier, a distributor and a retailer. The lot-for-lot policy is used between the supplier and the retailer.

The following notation is used:

TC	The joint cost per unit time of supply chain.
C_r	The ordering cost per order of retailer
C_d	The ordering cost per order of distributor
h_r	The holding cost per unit per unit time of retailer
h_d	The holding cost per unit per unit time of distributor.
h_p	The holding cost per unit per unit time of supplier
S	The setup cost per setup of supplier
k_r	The deterioration cost per unit per unit time of retailer
k_d	The deterioration cost per unit per unit time of distributor
k_p	The deterioration cost per unit per unit time of supplier
D	The annual demand rate of retailer
P	The production rate of supplier
θ	The inventory deterioration rate
t_p	The supply cycle time of supplier
t_r	The replenishment cycle time of retailer
t_d	The replenishment cycle time of distributor
n	The number of deliveries from the distributor to the retailers during t_d unit times
*	The superscript representing optimal value

Cost structure of the supplier

The production lot size Q_p , the production time t_p and the inventory level $I_p(t)$ are

$$I_p(t) = \frac{P(1 - \exp(-\theta t))}{\theta}, \quad 0 \leq t \leq t_p \quad (1)$$

One has

$$t_p = \frac{1}{\theta} \ln \left[\frac{P}{P - Q_p \theta} \right] \quad (2)$$

By summing the setup cost, the holding cost and the deterioration cost, the supplier's total cost per unit time can be obtained as:

$$TC_p(t_p) = \frac{S}{t_p} + \frac{h_p}{t_p \theta} \left(P t_p - \frac{P(1 - \exp(-\theta t_p))}{\theta} \right) + \frac{k_p}{t_p} \left(P t_p - \frac{P(1 - \exp(-\theta t_p))}{\theta} \right) \quad (3)$$

Cost structure of the distributor

The production lot size Q_p is equal to Q_d^1 . Additionally, an order lot size q is delivered from the distributor to the retailer at each replenishment cycle time of $\frac{t_d}{n-1}$. The change

in the distributor's inventory level is

$$I_d^j(t) = Q_d^j \exp(-\theta t), \quad 0 \leq t \leq \frac{t_d}{n-1}, \quad j = 1, \dots, n-1 \quad (4)$$

By summing the ordering cost, the holding cost and the deterioration cost, the distributor's total cost per unit time can be expressed as follows:

$$TC_d(n, t_d, q) = \frac{1}{t_d} \left\{ C_d + \left(\frac{h_d}{\theta} + k_d \right) \left\{ Q_d^1 - (n-2)q - \left\{ Q_d^1 \exp(-\theta t_d) - \frac{q \left[\exp\left(-\frac{\theta t_d}{n-1}\right) - \exp(-\theta t_d) \right]}{1 - \exp\left(-\frac{\theta t_d}{n-1}\right)} \right\} \right\} \right\} \quad (5)$$

Cost structure of the retailer

A lot size q is delivered from the distributor to the retailer at each replenishment cycle time t_r . The number of deliveries from the distributor to the retailers during t_d is n . Therefore, the retailer's replenishment cycle time t_r is equal to t_d/n . The change in the retailer's inventory level is

$$I_r(t) = \frac{D}{\theta} [\exp(\theta(t_r - t)) - 1], \quad 0 \leq t \leq t_r \quad (6)$$

By summing the ordering cost, the holding cost and the deterioration cost, and using the retailer's total cost per unit time can be expressed as follows:

$$TC_r(t_r) = \frac{C_r}{t_r} + \frac{h_r}{t_r} \left(\frac{D \exp(\theta t_r) - D - \theta D t_r}{\theta^2} \right) + \frac{k_r}{t_r} \left(\frac{-D + D \exp(\theta t_r) - \theta D t_r}{\theta} \right) \quad (7)$$

Joint cost sharing policy under the integrated policy

For one partner's gain may result in the other partner's loss in the integrated model, the joint cost should be shared among the parties in some equitable fashion. By applying Lee and Moon's method to our integrated model has

$$\lambda_i = \frac{TC_i(t_i^*)}{TC_r(t_r^*) + TC_d(n^*, t_d^*) + TC_p(t_p^*)} \quad i = p, d, r \quad (8)$$

Note that $\lambda_p + \lambda_d + \lambda_r = 1$

CONCLUSIONS

By using the proposed integrated approach that takes account of the supplier, the distributor, and the retailer, the joint cost is found to be much less than as those in the individual models. In addition, the compensation policy also acts as a fair profit sharing mechanism. The integrated policy saving is up to 23% the cost reduction of the individual policies. In addition, from our sensitivity analysis, the percentage of integration cost change is most sensitive to the production rate of the supplier, the annual demand rate and the setup cost per setup of the supplier, and less sensitive to the parameters k_r , k_d and k_p . These parameters should be treated carefully. Moreover, we found that when the retailer's demand rate decreases, the delivery lot size from the distributor tends to increase. Consequently, each player's total cost and the joint cost decrease. The reasonable explanation for each player's total cost saving is the increase in the delivery lot size. Finally, the proposed model has potential application in a multi-echelon supply chain inventory system. Our model can be extended to other inventory system with multiple suppliers, multiple distributors and multiple retailers.

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DYNAMIC WAREHOUSE SHARING IN SUPPLY CHAINS A SOFTWARE-BASED MULTI-AGENT COORDINATION APPROACH

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ABSTRACT

This paper develops an approach to dynamic allocation of material flows among multiple warehouses in a supply chain, in which distributed planning is used in conjunction with locally embedded information to integrate interorganizational information flows.

Key Words – Warehouse management, software-based multi-agent systems, capacity allocation

Introduction

Due to the high level of complexity of process management in dynamic environments, it is difficult for supply chains to cope with the requirement of coordinating multiple actors (Ito & Abadi 2002, p. 201). While in theory, supply “chain” models appear to be simple, in reality the material flow is processed in a complex, multi-echelon and multi-path network with dynamic characteristics. Moreover, hypothetical control mechanisms are statically designed for fixed configurations, while in practice there are constantly fluctuations, and new tools, machines or transport vehicles need to be integrated into the running of logistics processes (Shen, Maturan, Norrie 2000, p. 366). Thus the complex nature of supply chains renders the optimization of all material flows with a central and static approach virtually impossible. Mathematical models are capable of providing accurate results for local optimization, but cannot handle the prohibitively high computational complexity of the entire SCM problem due to long processing time and algorithm complexity (Julka, Srinivasan, Karimi 2002, p. 1760; Caridi & Sianesi 2000, p. 41). For example the inclusion of real-time information renders many existing logistics algorithms designed to operate in batch mode obsolete (cp. Landers et al 2000, p. 116). As depicted in Figure 1, there are several different approaches to material allocation discussed in the literature. While hierarchical planning methodologies like MRP II (cp. Zäpfel 1996) can be employed in stable systems, they prove inadequate in environments with non-deterministic behaviour, since dynamic aspects like moving bottlenecks are not considered in these approaches (cp. Olhager & Wikner 1998, p. 11). The same is true for methods of materials transshipments in cases of stock outs (cp. Kukreja & Schmidt 2005 for a review of recent research in this field), which prove mathematically intractable in a very volatile environment with a large number of actors (cp. Wong et al 2006, p. 1091; Kukreja A, Schmidt CP 2005, p. 2062). McFarlane & Bussmann (2000) identify further local planning and scheduling methodologies particularly solved with Lagrangian relaxation techniques (e.g. as in Czerwinski Luh 1994). These are driven by cost functions and constrained by

Hierarchical	Distributed	Local cost function with product constraints	Holonic semi-agents
	Static	MRP II	Materials transshipments
		Static	Dynamic

Fig. 1: Allocation approaches

global production requirements. Such an approach, though, could prove to be mathematically intractable even over a short period of time if implemented along a multi-echelon supply chain. Another major problem would be the identification of consistent constraints among dispersed actors. However, the key problem lies in the real-time optimization of scenarios where problems in supply chains are geographically distributed and where their subsystems exist in a dynamic environment and need to interact flexibly (Adler & Blue 2002, p. 441).

A software-based multi-agent system is particularly suitable for solving such a coordination problem, due to its ability to adapt the solution automatically to rapid changes in the network configuration. The agents correspond by first receiving signals and, in response, affecting their environment through effectors (cp. d'Inverno & Luck 2004, p. 3). Thus the system enables local optimization of resource allocation (Sugumaran, Dietrich, Kirn 2005, p. 84), while sharing information among all actors of the supply chain. In this case a software-agent can be defined as "an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives" (Jennings et al 2001, p. 199). The importance of these capabilities for efficient coordination is obvious, considering the highly interdependent and time sensitive nature of real-time coordination requirements in complex supply chains (Sugumaran, Dietrich, Kirn 2005, p. 86). Various authors (e.g. Julka, Srinivasan, Karimi 2002; Ito & Abadi 2002; Adler & Blue 2002; Adler et al 2005; Chen, Lu, Chang 2003) consider the application of multi-agent systems in logistics with an emphasis on decision making in an isolated environment. Yet the flow of materials along the supply chain leads to the need to bridge the gaps of interorganizational interfaces. This implies for the coordination problem that there is not only a requirement for local decision processes, but for decentral information provision as well. While short-term disturbances change the local availability of existing resources (e.g. conveyors or cranes), it is virtually impossible to assess the status and position of resources at all possible stages of a supply chain and to integrate them into an hierarchical planning system for a real-time optimization of a global supply chain. As will be shown later, an up-to-date topography is mandatory for a seamless and efficient flow of goods. Whereas different aspects of logistics could be subject to research with focus on dynamics and flexibility, this paper chooses to focus on one entity, which is one of the first and important ones in companies to cope with uncertainties and time lapses in physical flows: the warehouse (Ackerman 1999, p. 1). In order to smooth and allocate the flow of physical items in and between factories the planning instance realm has to cope with uncertain demand, which in turn is the major driver for the installation of a warehouse (Chen, Lu, Chang 2003, p. 195). Hence we can assume the operation of a warehouse to be intrinsically dynamic, since it is the function of a warehouse in manufacturing to buffer uncertainty and fluctuation in customer demand, and to provide fast delivery of materials as a rapid response to changes in the nature and volume of materials flow (Ito & Abadi 2002, p. 201). Further dynamics are induced by occasional reconfiguration, addition, order changing, or unavailability of various functional units due to machine failure, scheduled maintenance, or shortage of materials (Usher 2003, p. 488; Shen, Maturana, Norrie 2000, p. 366; Sugumaran, Dietrich). One well known approach to coping with such volatile behaviour within warehouses is to incorporate the concept of chaotic storage (also known as randomized storage) or of class-based storage (by contrast to the dedicated space principle), which distribute materials of the same type in

different zones of the warehouse to counter global impacts of local technical problems. Likewise empirical studies show that chaotic and class storage policies could procure a higher usage rate as well as a smaller mean travel cycle time compared to the dedicated space principle (Chen, Lu, Chang 2003, p. 195). Class-based location is designated according to the turnover level of the materials. The higher the turnover level is, the closer they are distributed to the entrance (Chen, Lu, Chang 2003, p. 197). The efficiency of this policy for quick retrieval of items notwithstanding, a sophisticated IT-system is mandatory to automatically handle the bin allocation. One example of class-based storage utilizes a constantly changing 80/20 rule, whereby the storage layout is designed to place the 20% of items that constitute 80% of activity where they can be easily retrieved and shipped to their receiver (Ackerman 1999, p. 3).

Capacity Allocation and Warehouse Sharing in Supply Networks

To expand this approach, software agents could coordinate different dedicated warehouses as zones of one geographically distributed "virtual warehouse". Again the value of chaotic storage and class-based policies should be pointed out: whereas dedicated storage with a wide range of inventories rarely attains high fill rates, every unoccupied bin in a warehouse is available within a chaotic storage warehouse, increasing the potential fill rates of the warehouse. A class-based storage policy has this same advantage but further raises the storage and retrieval efficiency by minimizing the total travel distance throughout the warehouse, overcoming two key problems in warehouse-management (Chen, Lu, Chang 2003, S. 195). These advantages can be achieved in a cross-company setting as well if transshipments are considered, that is sharing of inventory among locations – not only to avoid out-of-stock situations, but to supply the forecasted demand of particular actors of the supply chain with the lowest average lead-time and the least time variation (Evers & Beier 1998, p. 187) by reducing the travel distance between consignee and warehouse (Needham & Evers 1998, p. 149). Although transshipments can potentially increase transportation costs, Needham and Evers found that they also lead to potentially higher warehouse fill levels and savings in out-of-stock costs like lost sales, lost customers or production shutdowns (Needham & Evers 1998, p. 158 et seq.). This is an analogy to the privileged zones for important high-runner goods in the class-based storage policy within warehouses. As a reverse conclusion, the effect of centralization of infrequently demanded items across locations allows the reduction of overall inventory and consequently costs and capacity utilization (Evers & Beier 1998, p. 173). The basic warehouse sharing goal is to allocate the workload of supply-side entities (i.e. inventories to store) to network-wide capacities with a constantly changing demand for different customers with different preferences, i.e. cost, lead-time, timeliness. Further, the value of a dynamic real-time allocation through agents lies in the utilization of local differences of the fill level, availability, balanced capacity utilization (to avoid congestion-effects due to peaks in capacity utilisation), and – as in the operation of automated warehouses – to secure the supply of goods during break-down periods of functional subsystems. Moreover, a shared warehouse scenario combining the allocation of geographically and organizationally distributed warehouses taps into two unique effects to inventory management not feasible with single warehouses. The first effect is avoiding the problem of scalability of warehouses beyond the restrictions of building size, as excess capacity of other facilities is used during peak season. This allows companies to save costs by

avoiding investments to handle occasional surges in demand. The second effect regards different cost structures within the network that encompasses the warehouses. Since the arbitrage of different labour costs in different companies is a major driver for outsourcing activities in supplier parks (Morris, Donnelly, Donnelly 2004, p. 131), the authors expect this well established method of cost reduction in manufacturing to be further expanded to logistics. This comes about as the agents can allocate physical goods to different locations in the network to serve different preferences of the customers (i.e. higher handling cost for a particular high-priority item is accepted, if it is handled in facilities with smaller average lead-time to the customer, whereas a low priority good is expected to be handled in a facility with lower costs, which therefore may have a higher average lead-time).

To sum up, warehouse sharing is a strategy to realize different advantages in cost efficiency and efficient resource allocation while satisfying the demand of downstream actors. This complex structure of interdependent restrictions makes the application of software-based multi-agent systems a promising approach for network coordination. Since, different scientific studies have already been conducted on the control of widely distributed equipment (e.g. robots) that must provide response in real-time (Giret & Botti 2004, p. 649).

Communication and Negotiation among Agents and Objects

The authors propose the implementation of a multi-agent system to find matches of supply and demand on the exchange to provide the best set of facility utilization (Julka, Srinivasan, Karimi 2002, p. 1760). Multi-agent systems inherently have advantages in distributed process control because of their ability to provide solutions to distributed problems that draw from distributed information sources and can tolerate uncertain data knowledge (Caridi & Sianesi 2000, p. 33). Therefore software agents are used to emulate the entities and components (i.e. facilities) of enterprises; i.e. an agent is generated for every item order. For example, each item-agent contains the name of required materials, its quantity, due-date of delivery and other preferences. The autonomous item-agent is responsible for providing the materials by the due date (Ito & Abadi 2002, p. 204). Therefore it could search on a virtual blackboard, if and where the particular items are available. The communication is processed through a blackboard, which is accessible to all mobile agents in the multi-company network. A blackboard of facilities and contained inventories is an efficient way to exchange data across company boundaries (instead of bilateral message passing between stationary agents, cp. Shen, Maturana, Norrie 2000, p. 367). Since the facilities configuration (and the respective status) in the network is uncertain (Caridi & Sianesi 2000, p. 34) and the presence of mobile agents is potentially not registered, a direct-channel messaging is rendered impractical. Hence it is critical that these agents and their embedded information are mobile, across both the communications network and physical network (Adler & Blue 2002, p. 447). Mobile agents are not bound to one execution environment. Instead they can migrate to other platforms, even in other firms, in order to support interdependent and distributed decision processes (Ghiassi & Spera 2007, p. 168; d'Inverno & Luck (2004), p. 6). In this scenario the code of the

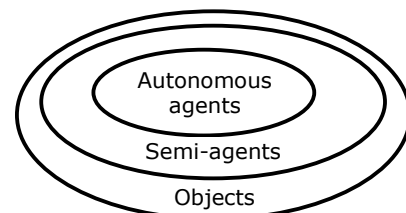


Fig. 2: Entity hierarchy overview, source: d'Inverno & Luck 2004, p. 17 (modified)

mobile agents wanders through a network and contacts other agents to perform tasks. But the complexity and dynamics in supply chains forces not only the migration of agents but also the provision of local information. Mobile agents may transfer their information concerning their goals in other executive environments (Ghiassi & Spera 2007, p. 168). This is associated with prohibitive requirements to encapsulate data about the downstream sites (represented by their agents and waypoint-matrix) in every single agent due to limited resources (Miyashita 1998, p. 147). Furthermore information usually resides in a multitude of platforms and is continuously changing (Julka, Srinivasan, Karimi 2002, p. 1755). Hence in settings where large volumes of data would have to be shipped over the network (in this case due to fluctuating inventories and changing status of facilities in every location), while the agent-code to process is relatively small (Giret & Botti 2004, p. 654), it is appropriate solely to migrate the agents and their capabilities, while the data concerning the topography of facilities is locally available. Therefore different classes of agents should be introduced in this framework: mobile agents capable for autonomous decision making (representing the item order), and complementary objects embedding information about the facility they represent. Interaction in a multi-agent setting requires the internal storage of information concerning the environment; otherwise the agents are limited, because they do not learn from experience (d'Inverno & Luck 2004, p. 94). Therefore objects – as stationary entities – possess knowledge of capabilities and the local status without any ability for decision making. Objects, even representation of physical ones, can be agents in a multi-agent system, if they serve a purpose (d'Inverno & Luck 2004, p. 39). These two categories of agents are mediated by additional *semi-agents*. While objects contain only local information and mobile agents have no knowledge of the topography of the different locations and their facilities, the semi-agents function as gateways for the migration mobile agents with a waypoint-matrix containing the local facilities, their capabilities and status (e.g. filling level), which renders them an incarnation of a blackboard for information exchange and guidance. D'Inverno and Luck define objects as collections of attributes and, in addition, as descriptions of capabilities (d'Inverno & Luck 2004, p. 16). While agents have preferences and intentions, autonomous agents additionally initiate actions proactively to implement their goals. Again, autonomous agents represent a particular order and administrate the shipping process. They cooperate with the semi-agents as gateways to adopt objects representing the warehouses or their functional subsystems in the software environment. These supply the demanded items due to goal adoption of objects representing facilities. Thereby agents extract knowledge from objects in order to reconfigure themselves, collaborate, and coordinate with other agents in solving enterprise problems (Ghiassi & Spera 2007, p. 168). This process is a holonic concept, which was first theoretically founded by Koestler (Koestler 1967), composed from the Grecian word "holos" (for whole) and "on" (part of) as a definition for creating a recursive structure of coordination. Thereby the holonic agents delegate a part of their autonomy to the master agent – from simple administrative tasks to complete decision making. This latter agent represents the holon to the environment. According to Giret & Botti, the strength of a holonic organization (holarchy) is the ability to construct efficient systems in complex conditions, highly resilient to disturbance (both external and internal), and adaptable to dynamics in the environment in which they exist. Within a holarchy, holons may dynamically create and modify hierarchies. Furthermore, holons may participate in different hierarchies at the

same time (Giret & Botti 2004, p. 646). Consequently, through the combination of competences of different agents and objects in a holon, difficult tasks can be fulfilled in a highly adaptable and scalable manner – moving beyond the characteristics of conventional multi-agent systems in adaptability, scalability and robustness by cooperation appropriate to the task. Furthermore they reconfigure themselves if one component suffers a failure or demands realignment in the dynamic context of the supply chain. Since agents have a degree of independence to cope with circumstances and problems on their dedicated level of existence without asking higher level instances for assistance, they can circumvent a global breakdown as a consequence of a minor local failure. As mentioned before, this is a key-factor for successful network coordination in a highly dynamic environment.

Due to the application of semi-agents as guides, agents are not only able to cooperate, but also to negotiate for the adoption of object (i.e. facilities and their resources). If an agent already uses a facility and the scheduling for the components does not require a pre-established sequence, two autonomous agents can negotiate for the adoption of the particular object. There are three possible alternatives for the adoption of occupied objects by autonomous agents: to share, to negotiate for release or (in a hierarchical relationship) to displace an occupying agent (d'Inverno & Luck 2004, p. 50). Negotiation in sharing an object may be related to finding tradeoffs among the local preferences of the bargaining autonomous agents and making commitments based on the negotiated results (Miyashita 1998, p. 150). When competing agents face unsolvable conflicts in engaging objects, semi-agents may also provide knowledge accumulated in past experiences of conflict to reroute physical goods to facilities with comparable or substitutable capabilities and resources, thereby inducing local learning and a simple kind of knowledge accumulation (embedded in the semi-agents) for process improvements and updating the topography of the running system in order to adapt to the internal and external dynamics of the supply chain. For example, semi-agents could monitor operations in order to accumulate information useful for the prediction of the facility-availability (e.g. by assessing repair schedules).

Cost and Benefit Benchmarking

Reviewing the literature, there is no consensus on an adequate framework for evaluating the effectiveness of decentralized logistic systems in general. Hence, based on the cost-benefit approach the objective is to derive appropriate indicators for assessing the discussed system. In order to meet these requirements a framework including monetary aggregates as well as non-monetary factors must be set up. The introduction process of a software-based multi-agent coordination system can be divided into *planning process*, *implementation process* and *continuous operations*. The objective is to derive and extract the relevant cost drivers for each of these stages. The following list gives examples for relevant categories:

- Planning and engineering costs: costs for as-is analysis, requirements analysis and for designing of the to-be process
- Implementation costs: system costs (costs for constructions, hardware and software – including interface adaptation and legacy systems integration), personnel expenses, costs for training and start-up
- Running costs: for personnel, material, machinery, energy, maintainance as well as licence fees and support costs.

Non-monetary factors to be included in the cost-benefit analysis are, for example, flexibility, robustness, acceptability and usability. The calculation of differential costs and benefits of this approach form the basis for decision-makers. Despite this framework for cost examination, the lack of comparative empirical data prevents a critical evaluation of the performance in terms of holonic control solutions by sound comparison to conventional static and hierarchical procedures, which limits performance assessments to qualitative approaches (cp. McFarlane & Bussmann (2000), p. 528).

Conclusion

The expansion of successfully practiced storage policies to a supply chain raises the efficiency of various aspects of storing and logistical processes in the network. This has a significant impact on competitiveness of the supply chain, since inventories often represent a significant amount of tied capital. Nevertheless the implementation of a supply chain-wide control of highly distributed and dynamic problems requires an automated and computer aided approach to decision support. Multi-agent systems – originating in the theory of distributed artificial intelligence – provide such support while at the same time – through holonic cooperation and local learning – increase the scalability, flexibility, and robustness of the network. Furthermore, storing information about the dynamic topography and frequently changing facility status locally avoids mistakes in allocation and scheduling, as well as a prohibitively high amount of data traffic between facilities, as only the code of the mobile agents has to migrate among locations. On the other hand, many problems have to be overcome before a multi-agent system can work frictionlessly among all companies of the supply chain, like requirements for IT investments and the standardization of data formats and interfaces (cp. Ito & Abadi 2002, S. 201). Furthermore choosing an approach that embraces distributed control and data storage might make the ex-ante attainment of predictable and consistent global of behaviour difficult, since the agents operate on the basis of local goals and information (Chan, Swarnkar, Tiwari 2007, p. 1031). Beyond these technical problems, mechanisms of cost-benefit sharing among actors have to be established to financially clear imbalances of burdens and gains in capacity utilization among different organizations.

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A STUDY OF CUSTOMER PURCHASE BEHAVIOUR - FACTORS OF GROCERY SELECTION -

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ABSTRACT

Recently, customer purchase behaviour in a grocery is diversified by change of life style. Therefore, many retail stores should grasp customer purchase behaviour typically, and need to manage based on marketing concept. In this study, our goal is to propose the model of customer purchase behaviour. Firstly, we begin to grasp customer purchase behaviour. We investigated 2 way of related questionnaire survey about customer purchase behaviour by internet research. One of them is about general customer purchase consciousness. Other of them is about evaluation of grocery by customer. As a result, we obtain 200 samples data by internet research. In this presentation, we report about factors of customer purchase behaviour which we consider important by using the result of internet research. We analyze the results of questionnaire survey about general customer purchase consciousness by principal component analysis. As the result, we derive 4 factors of grocery selection for customer. And, we give a name to these factors "Price", "Access", "Merchandise" and "Service", respectively. Moreover, we also analyze the results of questionnaire survey about an evaluation of grocery by customer by principal component analysis. And, we examine whether both results are identical. For example, if a customer is classified into "Price" as important factor in general customer purchase consciousness by principal component analysis, is an evaluation of grocery which this customer often use classified into factor as "Price"? As a result, we found out that both result are not identical. Thus, we examine the difference of customer purchase consciousness about other factors of customer purchase behaviour. And, we derive a tendency of customer purchase behaviour in a grocery.

INTRODUCTION

Recently, customer purchase behaviour in a grocery is diversified by change of life

style (e.g., diversified production of goods and so on). Therefore, many retail stores should grasp customer purchase behaviour typically, and need to manage based on marketing concept. In the previous study, data of customer purchase consciousness are obtained by a questionnaire survey. And the results of analysis, 5 factors of customer purchase consciousness are led by applying principal component analysis. In this study, our goal is to propose the model of customer purchase behaviour. In this paper, then we investigate the relation between customer purchase consciousness and customer purchase behaviour using newly data of a questionnaire survey. The data of customer purchase consciousness and customer purchase behaviour are obtained using a questionnaire survey by internet research.

QUESTIONNAIRE SURVEY BY INTERNET RESEARCH

To investigate customer purchase consciousness and customer purchase behaviour, we prepare questionnaire items. And, we set out a questionnaire survey by internet search. Summary of a questionnaire survey are as follows;

- Survey period: from 20/Mar./07 to 23/Mar./07
- Survey area: 2 cities (suburbs of Tokyo)
- Survey subject: 200 samples (women only)
- Survey industry: foodstuffs, necessities
- Survey items: attribute of answerer, incentive for selection of purchase, frequency of utilization about the specific retail store, evaluation about the specific retail store, etc.

The prepared questionnaire items are divided into 2 classes. One of them is about customer purchase consciousness which is not supposed specific retail stores. The other of them is about customer purchase behaviour which is supposed specific retail stores. The part of questionnaire items is shown in Table 1.

We prepare 131 questionnaire items about customer purchase consciousness. These 131 questionnaire items are answered using 6 ranks of evaluation by answerers. These 6 ranks of evaluation are as follows;

Table 1: The part of questionnaire items about customer purchase consciousness

Ordinary price of vegetables is reasonable than other stores.
Parking lane is widely.
Level of Freshness and quality of merchandise are higher.
Shop space is proper.

- rank 1: most important
- rank 2: more important
- rank 3: average
- rank 4: more trivial
- rank 5: most trivial
- rank 6: no detected

And, we prepare questionnaire items about customer purchase behaviour. In these questionnaire items, first, answerers have to select 3 retail stores which are frequently used. Next, they have to evaluate about selected 3 retail stores using 6 ranks of evaluation, respectively. These 6 ranks of evaluation are the same as mentioned above.

FACTORS OF CUSTOMER PURCHASE CONSCIOUSNESS

In this section, we investigate customer purchase consciousness. First, about 131 questionnaire items, the scores of every questionnaire item are aggregated. Next, the factors of customer purchase consciousness are analyzed using these scores applying principal component analysis by SPSS. Final, we derive the obtained factors of customer purchase consciousness, respectively. The details of analysis are described as follows.

About every questionnaire item, we decide the score of each rank as score of rank 1 is "1", score of rank 2 is "2", ..., and score of rank 6 is "6". First, we aggregate score of every questionnaire item for each answerer. We show the part of the results of aggregated score of questionnaire item in table 2. Next, we analyze using average score of questionnaire item applying principal component analysis by SPSS. The results of principal component analysis are shown in Table 3 and Figure 1.

From the result of principal component analysis, we estimate 4 factors about customer purchase consciousness. The reasons are as follows;

- The rate of accumulated contribution is greater than 50%.
- The difference of rate of contribution is larger among the factors.
- The rate of contribution is greater than 1%.

Table 2: The part of aggregated score of questionnaire item about customer purchase consciousness

Questionnaire items	Ans. 1	Ans. 2	...	Ans. 200	Ave.
Ordinary price of vegetables is reasonable than other stores.	1	2	...	1	2.15
Parking lane is widely.	2	3	...	4	3.58
Level of Freshness and quality of merchandise are higher.	1	1	...	1	1.26
Shop space is proper.	3	2	...	2	3.16

Ans. *: Answerer *, Ave.: Average

Table 3: The result of principal component analysis

Factors	1	2	3	4	5	...
Characteristic value	39.45	14.15	7.41	6.73	4.10	...
Rate of contribution	30.11	10.80	5.66	5.14	3.13	...
Rate of Accumulated contribution	30.11	40.92	46.57	51.71	54.84	...

And, we analyze correlation among the estimated 4 factors applying the factor analysis using oblique transformation. The result of analysis is shown in table 4. As shown in table, the correlation among the estimated 4 factors is not significant. Therefore, we decide that factors of customer purchase consciousness are 4 factors. Moreover, we select contents of customer purchase consciousness for decided each factor applying the factor analysis using orthogonal transformation. We show the part of result of analysis in Table 5. In Table 5, a content of questionnaire item belongs to the decided factor which factor loading is larger than 0.50. As mentioned above, we give a name to the following factor.

Table 4: The result of correlation among estimated 4 factors

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1		0.11	0.45	0.47
Factor 2	0.11		0.01	0.26
Factor 3	0.45	0.01		0.56
Factor 4	0.47	0.26	0.56	

Table 5: The part of result of the factor analysis

Contents of questionnaire item	Factor 1	Factor 2	Factor 3	Factor 4
Ordinary price of vegetables is reasonable than other stores.	0.82	-0.08	0.11	0.06
Parking lane is widely.	-0.07	0.79	-0.05	-0.01
Level of Freshness and quality of merchandise are higher.	0.20	-0.21	0.65	-0.14
Shop space is proper.	0.12	0.08	0.40	0.58

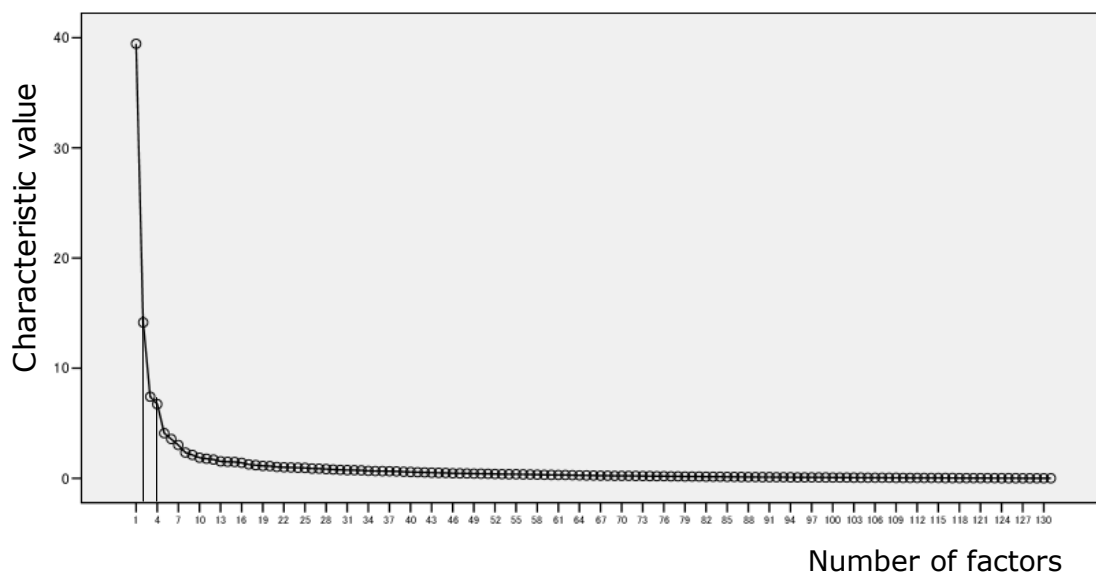


Figure 1: The result of principal component analysis

- Factor 1: Price
- Factor 2: Access
- Factor 3: Merchandise
- Factor 4: Service



Figure 2: Difference between customer purchase consciousness and customer purchase behaviour

DIFFERENCE BETWEEN CUSTOMER PURCHASE CONSCIOUSNESS AND CUSTOMER PURCHASE BEHAVIOUR

In this section, we examine the difference between customer purchase consciousness and customer purchase behaviour. From the result of questionnaire survey about customer purchase consciousness, the answerers belong to one of the decided 4 factors ("Price", "Access", "Merchandise" or "Service"). We analyze applying cluster analysis using group average method. And, from the result of questionnaire survey about customer purchase behaviour, characteristic of retail store is derived by the decided 4 factors. In the latter half of questionnaire survey, the answerers should evaluate the retail store which is most frequently used.

The characteristic of retail stores is illustrated by ratio of each factor so that the total of decided 4 factors equal to 1. 2 retail stores of the difference between customer purchase consciousness and customer purchase behaviour are shown in Figure 2. In retail store A, it seems that the answerers regard "Price" as important from the result of customer purchase behaviour. However, customer purchase consciousness of these answerers regards "Price" and "Merchandise" as important. In retail store B, it seems that the answerers regard all factors as important from the result of customer purchase behaviour. However, customer purchase consciousness of these answerers does not regard "Access" as important.

Thus, we found out that relation between customer purchase consciousness and customer purchase behaviour is not identical in this study.

CONCLUSION

In this study, we begin to grasp customer purchase behaviour. We investigated 2 way of related questionnaire survey about customer purchase behaviour by internet research. One of them is about general customer purchase consciousness. Other of them is about evaluation of grocery by customer. As a result, we obtain 200 samples data by internet research. We derive 4 factors of grocery selection for customer. And, we give a name to these factors "Price", "Access", "Merchandise" and "Service", respectively.

Moreover, we also analyze the results of questionnaire survey about an evaluation of grocery by customer by principal component analysis. And, we examine whether both results are identical. As a result, we found out that both result are not identical. Thus, we examine the difference of customer purchase consciousness about other factors of customer purchase behaviour.

In future tasks of this study, we grasp customer purchase consciousness from different viewpoints in this case, and we propose the model of customer purchase behaviour.

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SUPPLIER SELECTION FOR GARMENT INDUSTRY IN THAILAND

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ABSTRACT

The textile and clothing industry engages an important position in Thai's economy in terms of its value-adding, employment and exports. Recently, the Thai government has approved a mega project for "Bangkok Fashion City" in order to turn Bangkok to be a world fashion centre by the year 2012. This involves with the quality of manufacturing, design, higher level of skilled labour, as well as the quality of raw materials. Hence, it is almost impossible to successfully produce high value quality products without satisfactory vendor selection, especially in today's competitive environment. Therefore, this paper aims to propose a conceptual framework to investigate criteria for supplier selection in this industry. The proposed framework is expected to identify the relationship of those criteria with business process environment of the organization. The framework is expected to be tested empirically using data from the garment industries in Thailand.

Key Words- Garment Industry, Supplier Selection, Supply Chain Management, Business Process Improvement (BPI)

INTRODUCTION

The textile industry consist of thousands of businesses along the supply-chain which can be divided into five sub-sectors: (1) fibre production, yarn and thread industries; (2) spinning; (3) woven and knitted fabrics; (4) bleaching, dyeing, printing and finishing; and (5) apparel and other finished textile industries or clothing. These industries are linked together from upstream to downstream. Upstream industry comprises yarn and thread industries, accounting for 10 percent of the total. Midstream industry comprises woven fabric, knitted fabrics, bleached and dyed, printed and made up fabric industries, accounting for 32 percent of the total. Downstream industry comprises apparel and clothing accounting for 58 percent of the total. Figure 1 illustrates the value chain in this industry.



Figure 1 The value chain of the textile industry

The textile industry engages an important position in Thai's economy in terms of its value-adding, employment and exports. It is one of the largest manufacturing industries with accounts for about 20% of total manufacturing manpower with more than a million employees (Office of Industrial Economics, 2007). It is also the country's second leading export industry, with worth over US\$6 billion annual exports. In 2006, the growth of textile products performed well; however, it was lower than in 2005 due to the deceleration of in the global market. This industry will become more competitive in global economy in the future. Nowadays, this sector has faced up to the challenge of rising production and labour costs and greater outside competition, particularly from China, Vietnam, Indonesia, Sri Lanka and Bangladesh. Thai labour cost is now higher than these importance competitors for about three times. Even though, these countries have more benefit in terms of low cost production, the deceleration of in the global market will obstruct their export growth. Still, Thai textile and garment products are more widely accepted the global market due to the quality of those products.

Recently, the Thai government has approved a mega project for "Bangkok Fashion City" in order to turn Bangkok to be a world fashion centre by the year 2012. This involves with the quality of manufacturing, design, higher level of skilled labour, as well as the quality of raw materials. Hence, it is almost impossible to successfully produce high value quality products without satisfactory vendor selection, especially in today's competitive environment. Once a supplier becomes part of well-managed and established supply chain, it will have a long-lasting consequence on the competitiveness of the whole supply chain (Choi and Hartley, 1996). Thus, supplier selection is the most fundamental responsibilities for business management decisions. However, this task is very complicated and difficult to deal with for a number of reasons. For instance, a variety of factors must be considered during the selection process. Moreover, those factors may vary from times to times and industries to industries. The decision process also involves with multiple participants in the organization as well as the focus of core capabilities and activities of the organization. Several organizations have attempted to achieve competitive advantage by leveraging their suppliers' capabilities and technologies. The expected outcomes are to improve in performance measures such as quality improvement, cost and time reduction, shorter new product development lead times and so on (Ragatz et al. 1997) in the organization.

The main objective of this research is to propose a conceptual framework to investigate criteria for supplier selection in the garment industry. The scope of the study will particularly investigate only in a garment industry as the annual export of this industry is more than half of the whole sector. The paper looks into factors affecting supplier selection. This study attempts to identify the relationship of those factors with business process improvement (BPI) of the organization. BPI refers to the broad issues of an organisation's strategic which has been defined as "the critical analysis and radical redesign of existing processes to achieve breakthrough improvements". The expected results of the study will help firms to increase the understanding of the role of supplier selection in BPI.

The rest of the paper is organized as follows. The subsequent section summarizes related literature which is then followed by the proposed framework to investigate criteria for supplier selection in garment industry, as well as generated hypothesis and the research design. The final section presents the conclusions and the further study.

RELATED LITERATURE

This section provides the basic concept of business process improvement (BPI). Furthermore, it will summarised a number of significant contributions to the literature which provide insight into the topics of supplier selection both international and domestic scopes.

Business process improvement (BPI) is a systematic approach of improving the performance of organisation. Macdonald (1995) claimed that BPI covers three different approaches: process improvement, process redesign and business process reengineering. Harrington (1991) stated that BPI is making business processes more efficient effective and flexible in order to meet customer satisfaction in both products and services. BPI involve with process-restructuring programs to find root causes of obstacles and problems within an organisation. In doing so, any kinds of possible waste or non-value-added activities must be eliminated. However, how improvement can be reached may vary from firms to firms. Successful BPI programs depend on the involvement of top management, primary stakeholders and cross-functional teamwork. Most resistance comes from managers do not wish to change, lack of sustained management commitment, narrow technical focus and so on.

BPI can be categorised into two main criteria i.e. (1) improvement initiative and (2) customer focus (Harrington, 1991; Bhatt, 2001; Bhatt and Stump 2001). Table 1 illustrates details of those criteria suggested by earlier researchers and from conducting in-depth interviews which brought to this study.

Table 1 Business process improvement criteria

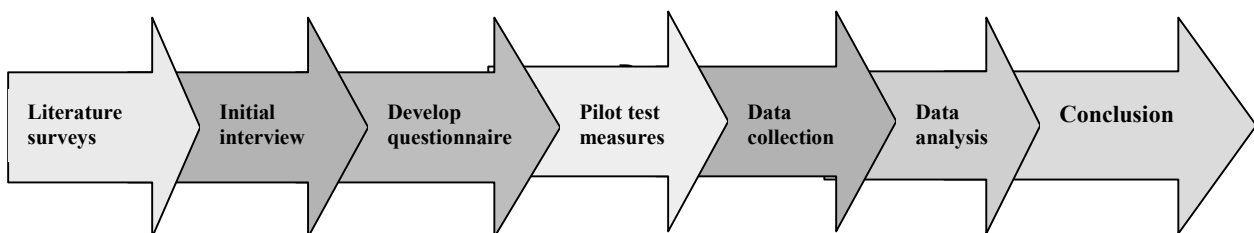
Criteria	Sub-criteria
Improvement initiative	<ol style="list-style-type: none"> 1. Defective prevention 2. Problem's root cause elimination 3. Standards improvement 4. Quality improvement 5. Simplicity redesign 6. Product differentiation 7. Process improvement 8. New product development via product innovation 9. Skills improvement
Customer focus	<ol style="list-style-type: none"> 1. Service improvement 2. Responsiveness 3. Requirement analysis/ Reaction on demand 4. Complaint analysis

Supplier selection: A wide range of studies have been addressed on supplier selection criteria. For instance, Choi and Hartley (1996) examined supplier selection for companies at different tiers in the supply chain. Several researches have investigated these issues in global arena (e.g., Katsikeas and Leonidou 1996; Piercy et al. 1997). Many evidences reveal that not only cost is the primary criterion, but quality, delivery, and service are commonly referred as well. Due to increasing consumer awareness and consumers' concerns over environment pollution, many companies incorporate environmental criteria into their supplier selection process. However, these factors may vary from business to business. Decision criteria can also be different depending on the size of a buyer organization (Pearson and Ellram, 1995), the preferred sourcing strategy, the existence of a supply chain (purchasing) strategy (Swift, 1995) and the type of products or service purchased (Svensson, 2004).

Sonmez (2006) had reviewed 147 academic journal articles on supplier selection practices and models between 1985 and 2005. He stated that twenty-three percent of those articles examined decision criteria used for supplier selection process. This study employed factors affecting selection criteria summarized in Sonmez (2006). Some of which are also identified via interviewing process with six garment companies in Thailand.

RESEARCH METHODOLOGY

In this paper, an empirical study is adopted to evaluate the supplier selection process. A survey questionnaire will be used to collect data. Research design applied in this study is shown in Figure 2.

**Figure 2** Research design

Interview approach: The initial part of this primary research was conducted via site visits and in-depth interviews. Principally, the objective of this stage was to understand the process of supplier selections, sourcing channels, and selection criteria in a real decision. To supplement the literature review, six companies in the garment industry were involved to compare theory with practice. This enables us to identify relevant factors determination before developing a survey instrument as well as better understanding the selection strategy and process of the company.

Survey instrument: A questionnaire was developed based on information obtained from interviewing six companies and a review of the relevant literature. The instrument focuses on four main issues, i.e. (1) the industry profile, (2) sourcing and evaluation supplier strategies, (3) the relative importance of BPI factors, and (4) the relative importance of supplier selection criteria. A Likert-type scale is designed to use to evaluate the perceived importance of various selection factors as well as the relative importance of BPI factors. The respondent will be asked to rate those relative importance ranging from '1' means least important to '5' means most important, with a midpoint of '3'. The questionnaire was validated by two expert panels and pre-tested on 5 firms. Modifications to the instrument were made based on expert's opinions before the final distribution.

The study conducts to understand the formulation of outsourcing strategy and decision. Hence, the relationship between supplier selection criteria and the core business improvement policies of the organization is explored. This leads to three main hypotheses:

- H1:* There is a significant relationship between supplier selection criteria and improvement initiative factors,
- H2:* There is a significant relationship between supplier selection criteria and customer focus factors,
- H3:* There is a significant relationship between supplier selection criteria and overall BPI factors.

Figure 3 presents conceptual framework of the study. The proposed framework will be tested using data from the garment industry in Thailand. The final results will be reported by the end of 2008.

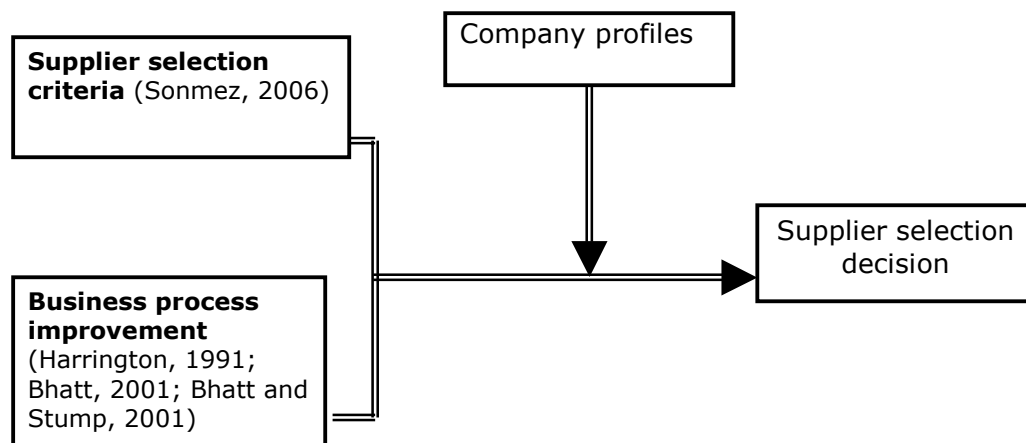


Figure 3 Conceptual framework of the study

CONCLUSION

In this paper, attempt has been made to assess the relative importance of supplier selection criteria and BPI factors. In-depth interview with six companies, in the textile company, were involved in the first phase of this study to understand the decision process as well as selection criteria. Survey research is selected as a cross-sectional research design for this study. A questionnaire is developed to collect data. The instrument focuses on the following four main issues: the industry profile, sourcing and evaluation supplier strategies, the relative importance of BPI factors, and the relative importance of supplier selection criteria. The study will employ factor analysis to identify main supplier selection and BPI criteria. Regression analysis will be then used to measure the relationship between two issues. This paper provides a framework that capture the relationships between the two types of internally and externally perspectives of BPI factors and supplier selection factors. The framework is expected to be investigated empirically using data from garment companies in Bangkok and Metropolitan areas in Thailand.

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ORDERING STRATEGIES FOR SHORT PRODUCT LIFE CYCLE MADE-TO-STOCK PRODUCTS

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ABSTRACT

As consumers, our daily lives are associated with many short lifecycle Made-To-Stock (MTS) products. Owing to short lifespan (quick obsolescence), the difficulties in repeated negotiations and procurement, long procurement lead-time and the lower unit cost of acquisition in committing to a larger trade volume, retailers would prefer for such products to commit to their supplier the entire SKU demand that they expect during the product lifecycle at the time of launching itself. However, depending on how the SKU performs vis-à-vis the retailer's original forecast, the retailer could end up in economic losses due to either short or surplus supply. In this paper we attempt to model this problem with the objective of maximizing the retailer's expected product life cycle profit keeping the initial business promised and subsequent lifecycle replenishment orders as decision variables. Our experiments suggest the importance of markdowns, splitting of the initial order, and not committing the entire SKU business in one go as significant contributors to the maximisation of retailer profit.

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INTRODUCTION

As consumers, our daily lives are associated with many short lifecycle Made-To-Stock (MTS) products. These are products that we often buy on impulse during visits to the supermarket. Examples of such products are electronic products (including mobile handsets and digital camera among others), garments, household goods, jewellery and toys. For a particular stock keeping unit (SKU) that could be termed as successful in the market, the product lifecycle for such products is generally in the range of six to 12 months. Such products are typically characterised by high demand volatility and it is difficult to predict the total lifecycle demand before the launch of the product. Owing to short lifespan (quick obsolescence), the difficulties in repeated negotiations and procurement, long procurement lead-time and the lower unit cost of acquisition in committing to a larger trade volume, retailers would prefer for such products to commit to their supplier the entire SKU demand that they expect during the product lifecycle at the time of launching itself. However, depending on how the SKU performs vis-à-vis the retailer's original forecast, the retailer could end up in economic losses due to either short or surplus supply. The retailer would have to negotiate with the supplier, in the former case for further business and in the latter case for early closure of the deal. In addition, the retailer would also have to decide whether the negotiated business volume should be received in one or multiple lot(s). The former case would be beneficial from the view-point of saving on fixed costs in ordering and transportation, while the latter would be beneficial from the view-point of quick response and low inventory costs. These products also are generally subject to a planned phase-out that coincides with the launch or establishment in market of a successor brand. In this paper we attempt to model this problem with the objective of maximizing the retailer's expected product life cycle profit keeping the initial business promised and subsequent replenishment orders as decision variables.

LITERATURE REVIEW

The sourcing problem for a new product facing stochastic demand has been investigated from different viewpoints. Earlier research work assumed that the procurement decision had to be made before the realization of demand. An

example of this research could be the classical newsboy problem where the entire demand for a style product occurs in a single period. Bitran et al. (1986) and Matsuo (1990) proposed enhancements to this problem and computed production sequence and production volume of the style products over the multi period horizon in order to meet entire demand that occurred in the final period. This stream of research did not include the time effects of the costs. Hence, Kurawarwala and Matsuo (1996) further extended this work and considered a more realistic situation where demand was realized over a product life cycle to dynamically determine optimal sourcing quantities.

The demand for the new product is highly uncertain and unpredictable at its launch; but, it becomes more predictable after analyzing an early demand pattern (Raman 1999). Quick response research stream used this more refined demand information and suggested some sophisticated sourcing options (Fisher and Raman 1996). They modelled the problem as a two stage problem where first ordering decision was made under complete demand uncertainty while the second procurement decision was made after observing the early sales. Given those profits in an apparel industry are about 3% of total sales, their models contributed significantly to the bottom line (Fisher and Raman 1996).

Recent work that focuses on retailer's inventory management problem for short life cycle product includes Bradford and Sugrue (1990) and Fisher et al. (2004). In both papers, the problem is to determine initial and subsequent replenishment quantities to minimize the cost of lost sales, backorders and unsold inventory. Unlike Bradford and Sugrue (1990) that assumed zero replenishment lead time and used explicit enumeration process to determine optimal order quantities, Fisher et al. (2004) explicitly considered replenishment lead time and also proposed a computationally efficient heuristic to compute order quantities.

The prior research assumes that per unit sourcing cost does not depend upon the ordered quantity. However, it is a common knowledge that a customer can receive a price discount after placing large orders (Silver, Pyke and Peterson 1998). In other words, per unit sourcing cost should decrease with the increase in the ordered quantity. Also, though that the previous research assumes that

clearance price remains constant, in some situations, it does depend upon the number of unsold units at the end of the product lifecycle. Clearly, under these situations, monetary risk is lower compared to the situations represented in the prior work. As a result, we believe that both initial and replenishments order quantities can be substantially different in the new situation. This has motivated us to investigate the sourcing problem of the new products when both sourcing costs and clearance prices decrease with the product quantity.

MODEL FORMULATION

The right ordering of short lifecycle MTS products is a challenging problem for the retailer owing to the high volatility in demand (volatility across markets and over the SKU life-cycle), and, hence, the inability to accurately forecast the total lifecycle demand before the launch of the product (at the time of initial negotiation with the supplier). For such products, there is evidence that the accuracy of demand forecasting improves considerably by the time the maturity phase of the product life-cycle is reached. Shah and Patil (2008) report that the product life-cycle demand (demand up to the SKU phase-out time) can be forecasted pretty accurately at about the end of the first quarter of the time between launch and phase-out. We describe this time point as Accurate Response Review Point (ARRP). The following table describes the tactical and operational decision-making involved at the ARRP. It is followed by the notations used and the model formulation.

Table 1: Possible ARRP Decisions

SKU launch scenario	Tactical	Operational
1. more successful than expected	maintain launch price negotiate with supplier for increasing overall purchases	Determine the optimal number of replenishments and replenishment quantities based on trade-off between inventory carrying cost, and fixed costs in ordering and transportation.
2. more or less as expected	maintain launch price	
3. less successful than expected	reduce launch price negotiate with supplier for reducing overall purchases	

Notations Used

Model Parameters

$T = \{t | t = 1, 2\}$; set of SKU life cycle phases

$S = \{s|s=1, \dots, S\}$; set of demand scenarios

ϕ_s probability of occurrence of Scenario s

d_{1s} demand of the SKU in Phase 1 at unit retail price p under Scenario s

D_s total demand of the SKU at unit retail price p under Scenario s

d_{2s} demand of the product in Phase 2 at markdown price q_s such that $d_{2s} = (D_s - d_{1s})(1 + \varepsilon(p - q_s)/p)$, where ε is the price elasticity.

p unit retail price planned at launch of the SKU

q unit clearance price at end of Phase 2; q such that $0 < q < p$

w_t backorder cost per unit in Phase t

c_x unit delivered cost of the SKU for a business volume x ; $c_x = a_0 - a_1x$ where a_1 such that $c_x x$ is a non-decreasing function of x .

h_t inventory holding cost per unit in Phase t

t_x unit transportation cost of SKU for a business volume x ; $t_x = t_0 - t_1x$ where t_1 such that $t_x x$ is a non-decreasing function of x .

b_{ts} backorder at the end of Phase t under Scenario s

i_{ts} inventory at the end of Phase t under Scenario s

Decision Variables

x_0 business volume in units confirmed by retailer initially (decision variable)

x_{01}, x_{02} batch sizes of the initial business volume transported in phases 1,2

x_{2s} business volume ordered and delivered in phase 2

q_s Unit markdown price at phase 2 under scenarios s ; q_s such that $0 < q_s < p$

Maximize

$$\sum_{s=1}^S \phi_s (pd_{1s} + q_s d_{2s}) - (a_0 - a_1 x_0)x_0 - \sum_{s=1}^S \phi_s (a_0 - a_1 x_{2s})x_{2s} - (t_0 - t_1 x_{01})x_{01} - (t_0 - t_1 x_{02})x_{02} - \sum_{s=1}^S \phi_s \{(t_0 - t_1 x_{2s})x_{2s} - (h_1 i_{1s} + h_2 i_{2s} + w_1 b_{1s} + w_2 b_{2s})\} \tag{1}$$

Subject to

$$x_0 = x_{01} + x_{02} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \tag{2}$$

$$x_{01} - i_{1s} + b_{1s} = d_{1s} \quad \forall s \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \tag{3}$$

$$x_{02} + x_{2s} + i_{1s} - b_{1s} - i_{2s} + b_{2s} = d_{2s} \quad \forall s \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \tag{4}$$

$$(D_s - d_{1s})(1 + \varepsilon[p - q_s]/p) = d_{2s} \quad \forall s \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \tag{5}$$

x_0, x_{0t}, x_{2s}, q_s non-negative

The above model has a quadratic objective function (equation 1) that maximizes expected profit by subtracting expected sourcing, transportation, inventory, backorder and lost sales costs from expected revenue. Equation 2 ensures that the quantity shipped in Phases 1 and 2 is equal to the initial business volume committed. Equation 3 and 4 are inventory balance equations for Phases 1 and 2 respectively. Equation 5 captures the impact of markdown in second phase on demand. The unit backorder cost in the Phase 2 is the unit lost sales cost and the unit inventory holding cost in Phase 2 is the salvage value per unit. We do not take into account the learning effects.

Modelling Extensions

We used a linear demand function and linear cost functions for both procurement and transportation. Several pricing models have been proposed in the context of new products. It is possible to incorporate such models and other cost functions for procurement and transportation in our model. The inclusion of such functions would result in a nonlinear model where it is difficult to obtain and verify the optimal solutions. A novel approach can be used to convert this non linear program into integer linear program to solve the problem to optimality.

NUMERICAL EXPERIMENTS AND RESULTS

Quick response manufacturing literatures advocates the importance of using replenishment orders that are responsive to recent demand information. In the numerical experiments, we suggest the importance of markdowns and splitting the initial order to evaluate inventory and transportation tradeoffs. We assume three demand scenarios (low, medium, high) with probability of occurrence (0.3, 0.3, 0.4), respectively; first phase demand forecasts (100, 150, 200); and second phase demand predictions (150, 200, 300) at the launch price. The launch price is set to 20. Inventory holding and backorder costs are 2 per unit per period. Second phase backorder is lost sales which is equal to 15 per unit. Price elasticity of demand (ϵ) in phase 2 is 0.75. Second phase demand can be increased by adjusting the clearance price. First and second phase procurement cost structures can be described by the expressions $c_x = 8 - 0.004x$ and $t_x = 12 - 0.001x$. Procurement cost structure in Phase 2 is costly because of shorter lead

times and loss of low cost sourcing option. Transportation cost structure is represented as $t_x = 1 - 0.0001x$.

The optimal solutions were determined for four trials (refer table below). When the firm uses a "No Markdowns, No Order Splitting, No Second Phase Procurement" option, the expected profit is 3435 with the initial business volume of 500 units. When the firm uses a "No Markdowns, No Order Splitting, Second Phase Procurement" option, the expected profit is 3792 with the initial business volume of 350 units. In the second phase 150 units are ordered under high demand scenario. When the firm uses a "No Markdowns, Order Splitting, Second Phase Procurement" option, the expected profit is 4106 with the initial business volume of 350 units. In the second phase 150 units are ordered under high demand scenario. Initial order is split into first and second phase batches of 150 and 200 units respectively. When the firm uses a "Markdowns, Order Splitting, Second Phase Procurement" option, the expected profit is 4207 with the initial business volume of 500 units. Initial order is split into first and second phase batches of 150 and 350 units respectively. The markdown prices are 15, 16.66 and 20 under low, medium and high demand scenarios.

Table 2: Experiment Results

Trial	Description			Optimal Decisions					Expected Profit
	Markdown	Order Splitting	Second Phase Procurement	Phase 1		Phase 2			
				Initial Business Volume (x_0)	Order Quantity		Business Volume (x_{2s})*	Mark-down Price (q_s)*	
				First (x_{01})	Second (x_{02})				
1	X	X	X	500	500	-	-	-	3435
2	X	X	√	350	350	-	0, 0, 150	-	3792
3	X	√	√	350	150	200	0, 0, 150	-	4106
4	√	√	√	500	150	350	0, 0, 0	15, 16.67, 20	4207

* Respective values for low, medium and high demand scenarios.

CONCLUSION and FUTURE PLANS

Experiments clearly suggest the potential benefits of incorporating markdowns, order splitting, second phase procurements. It will be interesting to study the impact of different cost structures and operations characteristics on the

optimal decisions. Are replenishments always a good option? Can one use markdowns instead of replenishments to increase profits? Can we characterize situations where the conventional practice of single large order is an optimal strategy?

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SECTION 7

DECISION SUPPORT SYSTEMS AND INFORMATION AND COMMUNICATION TECHNOLOGIES

**TRACEABILITY FOR LOGISTICS:
COMPOUNDING THE ISSUES THROUGH REGULATIONS**

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ABSTRACT

From the earliest of times mankind has found that trade helps a community to prosper. But today 'trade' has become a target of terrorism as was seen in the actual and symbolic destruction of the US World Trade towers. Quickly the US implemented several Acts, one was the Homeland Security Act (2002), and with it a came raft of mandatory technologies. We consider the US to overly rely on technological solutions and we will address this via the concept of 'terrorism': actions authorised by corporate and middle managers, and embraced by anomic individuals.

We will ask if the US-driven policies are successful. Or do they hamper the innocent party or the small trader who may not be able to afford the expense of compliance? In general terms our answer is a qualified 'yes' – the policies do work, but they also hamper the innocent.

INTRODUCTION

This paper will introduce the basic technology of supply chain management within which we note the driving force of the US military and the US Administration forcing the use of US-led implementations of technology. We will argue that without the force of law US hegemony would not have driven the use of these technologies into the global supply chain in the way in which it is presently enacted. That is, mandatory 'solutions' that have to be followed, even if one is a small trader at the opposite side of the globe to the US.

Supply chain management (SCM)

Essentially SCM is a collection of techniques sensibly applied to ensure that there is enough stock in hand to sell to the customer or to be ready for a manufacturing process. The stock control has to back-tracked through the intermediate processes to ensure that the initial activities – be they the husbandry of cotton bushes to ensure a good crop later, or the processing of raw materials readying them for a manufacturing process - are all activated. As this chain can become long and involve many actors its management is subject to many techniques from the behavioural to the mathematical; many of which are mediated by information systems, the World Wide Web, and the Internet. Naturally there are many weak points at which simple failure can occur, or at which fraudulent material may be inserted 'as though bona fide'.

We will not discuss techniques of stock control or SCM in detail, but we will look at aspects of tagging items so they may be 'counted', tracked, and traced. By using these tags we can perhaps control the fraudster whom we call "a terrorist" in this paper - be this the chief executive of a grey industry supplying fakes, or the middle man inserting fakes into the supply chain: both act in hostile ways which need to be exposed to guard the innocent consumer. With respect to the latter, it does not matter too much if they purchase a Gucci bag and it falls apart

quickly (they lost money while acting as a free-roaming advertising agent of the brand), but it is serious if the consumer expects sufficient medication in the prescribed drugs and the fraudster has minimised the costly drug dose by inserting a placebo: the consumer can die. The same dire end result may occur using any mission critical object if it is not manufactured, processed, stored, or used to the correct standard – the perpetrators are culpable, they are terrorists.

Bar codes

These were introduced some 40 years ago to aid stock control. They are ubiquitous now in the modern world with most product chains using them at some point. They have their failings – the labels can not carry much information, they are fragile and become illegible (for instance, if wet), and they can only be read over short distances, directly. Yet they are cheap.

In Table 1 we highlight some barcode standards, noting that modern variations with two or three dimensions of data coding can carry vast amounts of data (even read by a mobile phone camera, which, after calling a server [from the coded data], can receive downloaded detailed product information).

Table 1: Some well-known standards for barcodes & RFID

<i>Object</i>	<i>Type</i>	<i>Comments</i>
Bar Code	EAN EAN-13; ITF14 UCC/EAN 128	Used by more than 800,000 firms displaying product information via 1-dimensional bar code.
	RSS (Reduced Space Symbology). Now called GS1-Databar	Can encode 72 figures and 42 alphanumerics
	Datamatrix 2 dimensional - latest is named ECC200	Stores 2335 alpha or 3116 numerics Also has error correction
	UPSCode, now called Maxicode 2 dimensional	93 characters in one square image & 8 images may be concatenated to give more information
	QR-Code 2-dimensional	Numeric only: 7089 numbers Alphanumeric: 4296 Binary: 2953 Kanji: 1817 images & error correction too
	HCCB High capacity coloured barcode	One square inch can store 3500 characters. Is also 2 dimensioned
	ColourCode – Japanese 2D with colour A very new system which may become ubiquitous.	A standard, four-color 5 x 5 cell encodes more than 17 billion patterns. Will link 'barcode' via mobile camera to Web site of database server.
RFID	Passive or Active (contains own battery) EPC (Electronic Product Code) for data storage in RFID chips.	See Wiki for a long discussion http://en.wikipedia.org/wiki/RFID

RFID (Radio Frequency Identification)

RFID is a technology based on radio wave transmissions making it possible to reliably and uniquely identify a person, animal, or object carrying an electronic label (a tag). The RFID is capable of transmitting and receiving data in a brief

time and at varying distances. These tags are very small flat devices, filled with circuitry, and can be stuck on most types of objects just like bar codes, or even inserted in their fabric (like an under-skin tag for animal recognition, or as a chip inside a passport). The passive type is interrogated by a remote sensor to sense its data almost through any intermediate substance and over relatively long distances (not the short, line-of-sight needed by bar code readers). The active RFID contains a battery. It is bigger and more expensive, but can itself send signals to remote sensors to give details of its location, manifest, etc. The two types are therefore very flexible and offer SCM a very good tool – but this tool has been largely ‘ignored’. Perhaps because RFID add to the cost of the logistics process, and they are not perfect.

The 1990s saw some standardisation for the interoperability of equipment, but it was not until 2004 that a major policy change in the US was seen: the auto-ID Centre of MIT became EPCglobal. They promoted the EPC standard (Electronic Product Code) which is storable in an RFID. Its architecture contained ONS services (Object Naming Service) for routing information over the Internet, and the PML (Product Mark-up Language) – an XML-based language for describing objects. Today, the second generation of UHF EPC tags is becoming the standard of RFID identification in industry and distribution. The United States Department of Defense (DOD), Wal-Mart, and a limited number of other firms support the adoption of RFID-2. But some critics say Wal-Mart was ‘bribed’ by ultra-low product pricing to promote its adoption of the 2nd-generation RFID; and they in turn ‘forced’ their suppliers to be compliant with the new RFID. As usual, suppliers asked “Why? Is it only to make more money for Wal-Mart?”

We will not discuss RFID in detail (Wiki does that admirably), but we note that it is much more costly than a paper barcode, although it can be read distantly and even when hidden from view. Thus with its much greater data capacity it is much more flexible than the barcode, and it can be used in many more situations (see Table 2: Applications).

Table 2: Frequencies, features and application of RFID

<i>Frequency</i>	<i>Features</i>	<i>Applications</i>
Low frequency: 100-500 kHz Standard: 125 kHz, 134.2 kHz	Medium reading distance (10 to 150 cm) Medium reading speed Inexpensive	Identification of animals E.g.: glass tags, or in passports
High frequency: 10-15 MHz Standard: 13.56 MHz	Short reading distance, (a few cm) Good reading speed Potentially inexpensive	Volumetric access control Easy read/write in product chain Smart Cards
Very high frequency: 850-950 MHz Standard: 860-920 MHz	Large reading distance of up to 5 m High reading speed Costly	Logistics – multiple inventory management without data collision. Management of boxes, pallets
Ultra high frequency: 2.2-5.8 GHz Standard: 2.4 GHz	Very high reading speed Reading distance greater than 10 m Very costly	Motorway tolls

The frequency bands allocated to RFID are not the same on the various continents and may differ from country to another; differing mainly in the VHF or UHF bands. The big problem is in their receiving *false-positive* signals from ‘unknown’ originators. A partial standardisation of frequencies is currently sought by defining the world into three regions (Table 3):

Table 3: Assigned regional frequencies of RFID

<i>EU-Africa -Russia</i>	<i>Asia-Oceania</i>	<i>North-South America</i>	
125 kHz	125 kHz	125 kHz	LF
13.56 MHz	13.56 MHz	13.56 MHz	HF
869.4 - 869.65 MHz	950 MHz	902 - 928 MHz	UHF
2.446 - 2.454 GHz	2.427 - 2.47 GHz	2.4 - 2.4835 GHz	SHF

Traceability and tracking

Traceability is the "ability to trace the history, application, or location of an entity by means of recorded identification" (ISO 8402). In the later ISO 9000 standard "the entity" consists essentially of a material product and the requirements primarily are concerned with the identification of materials and parts throughout the production process; the indication of this identification on all corresponding documents; recording to make it possible to trace the history of an activity or a process throughout the quality loop; and archiving or filing of the data for a specified period.

Traceability is based on an exchange of events that are either routine (tracking) or upon request (tracing); and the exchange format is not directly linked to the format of the labels/tags. Within a given company any problems can usually be well controlled, but between companies there is a need for a precisely encoded electronic data interchange (EDI). In order to ensure flawless traceability, cooperation between the various partners in the supply chain is a necessity; tracking raw materials and goods within the domain of a company is not sufficient. In addition, information needs to be freely exchanged throughout the supply system, and at each transition from one company to another. Traceability can only result from an overall concerted effort.

CONTROL MEASURES

The control, tracking, and tracing of bone fide goods by compliant partners provides few problems. It is the volume of fake and thus dangerous goods that must be controlled and stopped. The International Anti-Counterfeiting Coalition (IACC), a group of brand-owning companies, says the annual global trade in fake goods has risen to approximately \$600 billion, up from \$5.5 billion in 1982. That accounts for five to seven percent of world trade: and the group says China is the biggest transgressor (IACC, 2008).

Apprehending the corporate terrorists

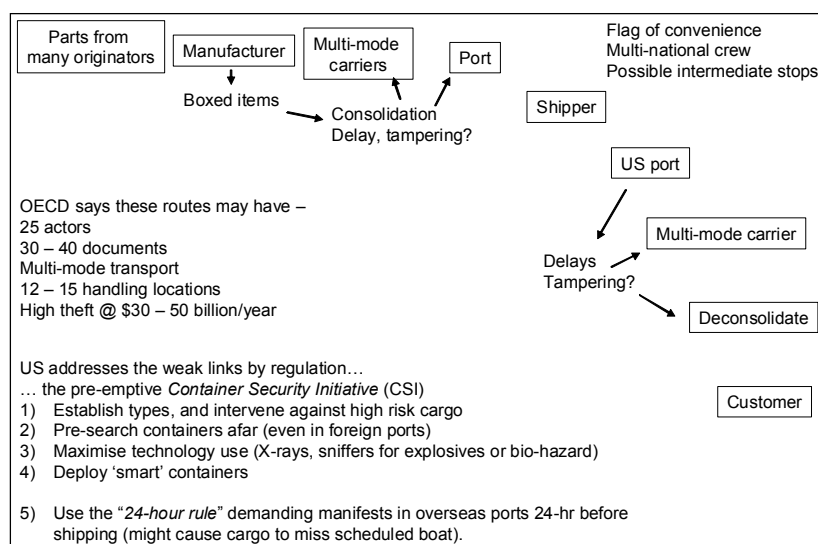
The United States exerts a strong influence on terrorism in many ways, but after the 9/11 attack on US soil its Administration became frightened (Ahmed & Frost, 2005; Chomsky, 2002); and corruption in its globally branded enterprises also unnerved it. The US Administration reacted violently through its legislature.

Quickly it introduced the Public Company Accounting Reform and Investor Protection Act of 2002 to control its accounting fraud - often called 'SOX', following the names of its two principle authors, Sarbanes & Oxley, (SOX, 2002). The Sarbanes-Oxley Act boosted other US laws relating to bribery committed overseas, and it mandated that anonymous 'whistleblowers' would be protected. Also it was hoped these measures might boost the ratings of the US by Transparency International: but still in 2006 it had indices that were too low - with its 'corruption' (at 20th of 179 countries), and of its 'propensity to bribe' (at 9th of 30 countries) (TI, 2007). However, there are three aspects of SOX that cause difficulty. First is the enormous extra cost carried by corporate America due to the rearrangement within their accounting practices as they have had to separate staff

roles so as not to overlap advice and control functions. Second is the poor acceptance of 'whistleblowers'. No one likes informers, especially in countries where historically there was a "1 in 3" culture - for instance, where, in groups of three people we find one is an informer to the authorities. And thirdly, the degree to which we support corruption varies globally (TI, 2007). This raises a difficulty when US firms have to be SOX compliant no matter in which country they work since they can not officially maintain a 'slush fund' budget. SOX is not only concerned with accounting fraud, but with transgression of all kinds. Thus the creator of fakes, the insertion of these fakes into the product chain, or knowing of and perpetrating the fraud all come within the range of the 'whistleblower' - hence our inclusion of "corporate terrorism" in a discussion of RFID and SCM.

The control of corporate terrorism

The US introduced two acts under the name "Homeland"; and although each had a major impact they ought not to be confused one against the other. The first we mention is the Homeland Investment Act (HIA), a provision of the American Jobs Creation Act (AJCA) of 2004. Specifically, this specifies an "elective temporary dividends received deduction" that allowed US corporations to shield 85% of the qualifying cash dividends that were distributed by their foreign subsidiaries from US tax. This act had considerable effect on the balance of



Foreign Direct Investments over 2005-6: but these have returned now to the former state of the US being globally the largest FDI donor (WIR, 2007). The second we mention is the Homeland Security Act of 2002 which created a Department of Homeland Security (Whitehouse, 2002). It is this 2002 Act which informs much of this paper.

Source: following Lukas, 2004

Figure 1: Representations of 'trade risk'

Before 9/11 the US Administration had determined that trade had weak links which could be found at transit points. Aaron Lukas (2004) writes about this aspect and many of his findings are summarized in Figure 1. Goods may be compromised at origin by accepting counterfeit sub-assemblies, possibly quite unknown to the assembler. Or the supply chain may be subject to tampering wherever it comes to a brief halt - on quaysides, in consolidators' warehouses, at multi-modal exchange points where [containers] are moved from road to rail

to ship or aircraft, or at Customs check points. Although the supply chain operators have a responsibility for the security of the goods they can not make the chain absolutely inviolate. Goods come to a halt in unguarded premises, operators may be bribed to allow tampering, or terrorists may be infiltrated into any workforce to enable easy access to all goods, and they can choose their target with impunity.

In the 'old days' it was deemed sufficient to observe goods and the containers that carried the goods, but now the flow of goods has become enormous and terrorists have become more inventive. In the fake drugs trade we find the fakes are wrapped as bone fide drugs: they carry the correct holograms and the correct embossed codes, and even the correct RFID – thus they are easily inserted into the supply chain. Some say that all components of assemblies ought to carry tags that can be scanned by technology. This should aid compliance with several 'laws' – of Intellectual Property Rights (only compliant manufacturing can authorise the goods), of build quality (only accredited parts will comprise the finished item), that container manifests comprise only accredited goods (since the container's own RFID will compile a manifest and keep it up-to-date), that the container has not been broached since packing (the same intelligent RFID), and so on. However, in the case of fakes the manufacturer can make so much profit that they can afford to buy-into the official supply chain: a purchase here, a bribe there... and thus they become authorised by the US authorities to pass their goods into the 'Green Lane'.

The Container Security Initiative (CSI) actions as noted in Figure 1 are pre-emptive actions in overseas ports which should ensure that containers are 'clean' before loading. It is implicit that cleared containers ought to be able to pass into the US along 'green lanes' not stopping at customs checkpoints (SST, 2003) so facilitating the trade of bona fide goods, but trapping fakes. But we think the US was more terrified about 'bombs' than fakes, so it has been less concerned about the "official faker" and more about detecting explosive material. The consequences of a terrorist activated WMD (weapon of mass destruction) in a US port area, or the exploding of a boat in a port approach is minimised, if not completely nullified. Estimates suggest that a WMD explosion and the resulting port closure could cost \$1 trillion, while a twelve-day closure following a discovery of an undetonated WMD could cost \$58 billion (O'Hanlon, 2002; Gerencser et al, 2002). But to be fair, the US has also researched the technology that detects illegal bodies in containers (the sex slave trade), and attempted to reduce the purchases of bone fide businesses to fake the 'green lane' process.

Smartening-up containers

These are (usually) containers with active RFID sensors which gather in-transit information in real-time to communicate, for instance, the container's status throughout its transit. Information relayed from the RFID system can be used to compare the electronic manifest to the physical goods in the container, sounding an alarm if there is a discrepancy, and to pinpoint the geographic point of intrusion.

Firms using smart containers have to ensure that container shipment data are kept confidential. But Giermanski concluded that RFID is inadequate in almost every way for the needs of global container security. Its use is certainly understandable for retail and warehouse controls, and in any situation where one can control infrastructure and location. He suggests that large globalised firms may have jumped prematurely on the RFID bandwagon, and many of those companies now want the U.S. government to support their RFID investment. He

believes the future of global container security is not RFID, but is satellite (Giermanski, 2007).

RFID market value & forecasts

In 2002 the RFID market was approximately \$1 billion and in 2007 was about \$4.19 billion, predicted to reach \$10 billion in 2010 and possibly exceeding \$36 billion by 2015. According to Vandagraf International, an RFID consultancy, a part of the market is being driven by the ability to create simple label tags. But stock management is still not well done: *Business Insights* (2005) said "... despite spending \$15 billion on supply chain software US companies had more than \$1 trillion of inventory which sat idle at the end of 2002".

RFID tags need to reach the five-cent-per-chip price point that is considered to be the threshold where RFID will really take off. Even at their present cost, Harrop & Das (2007) of IDTechEx, Cambridge UK, say that almost three times the volume of RFID tags were sold in 2006 than over all the years since their invention. Primarily because retailers and the military are demanding that suppliers fit tags to pallets and cases to save costs through improving services; and many other applications are growing very rapidly – for instance, the car-key tag.

The use of a tag carries a greater cost than a barcode, but the service provided may warrant their cost premium in certain niche uses without possible competition from barcodes. In this case the efficiency gain is obvious (for warehouse management with sensitive products and high security, for example; or driven by military mandate enforcing compliance across global suppliers).

Current usage and prospects

The current logistics market can still be considered proprietary or closed against competition – firms and suppliers buy into global bi-lateral agreements with DHL, UPS, etc. For them the barcode is and will remain for a long time a dominant technology for identification and tracking. It is completely mastered by suppliers and users, and furthermore is very price competitive. It holds the enviable position of the dominant technology. This can only be replaced by a very significant penetration by RFID – but is too costly.

However, in the case of tracking and/or monitoring hazardous, sensitive, or expensive shipments, or managing reusable containers such as pallets or shipping containers, the inherent qualities of RFID tags will lead to their relatively rapid generalization. In these cases the cost of the tags is negligible, given the high down-side cost of mismanagement. But many users do not understand the implementation procedures required for effective tracking which involves implementing coherent [digital] practices by all concerned parties.

A TYPICAL ISSUE (an illustration from Central Asia)

The use of proprietary codes and methods is in conflict with national and global standardisation to facilitate trade, so is in most cases contradictory to the aims and practice of the World Customs Organisation model. Liang and Aldaba (2005), both of the Asian Development Bank, carefully explain that data exchange for trade facilitation requires a combination of country-specific and regional efforts to minimize variety and to standardize data requirements by customs and trade-related agencies. The authors note that among the Regional Trade Facilitation & Customs Cooperation Program (RTFCCP) member countries, only three countries have recently completed the revision of their Customs Codes (Kazakhstan, Kyrgyzstan, and Tajikistan): Azerbaijan and Uzbekistan are planning to bring out their revised Customs Codes soon.

It would seem that the relevant authorities in Central Asia are 'just playing at co-operation' as they 'forget' to mention one or another aspect of compliance in their 'accords' – yet they know, theoretically, that full co-operation will lead to greatly enhanced trade so lead to the alleviation of their widespread poverty. If there is no local harmonization local trade will suffer, and local revenues will not be enhanced through rents from transit traffic if customs procedures are excessively cumbersome. It follows that RFID tracing and tracking would not operate consistently for transit traffic thus defeating an intended use of RFID.

CONCLUSIONS

We have discussed RFID use in terms of trade facilitation and the beneficial affect that RFID might have for Supply Chain Management provided, of course, that the cost of RFID can be reduced to compete against barcode systems. We noted that the US in 2002 implemented strong mandates against terrorism at corporate level down to individual levels. Herein, the US Homeland Act demands that goods are examined at a distance and to do this the originating ports have to apply digital techniques since decision-making is automated and occurs in the security of the US-based computer systems. We conclude that US Homeland Security Act has and is supporting the greater use of RFID. But while the US authorities may be becoming better at containing the fraudulent and the anomic [individual] terrorists it is at a huge cost to originators. They have to bear the costs of capital purchases of RFID equipment or sensors (often from the US or US-firms), the installation and training costs, as well as the operational costs (of machines), and the high cost of more validation personnel.

To work with the US authorities we all have to purchase RFID. Passports with our embedded biometric data become more costly to purchase, and their national data management become more onerous and costly. The ports of embarkation have to set up new systems and use new sensors to scan goods and people - these cause many queues. Individuals too may revolt against the on-costs of RFID passports (cf. REAL-ID cards in the US).

A basic problem for all security systems is that they work through a series of checks which may be circumnavigated by the truly corrupt. Individuals may be bribed to divulge computer codes or to submit false evidence so the systems indicate 'OK'. Eventually the terrorist is caught, but more by 'information supplied by surveillance' than by the direct action of technology. It is on this point that the US and European legislators and police forces differ in their approach. The US relies overly on technology and they say the Europeans are too soft. The Europeans respond, saying that with their many border systems (EU-27) they have to rely on information. Not mandated through the 'whistleblowers' of SOX or by the information from RFID data, but informed through the action of the community, which can defend against the anomic by supporting society. Their 'embrace' can reduce his/her feelings of anomic isolation so immunise them, thus guarding us all against their explosive actions.

Overall therefore we conclude that technology in the form of RFID devices are useful but because of their cost, or mandated imposition, lead to non-compliance so create flaws in the fabric of security. A fact undesired by the US, or indeed by each of us.

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PREPARING TRADITIONAL MANUFACTURING SMES FOR GLOBAL COMPETITION WITH AUTOMATIC IDENTIFICATION AND DATA CAPTURE TECHNOLOGIES

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ABSTRACT

Traditional Small and Medium-sized Enterprises (SMEs) in the manufacturing sector are an important economic factor. Changes in global business are affecting those traditional manufacturing SMEs exceptionally. It is vital for them to be able to offer build-to-order products and to handle an extensive number of different goods with a reliable overview about demand and stock in production and storage, which is often not possible with the existing inventory management system. In this paper, the results of a research activity to determine requirements towards identification technology for supporting the reception of goods and warehousing of traditional manufacturing SMEs are described. The challenges of those SMEs in inventory management, verified by a case study, are discussed and formulated into demands of a suitable Automatic Identification and Data Capture (AIDC) system. The analysis of internal business processes provides another set of requirements towards the system. Thus the proposed solution satisfies the needs of a global market as well as the limited resources of a traditional SME.

INTRODUCTION

Small and Medium-sized Enterprises are the major but often unappreciated force behind Europe's economy. Constituting more than 99% of all enterprises in the European Union, they provide around 65 million jobs and contribute to entrepreneurship and innovation (European Commission, 2007). This is also true for the manufacturing sector, where more than half of all employees work for an SME (Ayyagari et al., 2007, pp. 418 ff.). In many cases European suppliers only persist against the competition from low-cost countries by serving markets with high-tech or customized solutions, which leads to a wide range of products with many varieties (Svensson, 2002, p. 79). Additionally, the chance for traditional manufacturing SMEs to offer their products on a global market or take part in Global Supply Chains requires a permanent ability to quote and deliver. How can they successfully face those challenges and survive in a global context?

Especially traditional SMEs with their history of a small trade often have superior processing capabilities. International competitors countervail this competitive edge with lower prices and particularly with short response times. Hence SMEs which are now manufacturing on an industrial level for a global market or supply chain are forced to support their business processes by using modern technologies (Knight, 2001, p. 159). Therefore, the provision of SME suitable approaches for automated inventory management is the key for success on a global scale.

In this paper, a suitable Automatic Identification and Data Capture framework for inventory management in traditional manufacturing SMEs is developed. Appropriate technologies for the different elements of the AIDC system are selected, based on the specific requirements of the SMEs. The framework is verified in a case study at a traditional German manufacturing SME.

RESEARCH APPROACH

The methodology is based on a case study at a traditional manufacturing medium-sized company (Yin, 2003). The AIDC framework is developed, tested and implemented at the case company. Initially, a literature survey shows the challenges of traditional SMEs in the global market and the state-of-the-art of AIDC usage in this respect. Analyses of material and information flow, as well as interviews at the case company unveil existing problems and requirements towards an AIDC solution. Based on those requirements, the framework for automated inventory management is developed. It includes recommendations for identification technology and warehouse organization. An appropriate AIDC technology for the framework is selected according to the requirements and implemented and evaluated in the form of a demonstrator at the case company.

LITERATURE SURVEY

As for the definition of Small and Medium-sized Enterprises, there is no valid global classification available. Different countries use different criteria to define SMEs, and even the limits in a specific criterion vary between them. However, for the European Union the European Commission adopted a common definition for SMEs, valid from 2005. Thereby, an SME is characterized by the following three criteria (European Commission, 2007):

- Has fewer than 250 employees.
- Has either an annual turnover not exceeding 50 M€ or an annual balance-sheet total not exceeding 43 M€.
- Is not owned by one enterprise or jointly by several enterprises falling outside the definition of an SME for 25% or more of the capital or the voting rights.

For the manufacturing sector of many countries, SMEs are an important source of employment and GDP. Many manufacturing SMEs developed from a small trade, are still family-owned and have a long record of corporate history. The challenges of those traditional manufacturing SMEs in inventory management are in the focus of this paper.

SMEs often develop specific problems, typical for companies of this size. Frequently, work and company organization have little relation to modern concepts of management. Therefore, operative sales and marketing, customer contacts and technical know-how are normally the main focus. The high operative pressure leaves little time for strategic planning, adaption of operational infrastructure to market requirements and supervision of technical and organizational innovations (Schiemann, 2008, p. 12). However, just the adaptation of infrastructure and the introduction of innovations allow small and medium businesses possibilities of automation, formerly only available to large companies (Pfohl, 1990, p. 216). A special challenge for traditional enterprises is

therefore the constant development and adaptation of all processes to external factors (Flocken, 2001, p. 14).

In general, traditional manufacturing SMEs possess certain characteristics, which lead to specific requirements. In many traditional SMEs the process of capturing product data and forwarding it to the appropriate destination, like accounting or warehousing, is still a manual one. With increasing product quantities and varieties this approach becomes slow, cost-intensive and error prone. Mistakes in accounting make frequent stock-taking a necessity. The uncertainty about the quantity stored leads to overstocking and problems to quote. AIDC Technologies, like RFID or Barcodes, can help to achieve the quality of inventory management required for global competition.

Automatic Identification and Data Capture (AIDC) Technologies thus have a major role in preparing manufacturing SMEs for competition in global markets or supply chains. An AIDC System consists of several parts, which include hardware, software and personnel elements (Smith, 2002, pp. 110 ff.):

- The physical object or information to be processed
- The code that identifies the major characteristics of the object or information
- The reader of the code
- The computer hardware, which receives the information from the reader
- The Software that organizes the automatically read information into human-usable form
- The display/printer for displaying the information and printing codes
- The personnel to install and manage the information flow scheme

Those elements have to be organized into a framework, considering the requirements of the traditional manufacturing SMEs

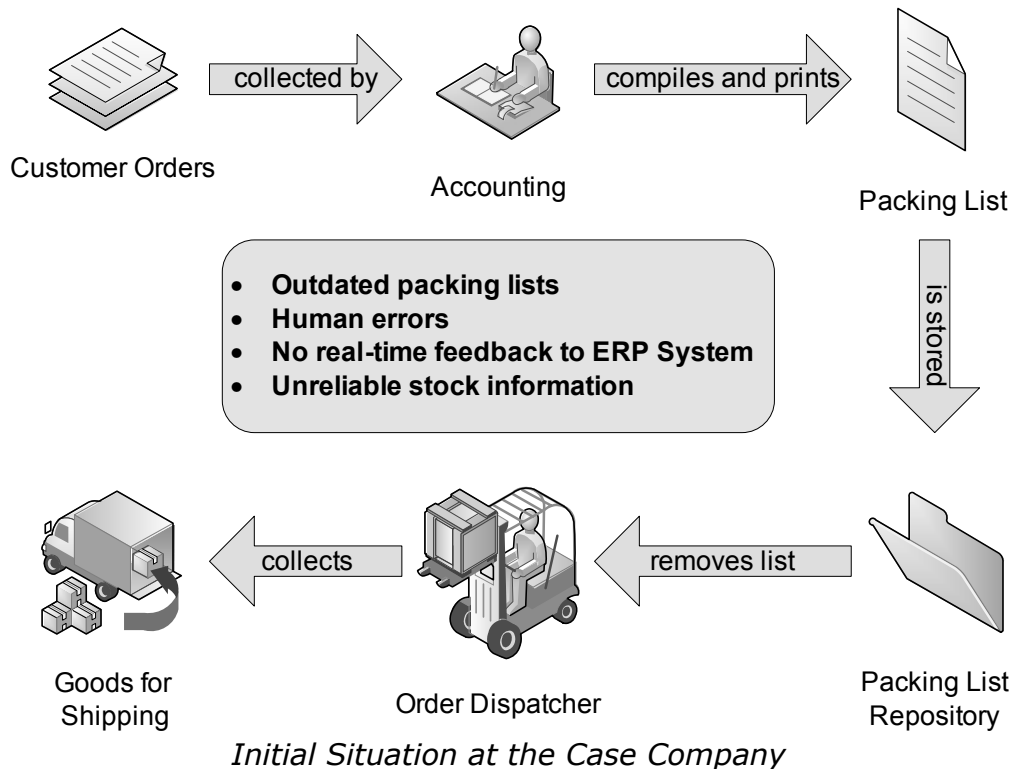
CASE STUDY

To verify the challenges of the global market and define the requirements of an AIDC solution, a case study at a traditional manufacturing SME has been conducted. The analysis is based on discussions and interviews at the company, as well as take-ups of material and information flow.

The case company is one of the leading German rope makers. It has a long tradition as handicraft enterprise and manufactures its products today in an industrial manner in several European plants for a worldwide market. The portfolio includes over 3,500 different products, many of them modern synthetic-fibre ropes. Besides the manufacturing of series products, the case company is also designing customized, individual products. Starting with a defined set of raw materials, a widespread range of semi-finished products with different qualities and properties are produced. These semi-finished products are combined with respect to the current order to provide various customer specific end-products. The multi-site operation combined with the sheer number of different products thus creates an enormous challenge for the inventory management.

Analysis of material and information flow show, that after receiving a customer order, the structure of the requested end-product has to be defined according to

the bill of material to be able to identify the required product contributions in terms of identity and amount of raw materials and semi-finished products. In the second step, the availability of the needed resources basing on the stock has to be verified to be able to plan procurement transactions for raw materials and internal orders for the production of semi-finished products. The in-process availability of raw materials has to be checked manually in monthly time-consuming counting procedures. In consequence, current stocks cannot be evaluated continuously in real-time - information is updated monthly and therefore only reliable for one day. For this reason, the resource planning considers additional safety stocks for raw materials and semi-finished products.



A couple of ABC-analyses were conducted regarding the composition of the warehouse. About 10% of the raw materials and 20% of the intermediate and end products hadn't been moved for more than a year. The stock represents in extreme situations a value of 50% of the annual turnover. The warehouse is not structured after the turnover rate of the products and thus accounts for additional distance and time consumption.

Another problem which turned out during the discussions is the manual picking process, using packing lists. The packing lists are eventually printed a couple of days before picking and can be outdated because of subsequent material movement. Additional errors can occur while reading the lists, packing the products and re-entering the data into the company's ERP system. An in-depth analysis showed that about 18% of the packing lists contain wrong stock grounds.

According to the interviews and analyses, the following requirements were defined for the case study's AIDC framework:

- Low probability of errors
- Robustness
- Unique identification
- Easy to implement and to use
- No interference with products or stock grounds
- Use of existing systems

The objectives for the demonstrator are the introduction of an AIDC system, optimization and digitalization of the picking process and automated accounting of stock changes during packing.

AIDC FRAMEWORK

The AIDC framework developed in this paper describes an approach to successfully implement state-of-the-art identification technology in traditional manufacturing SMEs. It is based on the fundamental components of AIDC systems, the requirements of the SMEs and the constraints of the supply chain, such as standardization.

As the framework is developed for traditional SMEs from the manufacturing sector, the objects of identification physically exist. For inventory management, primarily the products, raw materials and supplies have to be considered. In this context, the relevant information to be captured includes type and quantity of the object, as well as time and place of storage. In a supply chain, the process of receiving and delivering has also to be supported. Thus the identifiers for the framework must have the possibility to be fixed on the object or its package.

A great number of different identification systems are available today. AIDC technologies include (Hill, 2000, p. 270):

- Bar Code
- Optical Character Recognition
- Radio Frequency Identification (RFID)
- Machine Vision
- Magnetic Stripe
- Smart Cards
- Touch Memory
- Voice Data Entry
- Radio Frequency Data Communications (RFDC)

Recently biometrics have been added to this list. Remembering the requirement of the identifier to be fixed on the object and contactless reading for robustness in a manufacturing environment, only barcodes and RFID are appropriate technologies available at the moment. The decision for one of them has to depend on several points in the individual case:

- The nature of the object (mass product, customized product, bulk good)
- The SME environment (limited resources and knowledge, small scale)
- The needs of the Supply Chain (standardization, traceability)
- The information to be captured

The selection of any AIDC technology limits the range of possible readers, but there are still some issues to be decided upon. For many technologies it is possible to have stationary or mobile reading devices. The readers can transfer the data via cable or wireless. Apart from the reading function, some devices include more or less sophisticated data processing capabilities. In a traditional manufacturing enterprise, where still most stock-keeping is done manually, portable devices will most often be the first choice. Along with that, a wireless infrastructure offers the most flexibility. How much data processing is needed at the reader depends on the individual case again.

After an object is identified and its data captured, the obtained information has to be processed and converted into a useful form. This can be done by organizing it into a human-readable format, which is not helping automation. Better would be electronic processing, like transferring it directly into the SMEs ERP-System. In the latter case, the existing hard- and software could eventually be used.

It is often necessary to offer a display for the information, which e.g. was formerly available on paper. This provides the ability to control and check the automatic readings and correct them, or enter data manually if an object is not equipped with an identifier. This can be often the case in an SME environment, a label code printer would thus also be useful.

When introducing AIDC technology into an SME, the existing personnel and their skills have to be involved. Especially in traditional SMEs, many employees do not have experience in using IT solutions. It is important to keep the system easy to understand and intuitive to use.

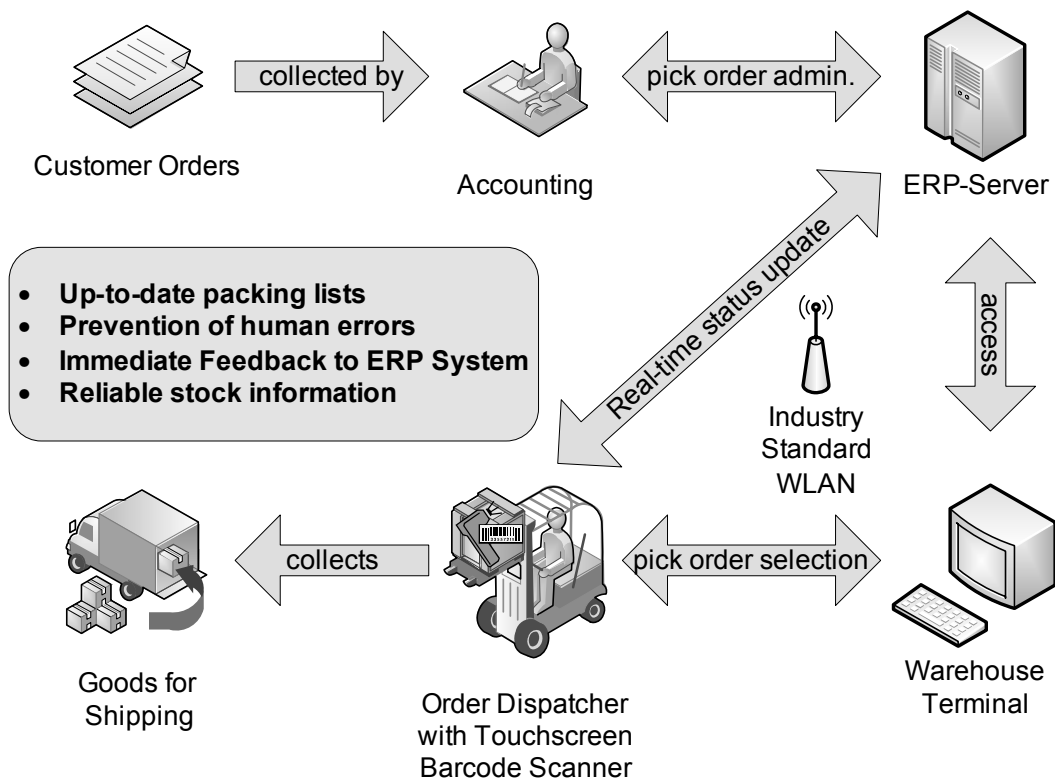
DEMONSTRATOR

A demonstrator has been developed after the defined requirements and installed at the case company's warehouse. According to the objectives it supports the picking process by automating the bookings in the ERP system. According to the AIDC framework, the utilized components are mentioned below.

The objects of identification are the end-products, mainly ropes on reels. Information to be captured includes the type of rope, the quantity, the weight and the stock ground. The AIDC technology used is Barcode, on the basis of several reasons. The majority of the products already had a Code 128 label on them, which hadn't been used before. Code 128 is a high-density alphanumerical barcode symbology, used in supply chains world wide. It is used in the EAN128 application standard, allowing the user to encode additional data by using so called Application Identifiers. Thus the case company could use the existing labels for their purposes, avoiding high conversion costs.

Therefore, the reading devices could be standard industrial barcode readers. They had to be portable for the order dispatcher inside the warehouse. As they should also replace the packing lists, it was decided to choose a reader with a touch screen. Thus they are able to display the items to be packed and their location in the warehouse. Additionally, the touch screens can be used to enter products weights or missing articles. For mobility reasons WLAN was selected for data transfer.

The warehouse hadn't been part of the SMEs LAN until then. To avoid massive network infrastructure installs, it was decided to cover the whole warehouse by standard IEEE 802.11g secured WLAN. In this way, the barcode readers are constantly connected to the company's existing ERP system. The ERP system is used to display the items to be packed on the reader's screen and the scanned information is transferred back to the system. Additionally, a touch screen terminal has been placed inside the warehouse, allowing the order dispatchers to see the remaining orders and their priorities.



Situation at the Case Company after Application of the AIDC Framework

The case company's order dispatchers had no experience with AIDC supported picking until then. However, the use of touch screens and intuitive user guidance made it easier for them to adapt. The required training only took a few days and generated a high rate of acceptance in the staff. Outdated packing lists could be eliminated by providing up-to-date online stock information. Packing errors are prohibited by alerts when scanning the wrong product and weight comparison of the whole order. False stock positions can be reported immediately and there is no danger of making mistakes when manually transferring data.

CONCLUSIONS

In a literature survey, the challenges of traditional manufacturing SMEs in the global economy were identified. Important issues are the adaptation of processes and support of innovation towards the modern economy. Additional requirements come from the case study of such an SME. In demand is a low-cost, easy to use AIDC system, based on industry standards. On this basis, a framework for AIDC implementation in traditional manufacturing SMEs has been developed and applied at the case company.

For the case company, the demonstrator yielded good results and adaption of the AIDC framework for all warehouse processes is planned. In this way, the costly monthly stock-takings could be avoided. In the future, lowering of stocks may be possible by identifying fast and slow selling items and sales forecasting. The structure of the warehouse could be adapted, to reduce distance and time consumption. Use of the identification technology in the supply chain is supported by using a standardized barcode system.

The literature survey and the case study have shown that the challenges faced by traditional manufacturing SMEs today require innovative approaches and improved process handling. For the area of logistics in general and warehouse management in particular, AIDC technologies can help to reduce error rates and enhance processing speed. By this, a real-time overview of the stock is made possible, which is the basis for better planning and stock reduction. On this foundation, global competition and participation in global supply chains is supported.

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IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) COST IN TOTAL LOGISTICS COST OF THE SERVICE SECTOR IN DEVELOPING ECONOMY

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ABSTRACT

The paper examines the corollary between ICT and productivity on one hand and profitability, on the other hand, with a view to knowing the extent at which ICT can enhance adequate, prompt and accurate customers' satisfaction without consequence on the firm's profitability.

The research employed multistage sampling techniques in the selection of Banks used for this study, therein, adopted a Cobb-Douglas production function in analyzing various components of ICT costs in the Banking sector in most populous black Africa country.

The result revealed positive, but weak relationship between investment in ICT and productivity, but inverse and insignificant relationship with profitability on the other hand. The implication of this is that banks in developing economy spend more on ICT relatively to training of staff and ICT development and maintenance, consequently, reduce the level of profitability, but enhance productivity.

The paper recommended, amongst many others, that adequate and accurate orientation in the use of these devices by customers, such that customers' service would not only be achieved, but at minimal cost and simultaneously having a competitive advantage over and above their contemporaries.

Key Words: Information and Communication Technology, Total logistics cost, service sector

INTRODUCTION

The application of information and communication technology concepts, techniques, policies and subsequent implementation strategies to all aspects of development at National regional and international levels, as well as, life style has become a subject of fundamental importance and concerns to all nations (Landon and Landon, 2001).

Similarly, Adetayo et al., (1999), Boyett and Boyett (1995) emphasized on the corollary relationship between business and ICT. They ascertained that in order to succeed in the dynamic world, companies must take not only traditional actions such as lowering cost, but keep pace with ever changing capabilities of ICT. It is in the light of this, that Harold and Jett (1995) contend that for financial organisation to remain viable in the present globalization era, they must modify their traditional operating practice.

In a related manner Ibrahim (2005) identifies various areas in which the application of information technology to Banking Services has assisted management. These include corporate planning. Control asset and liability management, legal service and manpower development. All these have assisted in enhancing in value of pay off on IT-investment and invariably banks performance.

In other words, the extent of the use of ICT devices in Banking sector has made new products and service available to customers, to be relevant, adequate accurate and timely that are all embedded in logistics. The identified technologies are computer systems, automated teller machines, electronic data transfer, electronic data interchange, magnetic link character reader, local area network, wide area network, electronic home and office banking and telephone banking. However, empirical study revealed that the most significant shortcoming in the banking industry today is a wide spread failure of staff in senior management cadre to comprehend the importance of technology and subsequently incorporate it into their strategies plans. Hence, this has a multiplier effect on promptness, effective and efficient service delivery that all negates the tenets of logistics.

For instance, in Nigeria, despite the recapitalization exercise of Banking sector that consequently propelled high investment rate of ICT in this sector, there is need to confirm the hypothesis of positive and linear relationship between high investment rate and productivity as well as profitability (Adewoye, 2007).

METHODOLOGY

The focus of this paper is on insured bank. The south west is selected for the study on the basis of the clustering of the banks. The commercial banks were stratified into two: Old and New generation banks. Out of 75 insured banks in Lagos, there are 9 old generation and 66 new generation banks. Using ratio method, 1 old generation bank and 7 new generation banks were selected for the study in Lagos. In all 8 banks were sampled. The choice of the selected old generation banks predicated on the fact that they has been in operation for ages and has consequently, built up a wealth of experience in the banking industry. This is equally in line with new generation with high level of technological sophistication that is reflected in their banking facilities and number of branches. Questions asked were basically in profitability, productivity and as well as inherent cost of the ICT and related to total logistics, which include that include investment, maintenance, and training costs.

In the analysis, a production functions in line why the Cobb – Douglas function was written for the paper thus:

$$Y = f (X_1, X_2 \dots X_n) \dots \dots \dots \text{eqn 1}$$

$$Y_i = \alpha + \beta_1(X_1) + \beta_2(X_2) + \beta_3(X_3) + \beta_4(X_4) + \dots \dots \dots \text{eqn 2}$$

Explanation of variables

$Y = \text{output}$

$X_i - X_n = \text{inputs}$

$\alpha = \text{constant}$

$\beta_n = \text{slope of the variables}$

These Cobb – Douglas functions parametise the relationship between dependent variable (Y) and the independent variables (X_1 X_n). To make relative comparisons about contributions to output, and the resulting marginal product, the function is linearised by taking logarithms of equation 2 and adding an error term. This is done by using a system of five equations, one for each year as follows:

$$\begin{aligned} \text{Log}(y) = & \alpha + {}_1\text{Log}(X_1) + {}_2\text{Log}(X_2) + {}_3\text{Log}(X_3) \\ & + {}_4\text{Log}(X_4) + e \dots\dots\dots \text{eqn 2a} \end{aligned}$$

Where Y, X_1 , X_2 , X_3 , X_4 , β_1 , β_2 , β_3 , and β_4 are defined in equation (1 and 2) and Σ is the error term. These equations were used to explain relationship between the dependent variable (productivity and profitability and the independent variables (IT-Investments)

IMPACT OF ICT INVESTMENT ON PRODUCTIVITY AND PROFITABILITY

The study examined the contribution of ICT toward firm-level productivity that subsumed accuracy, adequacy and promptness that are all embedded in logistics in banking industry, moving from the productivity perspective, where the focus is on ICT as an enable of internal effectiveness, to profitability study, which is concerned with the question of whether IT investment have contributed to firm profits or not. In otherwords, the major tenet of this research predicates on adequate and accurate customers' satisfaction, simultaneously with profitability. Such that the right product to the right customer at the right time as efficient and cost-effective as possible could be harnessed and attained (Somuyiwa, 2007).

For the analysis. This paper use the total of loans and total deposits and net income for each of the 5 years (2003, 2004, 2005, 2006, 2007) as representatives of output.

The main results were obtained through a weighted 2 step least square estimation of the system of equation.

Multiple regression generated from the Cobb-Douglass production function was used to test the hypothesis for the profitability analysis, the paper employed two measures that banks commonly use as indicators of profitability. These are Return on Asset (ROA) and Return on Equity (ROS). The SPSS results incorporated in the Cobb Douglas production function in which Return on Equity and Return on Assets were dependent variables (y); while ICT Capital, ICT labour, Non-ICT Capital and Non-ICT labour were the independent variables respectively.

Multiple R =.521 This showed that the parameters here little or no significant effect on each other, thus they are weakly correlated. R^2 , the multiple coefficient of determination was 0.2714 implying that only 27 percent (27%) of the total variation in Y was explained by ICT capital, ICT labour, Non ICT Capital and Non ICT labour.

Table 1.1

R	R-Square	Adjusted Square	F	Sign
0.521	0.2714	0.0112	0.202	0.936

Source: Output results of Cobb-Douglas function based on authors' fieldwork, (2007)

On the other hand the results of two-stage least square for the productivity is present in

Table 1.2

R	R-Square	Adjusted Square	F	Sign
0.6982	0.4875	0.0211	0.623	0.881

Source: Output results of Cobb-Douglas function based on authors' fieldwork, (2007)

Similarly, in the analysis of variance, $F = .623$ and $\text{Sig } F = .881$. Here the explained variance R^2 was 0.4875 and was adjusted some that lower to 0.0211. $F(0.623)$ was lower than 0.881, then it confirms that ICT investment make zero contribution to and not significant to profitability but positive contribution to productivity. The implication of this is that Banks in developing economy spend more on ICT relatively to training of staff and ICT development and maintenance, consequently, reduce the level of profitability, but enhance productivity.

CONCLUSION

The paper has shown the importance of ICT labour in the overall productivity and profitability of the analysis banking industry. However, while, it has been established that ICT investments make positive and significant contributions to productivity it made zero or no contribution to profitability. This is as result of socio-economic and environment factors which include training cost which is exorbitant, because of job mobility in the coming that is high as a result of inadequate job security. Others are ICT maintenance cost, maintenance of the existing system (ICT) and development of a new devices that are alien to our socio—cultural and environmental beliefs.

RECOMMENDATION

In the light of the above, the paper having realized the importance of ICT in the total logistic cost of service sector, proposed that memorandum of understanding between workers and establishment that should be revisited, such that it will reduce job mobility and training cost will be reduced. Again, maintenance culture should be adopted and imbibed. Above all, there should be adequate and accurate orientation in the use of these devices by customers such that customer's service would not only be achieved, but at minimal cost and simultaneously having a competitive advantage over and above their contemporaries, in which logistics is known for.

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RFID IN SUPPLY CHAINS: LITERATURE REVIEW AND AN AGENDA FOR FUTURE RESEARCH

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ABSTRACT

Recent advances in RFID technology, a reduction in costs and improved performance has precipitated a surge in Radio Frequency Identification Technology (RFID) activity in industry. There has been a similar escalation in the number of articles discussing RFID. Initially publications were restricted to mainly trade journals, newspapers and Internet sites. More recently, we note publications describing RFID research appearing in academic journals. Our review of literature identifies four distinct and interrelated RFID themes such as Physics, Applications, Benefits, and Challenges. We propose a research agenda that embraces the relationship between these themes and their impact on organisational preparedness.

INTRODUCTION

Radio Frequency Identification (RFID) is a recent innovation gaining interest due to technology advances, improvements in the Internet, reduction in costs and promising benefits for supply chains (Angeles, 2005). RFID is defined as a means of automatically retrieving and storing information about an item through electromagnetic transmission to radio frequency (RF) compatible circuits (Chiesa et al., 2002). Several world class organisations including, Wal-Mart, Tesco, Carrefour, and Metro, and USA Department of Defence (DoD), have been investigating RFID's potential to improve their supply chain's performance (Jones, Clarke-Hill, Hilliar, and Comfort, 2005).

There has also been a corresponding increase in RFID articles. Initially articles began to emerge in trade journals, (Materials Handling and Distribution, 2006), and Internet sites (www.rfidjournal.com, 2005). Those with a vested interest produced articles arguing the imperative for organisations to implement RFID or be left behind (Smith, 2005). However, scholarly papers have recently emerged including a focus on applications and empirical studies. Literature can be categorised into the following themes: RFID Physics, Applications, Benefits, and Challenges. The purpose of this paper is to review literature relevant to RFID in a supply chain setting and provide comment regarding future research directions.

PHYSICS

Literature provides a chronological account of evolving RFID physics beginning by comparing the emergence of early RFID technology with radio and radar technologies (Buderer, 1999; Shepard, 2005). Landt's (2001) history of RFID, provides a 20th century rendition and an expose of early technical information (Landt, 2001). The arrival of computers, advancement in integrated circuits and lasers, and digital data networks during the 1960's explains an important era

progressing rudimentary RFID physics to commercial opportunities (Shepard, 2005).

Most sources discussing RFID describe some detail about the physical structure of RFID. For example, Finkenzeller's (1999; 2003) RFID handbooks provide comprehensive details of algebraic theories, tag construction, operating and physics principles, electromagnetic theory, frequency theory, and system architecture. However, most literature sources are more inclined to discuss RFID in layman terms of tags, readers, antennas, frequencies and software (Asif and Mandviwalla, 2004; Lewis, 2004; Sweeney, 2005). These are the central components of RFID technology and must all work in harmony for the entire system to be effective (Wyld, 2006). The *tag*, or transponder, is attached to an object so that information can pass to a reader. *Readers*, also known as interrogators, pick up signals from the tagged products when they pass within range. Both the tag and reader have *antennas* to enhance the sending out and receiving of radio waves. Radio wave *frequencies* are the communication protocol selected for the tag and reader to exchange information. Ultra High Frequency Band (UHF) has been identified as the most suitable band for supply chain applications. Finally, literature discusses developments in the *software* associated with RFID technology (Asif and Mandviwalla, 2004; Lewis, 2004; Sweeney, 2005).

APPLICATIONS

Advances in both RFID technologies and Internet technologies have prompted a focus on open system models. EPCGlobal networks appears to be the more favoured architecture (Schuster, Allen, and Brock, 2007; Srivastava, 2004) when considering open systems infrastructures. EPCGlobal, a merger between European Article Numbering (EAN) and Uniform Code Council (Asif and Mandviwalla, 2004), has been developing RFID applications for supply chain environments for several years. Recent interest in RFID has resulted from EPCglobal's ambitious vision to develop an RFID enabled network (Sweeney, 2005). EPCglobal networks are designed to facilitate an EPCGlobal system whereby unique and registered EPC tags are attached to every product on their system. An Internet network connects local servers with object home pages enabling quantity, quality and timely information about product locations to be available to registered members moving products throughout the world (BITKOM, 2005; Schuster et al., 2007).

Recent literature focuses on retail supply chain applications. For instance, retailers (groceries, apparel, furniture, fast moving consumer goods, and pharmaceuticals) (Angeles, 2005; Mohsen, 2007), retail wholesalers and distribution centres (Jones et al., 2005), manufacturing (Sheffi, 2004), and logistics service providers (shipping, transportation and airfreight) (Choy, Chow, Lee, and Lau, 2005). RFID trials at Wal-Mart have been well-publicised. Wal-Mart is recognised as the largest retailer in the world and a prominent leader in the adoption of cutting edge technology (Sheffi, 2004). In 2003 Wal-Mart mandated its top 100 suppliers to install RFID technology and apply tags to cartons by January 2005 (Srivastava, 2004). Implementation proved difficult and many unprepared suppliers were granted a time extension to implement RFID (Twist, 2005). Suppliers encountered high costs and poor technical support. Many suppliers adopting a 'slap and stick' approach whereby tags are stuck on cartons with no costly technology involvement (Narsing, 2005). Wal-Mart's trials were studied by the University of Arkansas and stores installed with RFID statistically outperformed stores without RFID in terms of

'on shelf availability' demonstrating in a 14% reduction in out of stock products (MHD, 2006). Large European retailers including Sainsbury, Marks and Spencer, Tesco, Carrefour, and Metro Group are also currently involved in RFID trials (Jones et al., 2005; www.smart-rfid.eu 2008). The Department of Defence (DoD) has also been examining RFID potential to improve inventory management after a number of highly publicised problems with ineffective inventory management (Asif and Mandviwalla, 2004; Gilligan, 2004).

Research into EPCGlobal network applications in retail supply chains indicate mixed results. To illustrate, one study investigating the effect of EPCGlobal network on eCommerce found improvements in shipping, receiving and put-away processes (Wamba, Lefebvre, Bendavid, and Lefebvre, 2007). Results of a survey in a 3PL setting found similar results with reductions in inventory levels, out of stock levels, delivery times, and costs (Chow, Choy, and Lee, 2007). However, using a number of economic factors within an EPCGlobal setting another study found RFID economically viable *only* at pallet level (Bottani and Rizzi, 2007). In Australia, pilot studies known as the EPC Network National Demonstrator Project (NDP) (GS1, 2006) and the NDP extension project (GS1, 2007) yielded mixed results. A number of quantifiable efficiency improvements including productivity gains of between 14% and 22% were reported (GS1, 2007). However, participants acknowledged difficulties with tags not working on wet pallets, readers not compatible to Australian standards, read distances varying and different readers displayed different results with the same tags. CHEP, one of the primary participants conceded they would not proceed with implementation as previously intended (GS1, 2007). EPCGlobal applications are only in pilot study mode throughout the world.

Authors	Benefit
(Heinrich, 2005; Karkkainen, 2003; Lekakos, 2007; Lewis, 2004; Mohsen, 2007; Ngai et al., 2005; Sweeney, 2005)	Faster processing (efficiency)
(Angeles, 2005; Bardaki, Pramadari, and Doukidis, 2007; McFarlane, 2002; Mohsen, 2007; Narsing, 2005; Sweeney, 2005; Twist, 2005)	Increased information accuracy Increased tracking capability
(Sellitto, Burgess, and Hawking, 2007)	Information quality
(Kelepouris, Pramadari, and Doukidis, 2007)	Improved traceability
(Heinrich, 2005; Mohsen, 2007; Narsing, 2005; Ngai et al., 2005)	Increased inventory visibility
(Angeles, 2005; Heinrich, 2005; Karkkainen, 2003; Lewis, 2004; Narsing, 2005)	Decreased inventory levels
(AMR Research, 2005; Choy et al., 2005; Fish and Forrest, 2006; Fleisch and Tellkamp, 2005; Karkkainen and Holmstrom, 2002; Vijayaraman and Osyk, 2006).	Reduced out of stock
(Twist, 2005)	Increased inventory turnover
(Jones et al., 2005; B. Srivastava, 2004); (Lewis, 2004; Narsing, 2005)	Decreased Inventory shrinkage
(Heinrich, 2005; Jones et al., 2005; Karkkainen, 2003; Lewis, 2004; McFarlane, 2002; Narsing, 2005; Ngai et al., 2005; Twist, 2005)	Lower labour costs
(Asif and Mandviwalla, 2004; Bardaki et al., 2007)	Elimination of bullwhip effect Sharing information
(Sellitto et al., 2007)	Time and content value of RFID derived information
(Heinrich, 2005; Karkkainen, 2003; Lewis, 2004; Narsing, 2005)	Prevention of counterfeiting
Angeles 2005	Process freedom
(Jones et al., 2005; Ngai et al., 2005)	Improved customer service

Table 1. Potential Benefits of RFID Technology

RFID BENEFITS

A review of literature between 2002 and 2006 employing content analysis indicates benefits as the main driver for adopting RFID technology (Bhattacharya, Chu, and

Mullen, 2007). Literature describes a sizeable number of benefits (see table 1). One of the main incentives for adopting RFID is the reported relative advantage over Barcode technology. Unlike barcodes, RFID facilitates continuous information, more accurate information, simultaneous reads, read without opening case, more data stored on a tag, ability of some RFID to record data such as temperature and humidity (Sheffi, 2004). Some RFID tags have both read and write capabilities (Knosp and Pohl, 2004; Li et al., 2004; Shepard, 2005). RFID does not require line of sight between reader and tag (Knosp and Pohl, 2004; Shepard, 2005) and can operate in harsh conditions (Song et al., 2005). RFID also has the ability to incorporate anti tampering capability (Sheffi, 2004). However, 'experts' are divided when considering the likelihood of RFID replacing barcodes. Sources suggest RFID will only replace barcodes in specific industry sectors, and RFID coexisting with bar codes a more likely scenario (Ngai, Cheng, Au, and Lai, 2005; Zebra, 2005). Others argue high costs of investing in RFID as opposed to barcode technology will impede an transfer (Karkkainen and Holmstrom, 2002; Sheffi, 2004). However, it is also put forward that RFID will eventually replace barcodes (Michael, 2003).

RFID CHALLENGES

Literature also identifies many factors delaying the take up of RFID (See table 2). For example, managerial challenges, organisational barriers, technical limitations, economic constraints, legal hurdles (Curtin, Kauffman, and Riggins, 2007); technology issues, lack of common standards, patents, high costs, and infrastructure issues (Wu, Nystrom, Lin, and Yu, 2006). Drawing on extant technology adoption literature, Brown and Russell (2007) establish the suitability of *technological, organisational, and environmental* (Brown and Russell, 2007) categories impacting on wide spread acceptance of RFID.

Authors	Technological Challenges
(Davenport and Brooks, 2004)	Incompatibility (with ERP systems)
(Loebbecke, 2007; Spekman and Sweeny, 2006)	Too complex (Hard to use and hard to understand)
(Hingley, Taylor, and Ellis, 2007; Narsing, 2005; Srivastava, 2007).	Unreliable (False reads)
(Lewis, 2004; Sweeney, 2005; Twist, 2005; Viehland and Wong, 2007).	Incompatible standards (Frequency numbering, and power standards)
(Angeles, 2005; Lewis, 2004; Ngai et al., 2005; B. Srivastava, 2004; Twist, 2005).	High Data volume
(Asif and Mandviwalla, 2004; Brown and Russell, 2007; Jones et al., 2005; Wu et al., 2006).	High Costs (Tags, hardware and software, infrastructure, training)
(S. Li et al., 2006; Reyes, 2007; Reyes and Jaska, 2007).	Failure to show ROI
	Organisational Challenges
(Attaran, 2007; Fish and Forrest, 2006; Mohsen, 2007)	No support from top management
(Asif and Mandviwalla, 2004; Fish and Forrest, 2006; Sharma et al., 2007).	Failure to invest in IT resources
(Angeles, 2005; Jones et al., 2005; Narsing, 2005).	Organisational Size (Large have the resources)
	Environmental Challenges
(Bednarz, 2004; Hingley et al., 2007; Loebbecke and Huyskens, 2006; Murphy, 2003; Reyes, 2007; Sullivan, 2004b).	Industry Forces
(Bumbuk, 2005; Knosp and Pohl, 2004; Oswald, 2006; Smith, 2005)	RFID and Security
(Angeles, 2007; Atkinson, 2004; Potter, 2005).	Consumer Privacy

Table 2. Challenges for RFID Technology

Technological factors include compatibility, complexity, standards, data volume and costs. For example, RFID will not operate unless it integrates with other systems including Enterprise Resource Planning (ERP) Systems (Davenport and Brooks,

2004). An unacceptable level of false reads is exacerbating compatibility issues (Dew and Read, 2007). False reads are attributed to interference from water or metal, or other technologies operating in the same environment (Angeles, 2005). Frequency, numbering, and signal strength standards are often incompatible and attracting adverse attention (Lewis, 2004). A review of literature also indicates high costs are an issue impacting adoption patterns (Brown and Russell, 2007; Dew and Read, 2007; Jones et al., 2005). Return on investment (ROI) is difficult to predict and considered a barrier to adoption (Li, Visich, Khumawala, and Zhang, 2006; Reyes, 2007; Reyes and Jaska, 2007). Literature also identifies organisational factors influencing RFID adoption intentions. For example, organisational readiness (Asif and Mandviwalla, 2004), financial readiness, technological readiness, top management support (Sharma, Citurs, and Knonsynski, 2007). Organisational size (Vijayaraman and Osyk, 2006) is discussed with larger organisations more likely to find the necessary resources. Finally, environmental factors including industry forces (Loebbecke and Huyskens, 2006), security concerns, and privacy issues (Smith, 2005) are an influence on RFID adoption intentions.

RESEARCH AGENDA

Some of the recent studies have addressed the issue of research agenda in RFID. For instance, Curtin, Kauffman, and Riggins (2007) proposed future research under three themes such as the development, adoption, and implementation of RFID; using, supporting, and evolving RFID within organisation; and the impact of RFID on individuals, organisations and markets. Research proposals from other sources include modelling, the use of simulation, examining implementation, security, ordering rules, innovative ways to apply RFID (Prater, Frazier, and Reyes, 2005), adoption and diffusion comparison, standards, data warehousing models, integration with enterprise systems, prototype applications, ROI models (Asif and Mandviwalla, 2004), information flows, transparency and real time distribution, supply networks, and physical material flow (Auramo, Aminoff, and Punakivi, 2002).

We propose a research agenda focusing on the impact of RFID on supply chain performance. This research highlights the relationships between factors impacting on the intention to adopt RFID technology (technology, organisational and environmental factors) and improvement due to the newly created benefits. A more holistic model is required to reflect on organisational readiness for adopting RFID. Our review found no evidence of organisational preparedness in RFID research agendas. There appears to be a gap in the literature. Organisational preparedness fits between the adoption decision and continuous effort to overcome the challenges (Figure 1).

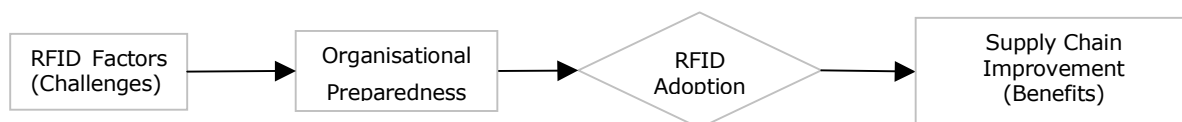


Figure 1: Research Proposal

CONCLUSION

Our review of literature identifies four distinct RFID themes (Physics, Applications, Benefits, and Challenges). These themes are interrelated. For instance, there are evidences suggesting at some point in the future, technical advancement (physics)

will overcome challenges (Reyes and Jaska, 2007) and benefits will then enable performance improvements. However, applications in the form of EPCGlobal networks are unproven. Therefore 'pre' adoption activities are an important consideration for research attention. This 'initiation process' (Rogers 2003) precedes adoption activity and diffusion throughout industry. We propose a research agenda that embraces the relationship between antecedent factors and their impact on organisational preparedness. This research would be suitable for other emerging technologies.

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DYNAMICS OF RSI: EVIDENCE FROM RFID ADOPTION

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ABSTRACT

Do relationship specific investments (RSI) actually matter? Academicians have shown that the scope and size of relationship specific investments (RSI) determines the governance structure. We argue that not only the scope and size of relationship specific investments (RSI) but the specificity of the investment matters. We adopt a dynamic view of investments between two parties to understand how the specificity of an investment such as RFID moulds of nature of longstanding relationships.

We develop a theoretical framework which views RFID investments from the perspective of relationship specific investment (RSI) theory. While RFID has received enormous attention from industry practitioners and media, few theories have been applied to this technology.

Radio Frequency Identification (RFI) technology is a leading edge technology which is increasingly being adopted in a wide range of scenarios. Radio Frequency Identification (RFI) technology has gained a great deal of popularity in the past few years. The technology uses radio waves to track assets, manage inventory, and share information using tags which can be detected by readers. Mandates issued by large retailers, decreasing costs of RFID tags and antennas and the drive towards the standardization of RFID technology has provided an impetus to the adoption of the technology. However several issues such as the sharing of costs amongst suppliers and buyers, accuracy in the detection of tags and concerns for privacy place a question mark on the widespread adoption of the technology. Using this technology enables one to automatically and uniquely identify objects or people. RFID tags can hold much more information than barcodes and have greater data capture (without line of sight requirements) since the information is transferred through radio waves.

The adoption of Radio Frequency Identification technology requires substantial amount of investment by the parties involved. Taking a cue from the previous literature, we explore the importance of 'highly specific' and 'capital-intensive' investments such as RFID and their impact on the economics of relationships.

Unlike barcode technology which is cheap and widely prevalent, RFID technology requires high capital investments and a commitment to a particular solution. Implementing a fully functional RFID system incurs multiple costs, including tags, readers, printers, middleware, infrastructure, consulting, R & D, system changes, implementation, training, change management, and service provider fees. There is additional cost for labor which is invariably required for RFID deployments. RFID tags are able to sense radio signals sent by RFID readers.

Using case studies – the world's largest retailer and aeronautical manufacturers and interviews with key personnel from the industry we explore the adoption of RFID technology in supplier network and the importance of "asset specific" investments such as RFID and their impact on evolving relationships. We explore how these investments have made the relationships between supplier and customers more specific, changing them from an arms-length contracting to a strong relational bond. We also develop an economic model to understand the economics of RFID implementation. From the academic view, this paper contributes to the RSI literature and provides a theoretical basis for RFID implementation.

INTRODUCTION

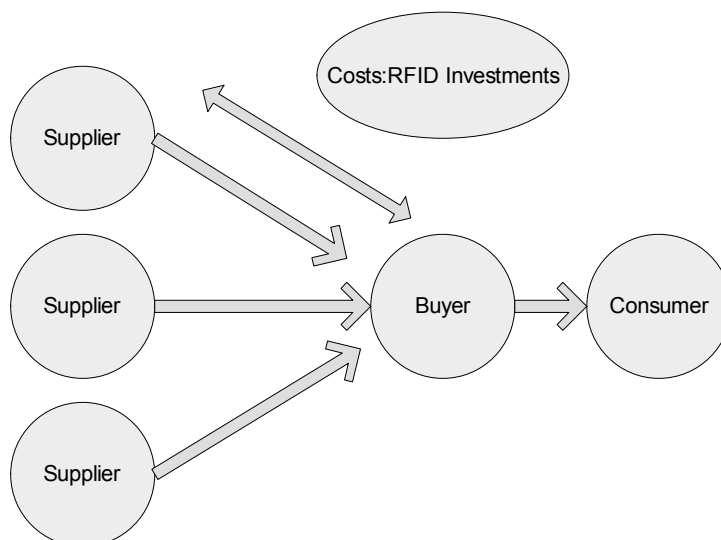
Technologies include "the hardware, software, and network investment and design to facilitate processing and exchange" (Bowersox et. al 1995). Examples of technology which provide a competitive advantage include RFID, EDI, e-commerce, and e-logistics (Zhao, Droge, and Stank, 2001) amongst others. These technologies can decrease costs, improve the management of inventory, order fulfillment timeliness and facilitate the sharing of information between firms (Sanders and Premus, 2005). Radio Frequency Identification (RFI) is one such technology which has been used to improve the management of inventory, order fulfillment times etc. and has gained a great deal of popularity in the past few years. The technology uses radio waves to track assets, manage inventory, and share information using tags which can be detected by readers. Mandates issued by large retailers, decreasing costs of RFID tags and antennas and the drive towards the standardization of RFID technology has provided an impetus to the adoption of the technology. However several issues such as the sharing of costs amongst suppliers and buyers, accuracy in the detection of tags and concerns for privacy place a question-mark on the widespread adoption of the technology. Amongst these issues, who should bear the costs in the implementation of this technology is a primary concern that is addressed in this paper.

The technology uses a tag embedded with a silicon chip and an antenna that enables one to communicate with a reader. Information is transmitted from tagged chips often smaller than the size of a stamp using radio waves. Using this technology enables one to automatically and uniquely identify objects or people. RFID tags can hold much more information than barcodes and have greater data capture (without line of sight requirements) since the information is transferred through radio waves.

The commercial use of the technology began in the 1980s. Several unusual and interesting uses of the technology are being found for RFID technology. It has found widespread deployment in the institutional environment, for access systems in hospitals, public libraries, public transport and toll roads for toll payment, logistics and anti-theft protection. RFID is being used in B2B applications which require repetitive transactions. RFID has found several uses in supply chain management, with suppliers and buyers attempting to make the supply chain mobile. In a mobile supply chain, the goods with the tags are kept stationary while the antennas are mounted on hand-held devices such as PDAs. Information from tags is gathered by individuals carrying these handheld devices. This method is particularly useful in asset tracking, inventory management and stock-keeping. This technology is used to manage supply chains by the automatic identification of products and reduction of errors caused by mis-shipments and loss of inventory.

Unlike barcode technology which is cheap and widely prevalent, RFID technology requires high capital investments and a commitment to a particular solution. Implementing a fully functional RFID system incurs multiple costs, including tags, readers, printers, middleware, infrastructure, consulting, R & D, system changes, implementation, training, change management, and service provider fees. There is additional cost for labor which is invariably required for RFID deployments. RFID tags are able to sense radio signals sent by RFID readers. When a tag receives a radio query it responds by transmitting its unique identification frequency code and data back to the source of the radio signal. RFID tags work either with its own energy source (active system) or without its own energy source (passive system). The radio signals wake up the 'passive tags' and trigger a response. **Theoretical Framework**

The figure below shows the main relationships between supplier and buyer firms and the role of relationship specific investments. Relationships between buyers and suppliers often involve investments which are termed as relationship specific investments (RSI) and yield quasi rents for the firms. Several authors in the field of economics, law and international business have explored relationship specific investments. Prominent and noteworthy studies include the research on relationship specific investments in the Japanese automobile industry (Miwa and Ramseyer 2000; Spencer and Qiu 2001).



Another branch of the literature explores the role of relationship specific investments especially inter-organizational systems (IOS) in buyer-supplier networks and supply chains (Subramani 2004). In this paper, we view RFID investments as relationship specific investments and examine how mandates for adoption of RFI technology influence the relationships between suppliers and buyers.

RELATIONSHIPS

Relationships can be differentiated based on types and magnitude of relationships. Golicic, Foggin, Mentzer (2003) introduce the concept of 'relationship magnitude' or the extent or degree of closeness or strength of the relationship.

Relationship magnitude is viewed as an antecedent to relationship structure type. The relationship structure type - arms length, contractual and integration are adopted by Golicic, Foggin, and Mentzer (2003). Cannon and Perreault (1999) differentiated types of relationships based on the characteristics of expectations of information sharing, degree to which operations are linked, contractual agreements, expectations about working together, and relationship-specific adaptations by the seller or buyer.

Relationships between buyers and suppliers often involve investments which yield quasirentsforthefirms. TheapplicationofRFIDtechnologyinsupplychainmanagement requires substantial capital investments by buyers and suppliers. These investments are termed as relationship specific investments (RSI). Cannon and Perreault (1999) suggest that 'relationship specific investments' are investments in adaptations to process, product or procedures specific to the needs or capabilities of an exchange partner. These adaptations may be a one time investment or investments over time. These investments have little value outside a specific relationship, and increase dependence between buyers and suppliers and contribute to the increase in switching costs (Jackson, 1985).

Relationship specific Investment theory has emerged as a much debated topic in literature. To maintain customer loyalty, in addition to offering quality, suppliers must

makes significant efforts to improve communication, and the flow of information through heavy investments in technology. These investments may be for the exploration of a new resource or technology or the exploitation of an existing technology or process. Such highly capital intensive and relationship specific investments are likely to change the relationship between the suppliers and buyer firms.

THE AIRCRAFT SUPPLY CHAIN

The aircraft supply chain consists of thousands of suppliers and large manufacturers such as Boeing and Airbus. About 70% of the suppliers are common to Boeing and Airbus. RFID has become the 'leading edge technology' that is helping these companies to face cost pressures and increase accuracy, trouble-shoot, improve parts inspection and increase the visibility of the logistics supply chain.

RFID technology plays a fundamental role in molding Boeing's relationship with its suppliers. Boeing shifted to RFID technology and started receiving tagged parts from its suppliers in 2006. Supplier parts for aircrafts are inspected by the Federal Aviation Agency (FAA) before being assembled, which makes the process a time consuming and cumbersome activity. Typically the inspection process involves a huge load of paper work tracking supplier parts. Boeing's transition to tagged parts with EPC compliant Gen 2 tags with 64 K bytes of capacity provides ample storage space for data about the tagged air plane part. RFID technology helps to ensure that the parts are genuine, reduces the risk of unapproved parts entering the supply chain. Typical information about the part includes information about the part history and status i.e. modifications, software versions, calibration, certifications, authorized documents, updated information. The advantages of using RFID to track parts are less or no paperwork, simple and accurate information and standardized documentation in compliance with the aerospace industry ATA specs 2000 (RFID-Supporting the Aircraft Supply Chain). The relationship specific investments in RFID technology has cut down the historical cycle time of aircraft manufacturing and assembly at Boeing from days to hours. The ability to track and trace parts and subassemblies through the manufacturing and assembly process has reduced the time required to build an aircraft and dynamically molded the relationship between the buyers and supplier firms since adoption of this technology requires heavy investments in RFID technology.

WAL-MART

Wal-Mart Inc. is the world's largest retailer with over 3900 stores in the US and 2700 stores spread across the globe. It is a front runner in the adoption of technology in the retail industry. Wal-Mart consistently outperforms its competitors and achieves the goal of 'everyday low prices' by sharing real time sales data and other critical information with its suppliers. The world's largest retailer had mandated that all its suppliers adopt RFID technology and place tags carrying Electronic Product Codes (EPC) on pallets and cases by the end of 2006. By using RFID Wal-Mart planned to automate most of the transactions with its top 100 suppliers and create a mobile supply chain. But the success of Wal-Mart's plans to rollout RFID technology has met with

several snags. The world's largest retailer discovered that the successful adoption of RFID technology at all its stores depended on its supplier's willingness to participate and invest in the technology. Due to the heavy investments involved only 3% of Walmart's suppliers were willing to tag their products with RFID tags. At the beginning Wal-Mart had RFID in three distribution centers and planned to increase that number to 12 by the end of 2005. But in two years Walmart only added two distribution centers with RFID technology, while it increased its use of RFID from 100 to 1,000 stores. Out of more than 20,000 suppliers, only about 600 are using the technology.

The resistance faced by Walmart in the adoption of RFID in its supply chain arises from three main areas. The first reason is the cost of compliance. The costs of RFID implementation can be split into the following- costs of tags, cost of readers, cost of software applications and the cost of integration into the existing ERP systems. Amongst these costs, costs of tags were noted as the most significant by suppliers. The second issue arises from the accuracy of the system or the read rate. Improving the read rate in RFID technology typically involves greater investment due to repeated exposure and more expensive tags. The third hurdle is in the level of tagging. The main issue is whether individual products are required to be tagged or the tagging of pallets is sufficient.

RSI IN BUYER-SUPPLIER RELATIONSHIPS

Supply chains can be viewed as networks between several suppliers and a dominant network leader such as Dell, Toyota or Ford. Network leaders often champion the implementation of information technology within relations. The use of technology helps the network leader to collaborate and co-ordinate supply chain activities within its network. Increasingly, network leaders are handing over costs and other activities to suppliers. Suppliers also use their bargaining power to streamline inter-organizational processes. Information technology benefits are often skewed or asymmetric and favor the network leader (Riggins and Mukhopadhyay 1994).

ECONOMIC MODEL FOR RFID IMPLEMENTATION

A comprehensive model for costs involved in RFID implementation includes the following:

Cost of Reader + Cost of Tags + Cost of Software + Data Storage + Cost of Tagging + Cost of maintenance of software and equipment + Cost of mishaps/misread entries + R&D = Total Cost of implementation and usage

Relationship specific investments (RSI) play a central role in orchestrating buyer-supplier networks. Several studies have been conducted to determine the benefits of supply chain management systems to network leaders or buyers but few studies examine the advantages of adopting information technology driven inter-organizational systems to supplier firms. This article emphasizes on the latter aspect and theorizes about appropriation of information technology for exploration and exploitation within the context of the buyer-supplier relationship. Exploitation

is the extension of old certainties to improve organizational efficiencies. Exploration on the other hand is the set of variance-seeking activities to solve old activities with new and novel solutions.

Relationship specific investments can be classified as specialized and non-specialized, generic investments. In the context of an exchange, specialized, relationship-specific assets create more value than non-specialized, generic assets. Specialized relationship-specific investments are a vital source of inter-organizational competitive advantage. Specific relationship-specific investments represent a source of competitive power for suppliers, enhance the bargaining power of suppliers, create exit barriers for buyers, thus becoming the crux of the relationship. These investments provide supplier firms with an edge over competitors who do not possess such assets and lead to enhanced value creation.

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IMPACT OF ELECTRONIC LOGISTICS SERVICES ON TAIWAN'S CELLULAR PHONE INDUSTRY

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ABSTRACT

The Purpose of this paper is Based on Taiwan cell phone industry, this study begins with discussing the relationship between the marketers' organizational performance and E-marketing performance. Also, from the perspective of dealers, this study discovers the effects on Relationship Quality, which generated by expected benefits derived from implementing the interorganizational information system on the management of marketing activities. The research conducted SEM on marketers and dealers respectively. First of all, the quality of the information system will affect marketers' intention to use. In addition, the system quality and information quality will affect marketers' satisfaction and then it will affect the Relationship Quality among dealers. From the implementation of information systems, the Relationship Quality has positive effects on the expected strategic benefits, informational benefits and transactional benefits. Therefore, combining the two perspectives from marketers and dealers, this study examines how the E-marketing channel contributes the effects of Relationship Quality on both marketers and dealers.

Key Words – Cellular Phone; DeLone & McLean Model; e-Marketing; Information Systems; Relationship Quality

INTRODUCTION

The internet technology of e-Commerce pushes enterprises to inspect their logistics services and look for more effective and innovative ways to distribute their products (Vlosky & Westbrook, 2002). On the other hand, the popularization of internet forces marketing managers to prioritize internet-related issues (Webb & Hogan, 2002). It can be said that how to connect information technology and internet with the enterprise features has become a huge challenge to entrepreneurs. According to 'Telecommunications Competitiveness Analysis in Taiwan (□)' conducted by the

Ministry of Transportation and Communications of Taiwan (MOTC, 2003), Taiwan's telecommunications competitiveness is ranked in the sixth place in the world in 2002. During 2001 and 2002, the penetration rate of cellular phone subscribers exceeds 100% and reaches 105.6%, which is on top of the world. Up to the present, every person in Taiwan has at least one cellular phone on average. Though the penetration rates seem to drop a bit, many international enterprises locate Taiwan as the best market for their Asian products. (MOEA, 2006).

The logistics services of cellular phones in Taiwan are not developed with the device: the supply chain largely remains in manual operation, such as the product distributions between agents and the salespersons' service to agents. In comparison, cellular phones are more advanced than the logistics service of it in terms of information technology. The main theme runs through this study is how logistics services influence on Relationship Quality, exploring how electronic logistics services in relation to the Relationship Quality. On the one hand, this study investigates how electronic logistics services are brought into the industry by a certain major cellular phone manufacturer in Taiwan. This study targets at agents to analyze their anticipated profits and anticipated improvement of the Relationship Quality after the use of electronic logistics services.

LITERATURE REVIEW

Delone & McLean Model

DeLone and McLean (1992) review 100 papers, published during 1981 to 1987, with a variety of topics related to assessing the effectiveness of information system. They find that information system is a multi-dimensional structure, so it is necessary to assess it via six dimensions, including (1) System Quality, (2) Information Quality, (3) Use, (4) User Satisfaction, (5) Individual Impact and (6) Organization Impact. DeLone and McLean (2003) collect the papers associated with the D & M model to modify it as a model with six dimensions, including System Quality, Information Quality, Service Quality, Intension to Use, User Satisfaction and Net Benefits. In this new model, these dimensions are interacted with each other, so that evaluating the effectiveness of information system has become more and more complex. After focusing on the exploratory, empirical, and conceptual framework of this new model for many years, they successfully implement this model into E-commerce assessment index.

Then, DeLone and McLean (2004) present the modified D & M model through the perspective of E-Commerce with many scholars' empirical researches which propose many supportive measurement indexes (see Table 1).

METHODOLOGY

The Model and Hypotheses Development

The theoretical framework of this study is build with reference to DeLone and McLean (2003) updated D & M model and Mirani and Lederer (1998) strategic, informational and transactional benefits (see Figure 1).

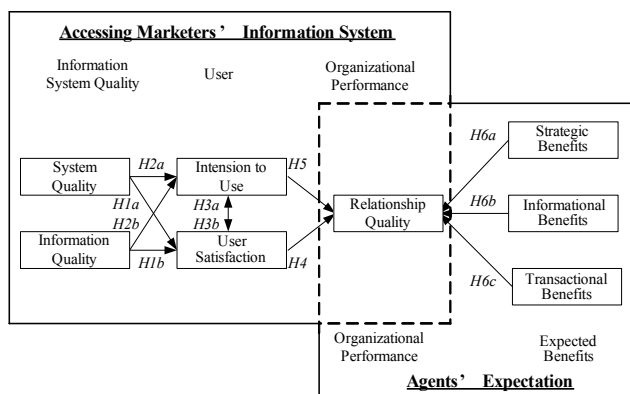


Figure 1 Study Framework

In the context of electronic logistics service of cellular phones, this paper looks into the internal information system of the logistics service in agents and focuses on how the Information Quality and System Quality are in relation to the Intension to Use and User Satisfaction. This paper assesses organizational effectiveness through Relationship Quality, to verify how Intension to Use and User Satisfaction influence organizational effectiveness. The researches relevant with D & M model are also compiled (see Table 1).

Independent Variable	Dependent Variable	Almutairi and Subramanian (2005)	Iivari (2005)	McGill et al. (2003)	Rai et al. (2002)	Seddon (1997)	Zhang et al. (2005)
System Quality	Intension to Use	N/A	**		*	N/A	N/A
System Quality	User Satisfaction	***	****	***	***	****	+++
Information Quality	Intension to Use	N/A			***	N/A	N/A
Information Quality	User Satisfaction	***	**	****	***	****	+++
User Satisfaction	Intension to Use	N/A	*	***	***	N/A	N/A
Intension to Use	Net benefit	***			***	N/A	N/A
User Satisfaction	Net benefit	N/A	****	****	***	N/A	N/A

Significant Level: *p < 0.1, **P < 0.05, ***p < 0.01, ****p < 0.001, +++ means strongly agree (Case Study), N/A means no related research area

Table 1 Each Dimensions of Relevant D & M model Study Results

From the perspective of agents, this paper will deal with their influence on Relationship Quality by means of the assessing the strategic, informational and transactional benefits.

As shown in Table 1, this study proposes the following hypotheses:

H1: The quality of logistics information system was positive associated with User Satisfaction.

H1a: Logistics information system was positive associated with System Quality and User Satisfaction.

- H1b: Logistics information system was positive associated with Information Quality and User Satisfaction.*
H1: The quality of logistics information system was positive associated with Intension to Use.
H2a: The System Quality of logistics information system was positive associated with user's Intension to Use.
H2b: The Information Quality of logistics information system was positive associated with user's Intension to Use.
H3: The Intension to Use and User Satisfaction in logistics information system are in positive relationship.
H3a: In logistics information system the users' Intention to Use was positive associated with User Satisfaction.
H3b: The User Satisfaction of logistics information system was positive associated with users' Intension to Use.
H4: Users' satisfaction was positive associated with Relationship Quality.
H5: Users have positive influence upon the Intension to Use and Relationship Quality.

Hennig-Thurau, Gwinner and Gremler (2002) indicate that relationship benefits would affect the commitment and satisfaction in Relationship Quality. Many scholars, such as Martensen (2000), investigate the model of ECSI (Europern Customer Satisfaction Index) and find that costumer benefits would affect Relationship Quality. Gerpott and Rams (2001) also point out that costumer benefits would affect their satisfaction, and that if the vendor would maintain the mutual profits, costumers would keep buying things from the same vendor. From the above, it can be seen that costumer benefits would affect the mutual Relationship Quality, and that the benefits of using information system can be divided into three kinds, "Strategic Benefits", "Informational Benefits" and "Transactional Benefits" (Mirani & Lederer, 1998). As a result, this study suggests the following hypotheses:

- H6: Agents' anticipated benefits of IOS were positive associated with Relationship Quality.*
H6a: Agents' anticipated strategic benefits of IOS were positive associated with Relationship Quality.
H6b: Agents' anticipated informational benefits of IOS were positive associated with Relationship Quality.
H6c: Agents' anticipated transactional benefits of IOS were positive associated with Relationship Quality.

Analysis of Marketers

Hypotheses Testing

Equation A: As show in Table 2, H1, H1a and H1b were supported, *Equation B2:* H2, H2a and H2b is not supported, *Equation E:* Result in H4 is supported and H5 is not.

Analysis of Agents

As Figure 2 shows, it has good indices, chi-square is not significant, and CFI, GFI and NFI are greater than 0.9, RMR and RMSEA are smaller than 0.05, it also show our model has good fit.

Equation	R ²	F	Hypotheses	Supported	Standardized coefficient	p
Equation A Dependent variable: User Satisfaction	0.937	89.839***	H1[+]	Y		1.000
Intercept				Y	0.670	0.000
System Quality			H1b[+]	Y	0.699	0.000
Equation B2 Dependent variable: 1/Use	0.594	8.033***	H2[+]	N		0.009
Intercept			H2a[+]	N	-1.141	0.018
1/System Quality			H2b[+]	N	-0.452	0.297
Equation E Dependent variable: Relationship	0.668	12.103***				1.000
Intercept			H4[+]	Y	0.810	0.000
User Satisfaction			H5[+]	N	-0.109	0.525
Use						

Significant Level: *** p < 0.001

Table 2 Regression Models

Confirmatory Factor Analysis

As Table 3 shows, we extracted two factors, with the of total explained variance being 62.365 %. One of these two factors was the same as the variable of relation quality we mentioned before and to name it satisfaction. The other one is composed of the trust and commitment, in the research about relationship quality by Hennig-Thurau et al. (2001), trust and commitment have positive significant effect on loyalty, and to name it loyalty.

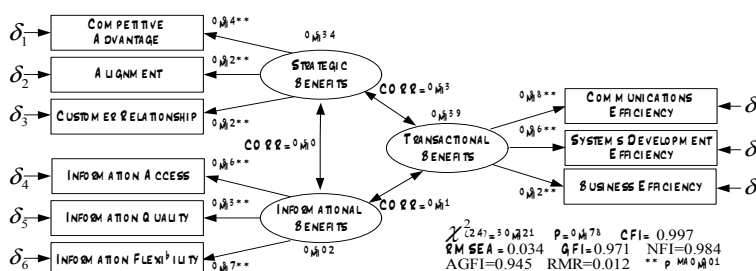


Figure 2 Confirmatory Factor Analysis of Agents Anticipation Benefits

KMO	Factor	Cronbach's Alpha	Cumulative variance	Index	Factor Loading
0.926	Loyalty	0.908	51.815 %	Trust Requirement Level	0.712
				Assist Benefit Requirement	0.789
				consistent psyche	0.802
				Promote Cooperation Desire	0.722
				Commitment Realization Level	0.708
				Attribution Feeling	0.718
				Relationship Respect	0.740
				Long Term Partner Relationship	0.715
				Service Satisfaction Level	0.782
				Reduce Complaint Level	0.647
Satisfaction	0.808	62.365%	Anticipation Achievement Level	0.787	
			Provide for Kind Usefulness	0.782	

Table 3 Components Matrix of Agents Relationship Quality Dimensions with Factor Rotation

Hypotheses Testing

As show in Figure 3, H6, H6a, H6b and H6c are supported.

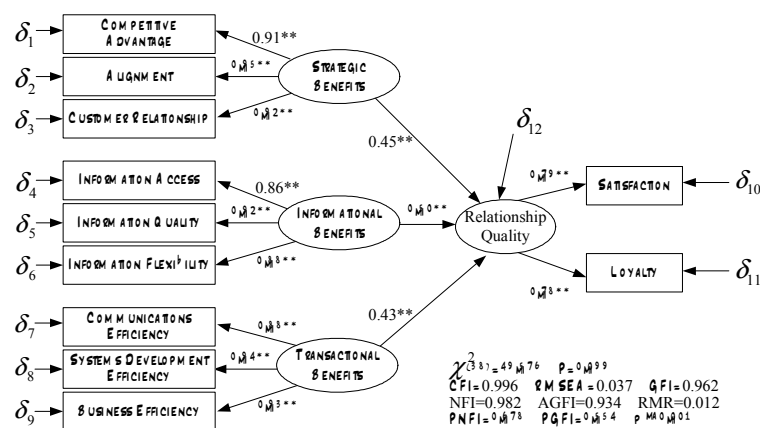


Figure 3 Research Model of Agents Relationship Quality

CONCLUSIONS

Electronic logistics services in Taiwan are in the beginning level. If the Information Quality and System Quality can be stressed in developing the information system, profits should be generated. The purpose of using computers and internet is to downsize the men power, offer convenience to the users, and to promote effectiveness and efficiency. If the weakness of the information system can be strengthened, such as the response duration and accuracy, more advantages could be created under the same circumstances. At present, the cellular phone industry in Taiwan is lack of a satisfactory logistics system, so how to build a well-constructed information system to generate mutual profits for the seller and buyer would be an important issue for the industry. If the profits of the seller and buy can be maintained and managed through information technology, the relationship of them can be extended in the fierce competitive market, and through the internet, the system of the high-end and low-end business partners can be integrated as a whole, so that email system, information exchange and transactions can be connected, or to create competitive advantages by means of EDI, link-ups, online catalog ordering, online auctions, XML or E-Commerce (Min & Galle, 2003).

This study has found that agents' anticipated profits toward the interorganizational system and their Relationship Quality are positively connected. For Kendall *et al.* (2001), E-Commerce is an innovative mode for enterprises, so enterprises use E-Commerce differently nowadays, which is not perceived as an organizational or technical innovation anymore. The use of information technology in enterprises is deemed as an organizational

innovation and invokes extensive discussions (Patterson, Grimm, & Corsi, 2003). Though information technology indeed helps promote competitive capacity, enterprises' attitude toward it is cautious. Many factors would influence enterprises' to purchase information technology equipment. In Avlonitis and Panagopoulo (2005) study, TAM model and D & M model are combined together, to investigate CRM system in five companies. Therefore, subsequent researches could combine new theories with D & M model to investigate this area. If profits of the information system can be assured, the product distribution could be expanded, stock could be reduced and better service can be provided, which furthermroe could transform the intangible quality into tangible assests.

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DEVELOPMENT OF A WEB-BASED ROSETTANET AUTOMATED ENABLE APPLICATION FOR SMES

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ABSTRACT

The RosettaNet standard is a standard process for sharing business information among business partners in the value chain. The RosettaNet standard is commonly used in the global semiconductor Industry, electronic components, consumer electronics, telecommunications, logistics and continue to be adopted in many industries. However, most companies which already adopted the RosettaNet standard usually have a complex information technology such as the enterprise resource planning system (ERP) and information technical staffs available at their companies.

Unlike, the well-established organization, many small and medium enterprises (SMEs), especially the start-ups, can not afford the cost of complex information system. The web-based RosettaNet automated enable application is proposed in this article which aims to assist the SMEs to connect and communicate with their international customers without high installation, operation and maintenance cost.

However, the information system alone is not able to make the SMEs become competitive. This article also proposes the operational guidelines for SMEs to effectively use of this RAE application.

INTRODUCTION

Due to the globalization, improving operation performance becomes unavoidable mission for business organization to stay competitive [1]. With small financial capital and sale volume, improving operational performance is critical to SMEs than for large business organizations. Before Internet era, the Electronic Data Interchange (EDI) was first developed to support communication between business enterprises [2]. EDI had become popular and had been offered as business service by many telecommunication companies. As a result, there are many EDI communication standards and data formats between trading partners [3]. To address this problem, later, EDI has been combined with XML technology [4, 5] to be a standard trading message structure which is used by many firms over the internet. In contrast to typical XML/EDI, RosettaNet provides coordination protocol that assists and automates activity which allows two or more companies automatically perform business transactions e.g. purchasing over XML/EDI standard trading exchange message. RosettaNet is developed by a consortium of major Computer and Consumer Electronics, Electronic Components, Semiconductor Manufacturing, Telecommunications and Logistics companies to create and implement industry-wide, open e-business process standards.

As a result, RosettaNet becomes a tool to enable automatic coordination among business partners in complex supply network. For many companies and industries that implement RosettaNet, automatic coordination in purchasing is only a small part of RosettaNet capabilities. By integrating with company

management information system like ERP [6], the company can tremendously improve its operational performance.

BACKGROUND

Although there are many advantages in adopting RosettaNet, expensive infrastructure (i.e. hardware, software, middleware and high availability internet connection), initial implementation learning curve and need for specialized IT resources [7] are barriers of RosettaNet implementation for SMEs.

To reduce the initial barriers and investment, RosettaNet Automate Enablement (RAE) is developed as low cost RosettaNet gateway for SMEs [7]. RAE applied Portable Document Format (PDF) which is the file format created by Adobe Systems in 1993 for document exchange. With PDF architecture, RAE can support RosettaNet communication function to SME users.

To improve business performance, only RosettaNet communication function is not enough. The company that able to integrate its information system such as ERP (Enterprise Resource Planning) with RosettaNet has shown significant improvement [6]. Unfortunately, RAE does not have ERP integration capability or it is too costly to do.

The main goal of SMEs is to be able to communicate and received the order from large company. When most of large companies implemented RosettaNet, they required all of their suppliers to connect to their system using RosettaNet. As a result, the process related to customer order and purchasing is critical to communicate via RosettaNet standard is critical for RosettaNet adoption by SMEs [From Kasetsart University Business Incubation Center, KUBIC, 2007]. In addition, communication capability alone is not going to significant improve performance without considering operation management. This article purposes solution that improves RAE system from PDF based architecture to web based architecture with operation management guideline for SME users to operate its business process.

In Figure 1, typical RAE is concerning only about communication function, but to help SMEs, another important function is to provide them the guideline to improve their operation management.

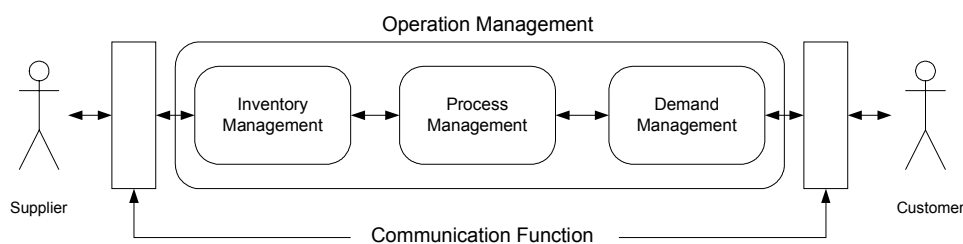


Figure 1 SMEs Business Operation Diagram

All of the factors describes in Figure 1 and 2 (Inventory Management, Process Management and Demand Management) can be improved by implementing ERP system and strictly following the instruction. For SMEs in Thailand, they cannot afford expensive information system like ERP to improve their operation.

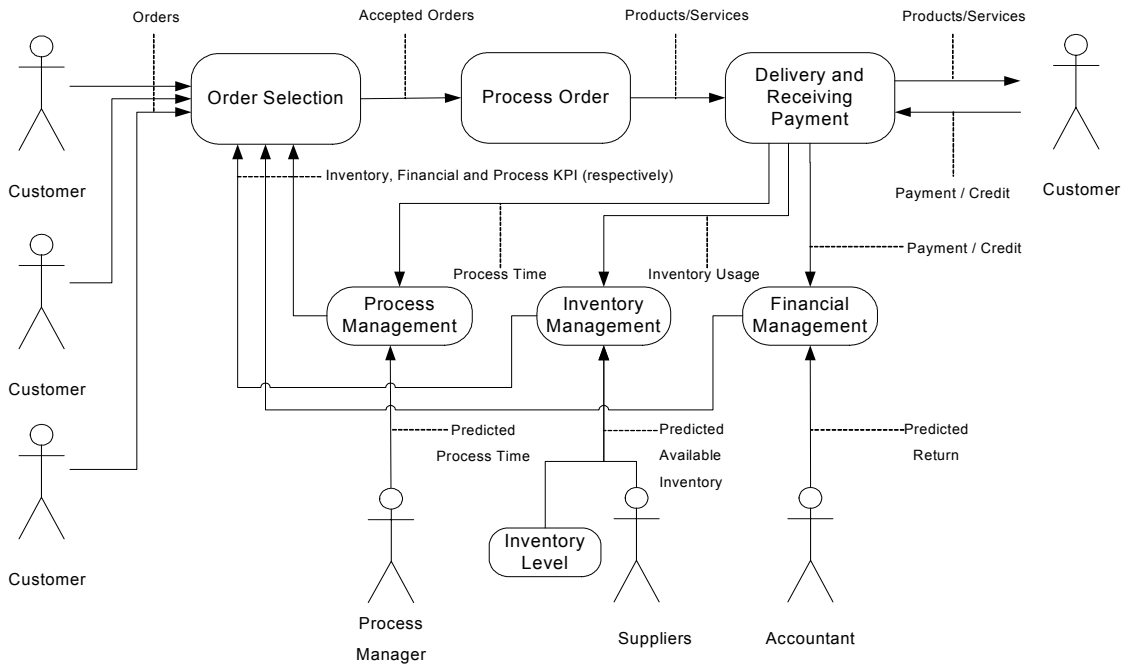


Figure 2 SMEs Business Materials and Data Flow Diagram

From process flow diagram above, this article focused on providing guideline for customer order and raw material management processes. The guideline factors are created by using matrices method [8] as follow.

	Real	Predictive
Finance	Return	Predicted Return
Process	Process Time	Predicted Process Time
Inventory	Inventory Usage	Predicted Inventory Usage

Figure 3 Guideline Factors (Applied from Matrices typology [8])

Predictive values are created to assert possibility of finishing orders. In the real world, Real values (value captured from real world) are normally not exactly the same as predicted (Predictive values). If real values are worse than predicted values, lost will occur. To prevent the lost from accepting order, SMEs need to use safety factors as follows:

$$Real\ value = Predictive\ value + Safety\ factor \tag{1}$$

WEB-BASED ROSETTANET AUTOMATE ENABLEMENT APPLICATION

The purposed solution is to improve RAE system from PDF based architecture to web based architecture with operation management guideline foe SME users instead of ERP integration.

SYSTEM ARCHITECTURE

The purposed solution is changing architecture from PDF system to web-based system in order to improve typical RAE system to gain more flexibility to

install new functions. Avoiding speed and data security problems, the recommended solution is deploying the application into SMEs own website and used as back office application. Due to the dramatically reduced of web hosting rental cost, SMEs can spend less than US\$ 20 for yearly rental cost for deploying the system, if they did not have their own websites.

Due to the flexibility of web hosting services, SMEs can get not only web-based RAE system application, but also other applications, such as website and email, within hosting space. Developed as an opensource project, SMEs can also freely continuous develop or modify web-based RAE system with other applications to improve their business performance.

As opensource platform, the basic technology will depend on other opensource technologies. The web application will be built using PHP technology and MySQL as database engine. These technologies are normally provided by web hosting service. As web users, SMEs can participate the application by simply browse the web site. To automatically update the trading status, SMEs can configure to receive notification emails from the application.

Handling both RosettaNet communication and operation management guideline functions, we use modular design technique to design the application.

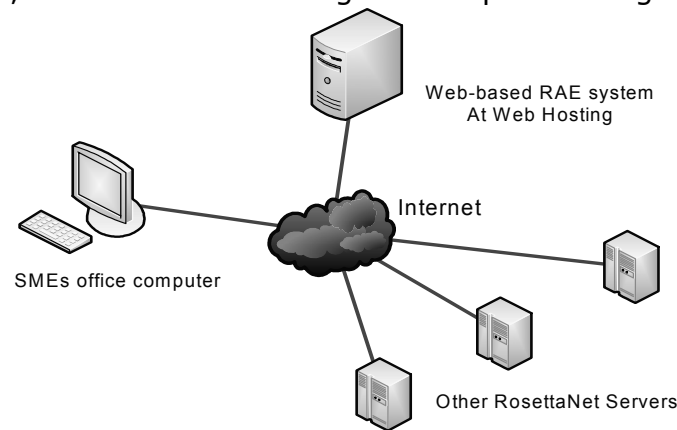


Figure 4 Web-base RAE system Connection Diagram

SYSTEM COMPONENTS

The purposed web-based RAE system consists of four main components as shown in Figure 5.

RosettaNet Communication

RosettaNet Communication Module functioned as communication channel of the application with RosettaNet network.

Message Translation

Message Translation Module will translate information between TPIR-PIP message and application's internal data structure. This module has permission to access database to read and record necessary information.

Data Analysis and Operation management guideline functions

Main function of this module is to provide operation management guideline functions to users. The main mechanism of the function works on data analysis process. So, database access is necessary for this module.

User Interface

User Interface Module provides data and user configuration forms. This module is the only module interacting with users.

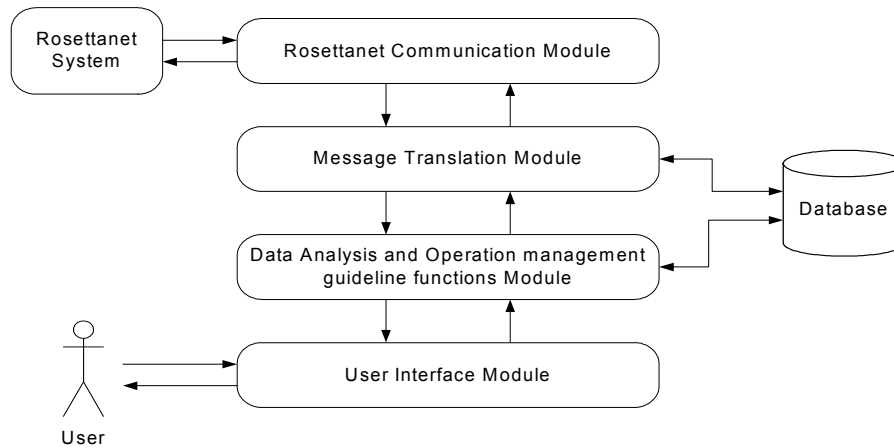


Figure 5 Web-based RAE system modules

SYSTEM COMMUNICATIONS

As improved from typical RAE system, the basic functions are inherited from typical RAE system. When using web-based RAE system, the system will communicate with partners in the same way as typical RAE system does. Typical RAE system can communicate with trading partner by using both PIP (Partner Interface Process) [9] and TPIR-PIP (Trading Partner Implementation Requirement-PIP) [7].

PIPs are communication message generally used between each RosettaNet trading partner. Different PIPs represent different business documents or purposes [9]. In this research, we will implement only necessary PIPs for SMEs to use. So, selected PIPs are only in group 3 (Order Management). Written in XML format, PIPs describe necessary trading information between partners.

TPIR-PIP is the communication message used in each trading partner network. TPIR-PIP message structure is the same as that of PIP except some unnecessary information in the partner network [7]. With the same PIP code, such as 3A1, typically message size and complexity of TPIR-PIP is less than those of PIP. TPIR-PIP is specially designed for RAE system by concerning manually processing information of SMEs. So, TPIR-PIP is designed by related trading partners to be as small as possible for RAE users to be easier in processing information.

After receiving TPIR-PIP, typical RAE system will translate TPIR-PIP XML data to PDF user interface form called TPIR-PF (TPIR-Personal Format) [7] and let SMEs to use manually.

Figure 6 shows a comparison between typical RAE workflow and proposed RAE. Partner A is the trading partner who implemented full RosettaNet system. Partner A will act as message translator (among PIP, TPIR-PIP and TPIR-PF). Registry [10] is a high security public server between trading partners. Registry can be either Public or Split type [10] keeping public and partners' information. Registry will receive and provide both TPIR-PIP and TPIR-PF information. Partner B, using typical RAE system, will receive TPIR-PF from email, manually process the form and submit data back (as XML format). Web-based RAE system user, Partner C, will receive TPIR-PIP data from Registry. Data form and guideline function will appear after translating TPIR-PIP message. After manually processing the data form, the system will submit data back as XML format.

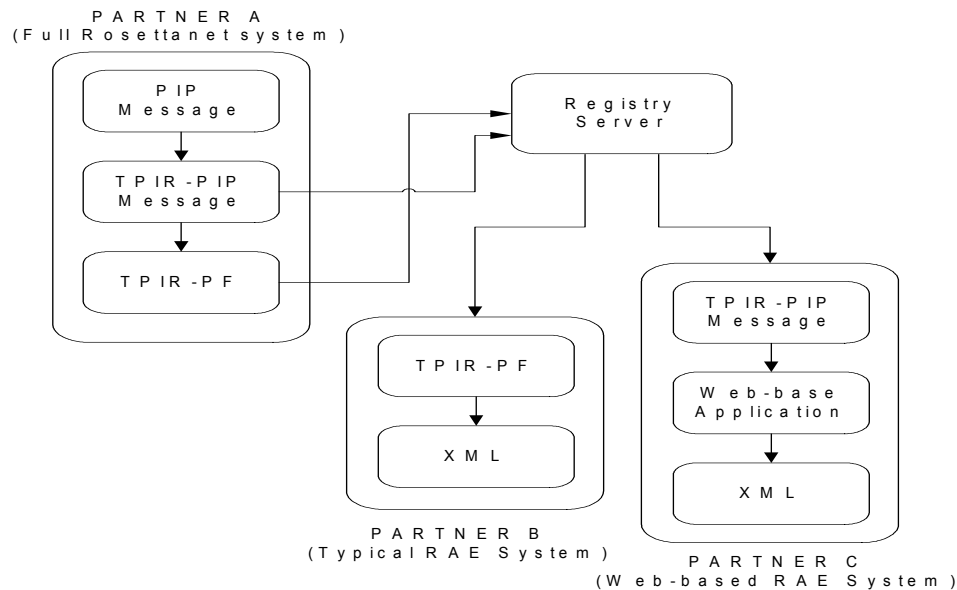


Figure 6 Work Flow of typical and web-based RAE
(Applied from AE Information Exchange Model [10])

The difference between typical and web-based RAE system from system point of view is only changing client program. Users can choose suitable solutions for their business without effects other trading partners.

OPERATION MANAGEMENT MECHANISMS

As mentioned before, challenge of this research is to create application providing both RosettaNet communication and operation management guideline functions. It is not different idea from typical RAE system in providing RosettaNet communication function. In this research paper, we will demonstrate only mechanism of operation management guideline functions.

Form operation management guideline concept described before, there are many input and output data set associated with the concept. Before performing operation management guideline functions, Minimal Data Set is needed from SME as show in Table 1.

Table 1: Minimal Data Set to be asserted by SMEs

Inventory Parameters	Process Parameters	Product parameters
Inventory Code (IC)	Process Code (PC)	Product Code (PDC)
Current Stock (IS) e.g. 100 Kgs	Process Time (PT) e.g. 1.5 hrs per unit	Inventory Code List
Unit cost (ICT) e.g. 100 USD per Kg	Process Capacity (PCP) e.g. 7 hrs per day	Process Code List*
	Process Cost (PCT) e.g. 50 USD per day	

* When adding processes list, if adding more than one process (different Process Code) with same process order number, it means that those process codes can paralleling run.

Minimal Data Set given by SME is collected for operation management guideline functions. However, it is not necessary for SME to entry all of the data fields. The operation management guideline functions will partially enable based on given data. When receiving purchase offers from customer, offering information (PIP 3A1) should be, at least, consisted of Product Code, Product Quantity and Delivery Date. The system will use offering information to search initial given data to create the guidelines.

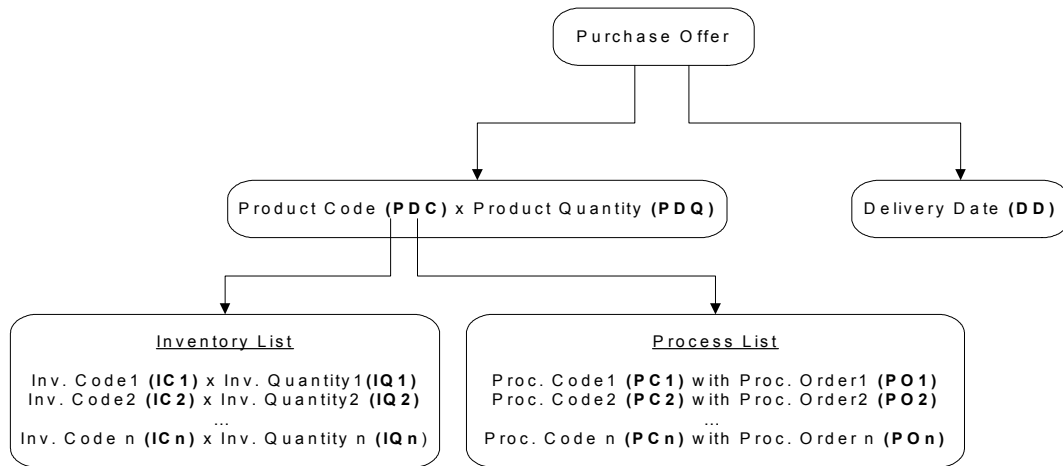


Figure 8 Simple Purchase Offer Structure

From data tree above, the predicted values can be calculated as follows:

PIU = Predicted Inventory Usage; $PIUn = IQn \times PD$

From equation above, the application will inform user (SMEs) if, for each inventory code, inventory level is less than predicted inventory usage.

PTFn = Process Time Factor of Process n $PTFn = \text{RondUp}(\frac{PDQ}{PCPn})$

Pot = Predicted Process Order Time $POTn = \max_{i=1..m}(POi = n | PTFi \times PTi)$

The predicted total process time can be obtained as follows:

TPT = Predicted Total Process Time $TPT = \sum_{i=1}^n POTi$

The application will inform user (SMEs) if predicted process time spans over delivery date. The products will not be delivered on time.

PICn = Predicted Inventory Cost of Inventory n $PICi = PIUi \times ICTi$

TIC = Total Inventory Cost $TIC = \sum_{i=1}^n PICi$ and $PCFn = \frac{PDQ}{PCPn}$

PCFn = Process Cost Factor of Process n

POCn = Process Operate Cost of Process n $POCi = PCTi \times PCFi$

TPC = Total Process Cost $TPC = \sum_{i=1}^n POCi$

TVC = Total Variable Cost $TVC = TIC + TPC$

Moreover, the application will alarm user when short of inventory and unable to deliver products on time. From all equations shown above, guideline operational performance indicators that application demonstrates to SME are as follows;

Table 2: guideline Operational performance indicators

Web-based RAE Operational performance indicators
Inventory area: PIU
Process area: POT, TPT
Financial area: PIC, TIC, POC, TPC, TVC

CONCLUSION AND FUTURE WORK

In this paper the web-based RAE system is proposed as a low-cost solution for SMEs to use. Improving from typical RAE system, the solution not only provides RosettaNet communication functions, but also operation management guideline functions. Operation management guideline functions will help SMEs in considering purchase offers from their customers. As benefits of the solution describe above, the solution still have rooms for improvement as follows;

- (1) Too few available PIPs message, this solution can recognize only PIP 3A family. It is better if enabling more PIP families.
- (2) Too few initial parameters collection, the predicted values are still not accurate. In the future, after SMEs in Thailand get used to this solution, it is necessary to add more required data to get more accurate predicted values.
- (3) Operation management guideline functions cannot effectively deal with uncertainty. But if SMEs are able to put more data, dynamic tracking and controlling are possible.

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STUDY OF RFID BASED BONDED WAREHOUSE PROCESS

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ABSTRACT

There has been increasing interest in improving the efficiency of bonded warehouse operation due to the collapse of the barriers between countries or Free Trade Agreement (FTA). Even though there are increasing demands to enhance the efficiency of warehouse operation, due to the manual operation of processes, the handling of event is not real time. For that reason, immediate response to events should be timely, relevant and accurate in order to minimize deviations from the original operation plans and customer commitments.

In this paper, we present a new process for bonded warehouse which is supported by Automatic Identification System (e.g. RFID). In order to develop RFID based bonded warehouse process, we firstly review existing process of bonded warehouse and study existing event handling mechanism and develop real time process using RFID system. We believe that our study will help to improve the performance of warehouse operation.

INTRODUCTION

A warehouse management system (WMS) is a key part of the supply chain and primarily aims to control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, putaway and picking. A Bonded warehouse is a warehouse in which goods on which the duties are unpaid are stored under bond and in the joint custody of the importer, or his agent, and the customs officers (Wikipedia, 2008).

Normally, when goods are imported into the free circulation of a nation, Value Added Tax (VAT) and customs duties should be paid before the goods can be stored, waiting to be sold. However, it is possible to store the goods in a customs bonded warehouse, which results in a postponement for an indefinite period of customs duty/VAT at import. In this case, customs duties and VAT at import only need to be paid when the goods are actually imported into the free circulation of a nation.

Even though the introduction of barcode system had improved the efficiency of bonded warehouse process, there are increasing user requirements which are beyond the capability of barcode system, such as location management, integration of EDI with automatic storage /retrieval system, automatic calculation of fee, real time information provision for inventory and etc. Especially the use of different barcode standard among countries created problems in the operation of bonded warehouse.

Breaking down of trade barriers and increasing trade volume have stressed the importance of international logistics, especially, the efficiency issue in bonded warehouse. As one of potential solutions for such issue, Radio Frequency Identification (RFID) is getting much attention. According to ABI Research, worldwide RFID markets are expected to reach \$8.4bn in 2012 from a base of \$3.8bn in 2007. They said that the 2007 figure represents 24 per cent growth over 2006, and that the growth curve to 2012 indicates a compound annual growth rate of 21 per cent.

In this paper, we will compare the process of conventional bonded warehouse with RFID based bonded warehouse and analyze the estimated result using discrete event simulation.

CONVENTIONAL PROCESS IN THE BONDED WAREHOUSE

Bonded warehouse processes can be divided into 4 processes such as receiving, putaway or storing, picking and shipping (Bowersox and Closs, 1996).

- Receiving: a truck dock is assigned for a truck entering in the bonded warehouse area. Most of receiving goods are contained in the case or pallet and they should be inspected right after arrival to check whether the goods physically arrived are the same as the information previously given. When arrived goods are palletized, goods are assigned to a location without further tasks. When goods are arrived as box level, they have to be palletized by B/L level and then stored. When there is a problem, operators should report to the office of Customs Administration. When there is no problem, they have to submit an import declaration to custom office.
- Storing: Storing location is decided by the size of goods and inventory turnover ratio. Storing process is related to the following three management tasks: management of goods with custom clearance, returned goods management, aging goods management.
- Picking & Shipping: When the owner of goods request, goods should be compared with the custom proof of export and then shipped. Warehouse operators should submit the shipment report to the custom office.

Among the processes in conventional bonded warehouse, there are events that are handled by manually and inefficiently:

- Arrival: identification of authorized truck
- Receiving: identification of trucks to be unloaded
- Inspection: Comparison and inspection of information and physical goods.
- Storing: identification of storing location
- Picking: identification of storing location; comparison of physical goods with delivery order information; checking of the right trucks to load goods

Because of errors occurred by manual identification, errors occurred by manual input and delay in inspection time, such event handling practices cause problems and creates inefficiency in warehouse operation.

RFID BASED BONDED WAREHOUSE

Recently because of Wal-Mart effect, there are growing interests on the RFID assisted warehouse management and distribution centre (Alexander et al. 2003,

Garcia et al. 2006, Chow et al. 2006). RFID based bonded warehouse processes can be described as Figure 1. As in the figure, in receiving and shipping, using carrying in information and RFID data, link information on the goods (to be stored) with location information (to be stored). In storing and pickup, using RFID reader on the forklift and fixed reader in the storing location, collect goods information and storing location information.

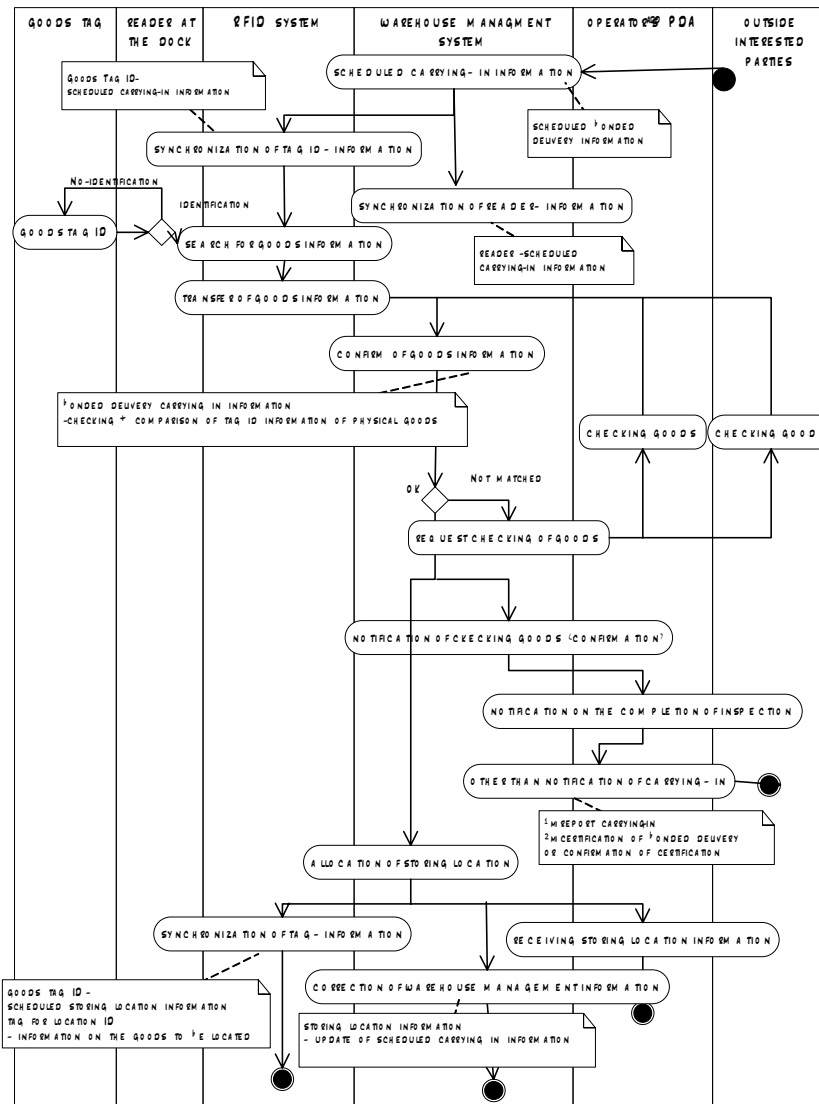


Figure 1. RFID assisted Bonded Warehouse Process

SIMULATION

We have reviewed a bonded warehouse in Korea. The total size of warehouse is about 5289 m² and there are fixed 780 racks and some movable racks. Work hours for the warehouse is 9 hours (i.e 8:30 am ~ 18:30pm including 1 hour lunch time). Table 1 shows cargo volume used for our study. Simulation model is built and tested by Extend (Extend 6.0, 2006)

month	Number of B/L	volume	weight
Jan	2,543	1,578	1,129,929
Feb	2,269	2,176	1,131,854
Mar	2,918	2,970	138,549
Apr	2,658	3,007	1,347,247
May	2,481	2,366	1,037,678
Jun	2,633	3,241	1,307,965
Jul	2,686	2,655	1,086,562
Aug	2,512	3,075	1,222,803
Sep	2,782	4,039	1,579,517
Oct	2,709	8,883	1,278,024
Nov	2,506	2,110	938,957
Dec	3,082	2,503	117,548
Total	31,779	38,603	14,620,514
average	2,648	3,217	1,218,376

Table 1. Cargo Volume

Currently the bonded warehouse is managed by B/L level not pallet level and in this research we considered both weight and volume. Table 2 shows details of simulation model.

Simulation block name	Input value	Unit processed in this block	Comment																				
Generation	- Average: 5.44 -Standard variation : 6.15	B/L																					
Input data	<table border="1"> <tr> <td>0</td> <td>61</td> </tr> <tr> <td>510</td> <td>33</td> </tr> <tr> <td>540</td> <td>4</td> </tr> <tr> <td>600</td> <td>33</td> </tr> <tr> <td>720</td> <td>10000</td> </tr> <tr> <td>780</td> <td>33</td> </tr> <tr> <td>990</td> <td>5.2</td> </tr> <tr> <td>1080</td> <td>33</td> </tr> <tr> <td>1110</td> <td>10000</td> </tr> <tr> <td>1440</td> <td>10000</td> </tr> </table>	0	61	510	33	540	4	600	33	720	10000	780	33	990	5.2	1080	33	1110	10000	1440	10000	B/L	Use quantities of peak time B/L
0	61																						
510	33																						
540	4																						
600	33																						
720	10000																						
780	33																						
990	5.2																						
1080	33																						
1110	10000																						
1440	10000																						
Check-Truck	5 minutes	Truck	checking truck																				
go/build_up	-	B/L	80% are palletized 20% are not palletized																				

Manual-Pallet	20~30 minutes	B/L	time to palletize
Inspector		Number of inspectors	total number of inspectors: 6
Checking_In	4 minutes	Target	inspection
Accumulating	10 minutes	B/L	pile up at truck dock area before moving to rack
Put Away	5 minutes	Pallet	move pallet to rack using forklift
Forklift put away	5 EA	Pallet	putaway. Forklift is also used for picking
-go	0.5 minutes	Forklift	time for forklift to go
-return	0.5 minutes	Forklift	time for forklift to return
Customer order	40 order/day	B/L	customers' request for taking out their goods
Forklift_pickup	5 EA	Forklift	picking up. Forklift is also used for putaway
Pickup	20 minutes	B/L	time to take pick up process
Inspector	-	No of inspectors	available operators: 6 man
Checking out	2 minutes	Pallet	inspection

Table 2. Simulation Details

Table 3 and 4 show results of simulation considering different reading accuracy. As in the Table, by applying RFID in the existing process, we could achieve improvement in queue time and queue length which will lead to cycle time reduction.

		Average queue length	Max queue length	Average time	Max time (minutes)
As-Is		0.75	16.67	25.72	198.48
To-be	100%	0.00	2.70	0.13	9.32
	90%	0.02	9.60	0.83	39.31
	80%	0.03	10.5	1.08	58.655
	70%	0.08	13.00	2.56	84.27

Table 3. Cargo Volume

		Average queue length	Max queue length	Average time	Max time (minutes)
As-Is		0.17	6.00	7.98	83.74
To-be	100%	0.00	2.70	0.13	9.32
	90%	0.01	3.30	0.27	21.00
	80%	0.01	4.10	0.30	34.90
	70%	0.02	5.00	0.84	53.54

Table 4. Inspection Time for Shipping

Usually receiving processes take more time than shipping because more tasks are required. As in the table 3, conventional receiving process requires 3 hours 10 minutes however, RFID assisted receiving process will take 40 minutes with 90% of reading accuracy. Table 4 also shows that it takes 84 minutes for conventional shipping process while it takes 21 minutes for RFID assisted shipping process with 90% of reading accuracy.

CONCLUSION

In this paper, we present the RFID applied bonded warehouse process model and compare it to the conventional bonded warehouse. This analysis has been performed for a specific facility, but this particular case has the common features of most of bonded warehouses; which makes the study relatively general and transferable to other warehouse. From our study, it is considered that RFID could bring performance improvement by handling warehouse event in real time.

ACKNOWLEDGEMENT

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SECTION 8

LOGISTICS IN THE SERVICE SECTOR

HIGH SPEED MAGLEV LOGISTICS. IS THIS THE 'GOLDEN GOOSE' WE ARE LOOKING FOR?

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ABSTRACT

The globe is running out of logistics capacity due to congestion in 'pinch points' and the future pollution controls will reduce global freight intensity. In turn, the diminution of trade volumes will reduce global GDP. We propose the installation of ultrahigh speed maglev logistics backbones from China to Europe (the so-called "Eurasian Landbridge") and China to the US (via the Bering Straits). These will maintain global trade volumes and GDP, reduce total pollution, and alleviate poverty (through trade enhancement along its routes). The costs of implementation (tracks + vehicles) can be met from the national foreign reserves of the concerned nations or very easily from current Sovereign Wealth Funds.

INTRODUCTION

Some critics suggest that "maglev is a white elephant looking for a graveyard" but we contend we may be ignoring "the golden goose laying its golden eggs". We ought to be as courageous as the Victorians who invested in railway and telegraph infrastructures when really they had no coherent vision about the effect these would have on the future local, national or global economy. Maglev can create similar new transformations, making trade between nations easier and faster, increasing global GDP, lowering pollution, and ameliorating poverty along its routes.

Firstly let us be clear – maglev transportation systems are a new transport mode: they are not "a different form of railway". Maglev is as incompatible with other transport systems as are pedestrians with respect to airplanes, or cars with boats. All transport systems need exchange nodes – like airports, docks, railway stations and goods yards that allow multi-modal systems to operate where for instance, deep- or short-sea shipping can tranship containers to be carried forward by canal boat, railways, road or air transport: maglev is simply another mode to consider.

Maglev systems can integrate with existing exchange nodes, but importantly we think that maglev will offer a new hub & spoke concept quickly delivering goods and people at 500km/hr over hundreds or thousands of kilometres, with standard electrified rail passing on the goods over a limited few hundred kilometres and road logistics being involved only for the 'last kilometre', where they can use their flexibility effectively. This integration will reduce global pollution by moving long-haul freight from road, sea and air, and even from the less efficient standard rail, onto the very efficient, fast, non-polluting maglev. And of course, more flexible transport modes will open up hinterlands.

JUSTIFICATION OF MAGLEV

Some reviews of maglev have been comprehensive and positive (Coffey, 1991; Lever, 1999); others precisely detailed, for instance, the low noise of maglev was noted by Bariskow (2002), and the low propensity to cause travel sickness found by Harding et al (1999).

Good reference links may be found at

<http://faculty.washington.edu/jbs/itrans/index.html> and

<http://www.monorails.org/tMspages/MagMono.html>)

Meanwhile critics have not been silent (Kemp & Smith, 2007; ICE, 2006; Talotte, 2000).

Major design factors

There are several competing variants of maglev transportation systems ranging from small dimensioned capsules travelling in underground 'tubes' to full sized systems capable of carrying passengers, freight containers, or RoRo (Roll-on, Roll-off vehicles). Herein we will concentrate only on the standard container variant, not the RoRo nor the Magtube type: we will not ignore passengers who can also utilise the same tracks as container maglev.

Core aspects of maglev

There are two types of levitation systems - the EDS and the EMS (see below). Their science is simple - passing magnetic arrays over a conductive loop creates a magnetic field, or force. At a critical velocity the induced magnetic field will be strong enough to create levitation, and the magnetic force may be used to create propulsion.

Basically the vehicles 'surf' along a track on an air gap, lifted by magnetism and guided by magnetic side panels: they can not fall out of the track. They are also intrinsically safe - if two vehicles are on the same electrical segment of the track at the same time the nature of the pulsation will determine they both travel in the same direction at the same speed: they can not crash into each other. This effect also allows vehicles to be scheduled very closely - with a gap of only a foot or so. Both will 'surf the same wave' without moving closer to each other thereby delivering goods just like a pipeline.

EDS: electro-dynamic systems

Electro-dynamic systems (EDS) have their magnets mounted along the lower sides and base of the vehicles. The magnets could be ferromagnetic but they usually use the much more powerful superconducting type. These [magnetically] press against coils fixed in the upper floor and sides of the support track, the former repelling the vehicle so lifting and enabling propulsion, while the magnets along the sides of the vehicle maintain guidance. The vehicles float about 150 - 200 mm above the track on their powerful superconducting magnets, but they do not have the ability to generate lift (to hover) when the train is stationary. An auxiliary wheel system (or air float system) is needed for low speed motion until the transition speed is reached, thereafter the vehicles levitate and quickly reach full speed. The EDS repulsive systems are inherently stable as any decrease in air gap is met automatically with a stronger repulsive magnetic force - whether this in the primary levitating gap, or the side gaps maintaining directional stability. Note that modern superconducting magnets require cooling only by liquid nitrogen which is cheap to liquefy, cheap to keep refrigerated, and is non-polluting when evaporating.

EMS: electro-magnetic systems

Electro-magnetic systems (EMS) use ferromagnetic magnets located on the upper sides "of fingers on hands" clasped as in a figure C. These reach under the support track forming the basic security system preventing cars falling off the tracks. Their magnets attract to fixed coils mounted on the underside of the

track and, being attracted, lift the vehicle. Although modern permanent ferromagnets are strong they can only lift the vehicle by only 8 – 12 mm: but they have the ability to float the vehicle at low speeds, even when stationary so they do not require auxiliary wheels. EMS also have side guidance magnets. The EMS is dynamically unstable and requires complex and rapid computations to constantly vary the attractive force to maintain their float gap; otherwise, if the gap decreases, the cars descend onto the track surface. Clearly the civil engineering of this form of track must be to much closer tolerances than for the EDS system. Also the EMS require frequent more rigorous safety checks and adjustments to the track alignment.

LSM: linear motors

Linear Synchronous Motors (LSMs) consist of two electromagnetic members - the armature and the field windings - which are likened to a standard electric motor when flattened into two component parts. The long-stator systems used by most maglev designs have the LSM armature buried in the guideway and the field coil is located on the vehicle. And, just as with a normal motor, once electricity passes through the armature it reacts against the field coil magnetism and motion is effected.

We accept that all magnets produce stray magnetic fields. However good design of the vehicles, with correct shielding of cables and of the public space will protect against the magnetic flux of the guidance systems, thereby minimizing personal exposure (Lever, 1999). Transrapid, a German manufacturer of an EMS maglev, state their stray magnetic flux is less than found normally in the typical real world (see www.transrapid.de; Brecher et al, 2002).

Track basics

Maglev track are constructed with the necessary electrical power supply loops of the LSM built-in at a factory site. The supporting columns only require footings to be laid at-grade then prefabricated columns and overhead arches may be simply added and linked to provide a continuous electric circuit: quite a speedy operation in fact. As there is no physical contact between vehicles and track the maglev track systems do not suffer wear.

The raised maglev track does not suffer from minor flood or snow inundation, and being elevated allow pedestrians, animals or other traffic to pass unhindered below. The total functional separation contributes to their predicted very high safety level. Of course the track accuracy must be built to tight standards, but importantly, the Japanese research team have shown their maglev units (an EDS with 150 mm gap) can pass over step changes in track alignment in their simulations of the effects of ground heave due to earthquakes (Harding, 2007). TGV or standard rail track are disrupted totally by ground heave.

Maglev's ultimate capacity can be considered as a 'pipeline' of 15-meter units (2 TEUs) end-to-end all moving at 500 km/hr [or 500,000 m/hr ... $500,000/15 \sim 33,000$ units/hr or 800,000 units per day $\equiv 1,600,000$ TEU per day]. In practice the maglev units would not be pipelined, but 600,000 TEU/day is imaginable as the one-way track delivery volume.

Terrorism

Maglev is no more or less resistant to attack than other logistics systems. All of us know that if we blow up the bridge that a train is approaching it will fall into the chasm (do you recall watching movies showing that scene?) Maglev tracks are vulnerable to attack – but what railway is not? Remember the bombs in

Madrid (March, 2004), London (July, 2005), and on the 'Friendship Express' between India and Pakistan (February, 2007)? We must be vigilant against terrorism and not give in to its pressure.

Further design factors

Having reviewed many texts we have decided to create a simple comparison table. Citations will not be used herein but full detail is available from the authors.

Table 1: Maglev vs. other systems

<i>Aspect</i>	<i>Maglev</i>	<i>TGV and other rail</i>
Costs		
Track costs	27 €/km (might reduce due to learning curve). Construction may be less polluting than TGVs.	TGV: 34 €/km – is the current European average. Other rail: ≥10 €/km
Vehicle costs	2.5 €/m per unit (includes magnets, etc)	TGV - 1.5 €/m for passenger units 3.0 €/m for engine units (2 per train)
Operational costs	Very low – no moving parts Maglev is electrically much more efficient than TGV.	Much higher – motors, wheel, track & pantograph wear. TGV more efficient than standard rail systems.
Freight and passenger delivery volumes	Probably 600,000 TEU/day one-way track. Many passengers can also be accommodated. All at ~500 km/hr	TGV for passengers @ 250km/hr Standard rail – for freight & people. 5,000 TEU/day (much slower than TGV)
Operational factors:		
Signalling	Same as for TGV but safer with total separation of track from people, animals and other traffic.	TGV is very safe, but constructed at-grade so more at risk of crashing into objects on track.
Acceleration/ deceleration	LSM motors very strong: very much better than TGV. Faster to top speed, quicker to stop. Can have very close headways	As with all wheeled systems is dependant on friction – and thus needs long headway to allow for stopping. Also slow acceleration.
Pollution aspects	Uses much less electricity than TGV as LSM is more efficient than electric motors. Implicitly much less polluting as less electricity needed.	TGV needs less electricity than standard rail. Electricity has large up-stream pollution costs, yet is clean in use.
Route design:		
Route gradients	Can climb/fall gradients over ± 10% with strong LSM 'motors':	Limited to ≤4% due to wheel skidding
Twists & turns	Units can be banked to ±30° tilt, also passengers are OK with 8°/second roll rate - so can run at very high speed round tight bends in mountainous regions.	Can't be banked much, needs large 'flat' curve radius for high speed – limits route design: tight bends severely reduce speed.
Route planning	Good ability to rise/fall, twist & turn allows maglev to follow open routes minimising need for tunnels	High speed needs track to be straight and 'flat' so many tunnels and bridges are needed.

	and bridges. Same argument in town planning – can follow the built environment along roads, etc., with ease.	and bridges are needed. In town special routes are needed as with current TGV or standard rail.
Urban operations	Almost silent, no motors, no wheels, no friction contact.	Wheel noise, motor noise - not silent.
Rural operations	Air noise only, no motor or rail noise.	As well as air noise there is motor, wheel and pantograph noise.
Multi-modal	Can operate mixed mode (freight & people) all at same speed of 500km/hr in different cars on same track sectors.	Freight mode limits speed using standard rail, this cripples higher speed averages of TGV passenger traffic.

FUNDING SOURCES

The capital costs of building the Eurasia Landbridge from China to Europe might be considered to be 27 €/km * 10,000 km = 270,000 million euro (\$415,000 million). Eventually we would expect the total build cost to be about \$400,000 million – rising due to inflation, and falling due to moving down the 'learning curve'.

In passing we ought to recognise the magnitude of these costs - one trillion in the US has 12 zeros (10^{12}), although this is called billion in the rest of the world. We note:

Maglev Eurasian route might cost	\$400,000,000,000
The Iraq war may have cost over	\$3,000,000,000,000

Stiglitz & Bilmes (2008) agree the three trillion dollars cost to the US alone for the war in Iraq is an incredible amount, almost beyond comprehension, and certainly far beyond the figures provided by the Bush administration. They calculate, as a cost of the war, what would have been saved if there was no war, that is the "opportunity cost". Many of these costs are usually hidden yet they are usually paid-out over time – for instance, to recompense the dispossessed and wounded, and to rebuild infrastructures.

Maglev implementation needs considerable cash injections over time. We note the huge foreign reserves held by some nations. China is one such nation with \$898 billion, and Japan's reserves are slightly higher (Economist, 2007). Even Central Asian countries are not short of cash (Floerkemeier & Sumlinski, 2008): generally this is true globally (Aizenman, 2007). These authors say the study of reserve adequacy and optimality provide valuable insights for policymakers and can help guide monetary and reserve policies.

Therefore, we surmise, if Ministers are so minded to install maglev they have reserves in place, at least to commence building the infrastructure.

... world foreign exchange reserves have surged from \$2 trillion in 2001 to an unprecedented \$5 trillion by early 2007. Of this total, the share of emerging Asia has risen from \$600 billion to more than \$2 trillion. In addition, the reserve assets of oil-exporters boomed in 2005 and 2006 by more than \$200 billion each year.

Source: Christian Noyer: Governor, Banque de France (Noyer, 2007)

Sovereign Wealth Funds (SWFs) are another source – they have been around at least since the 1950s but have grown in prominence recently. This is partly due to some SWFs being involved in the 'bail-out' of a few US banks and other financial institutions following the late 2007 US sub-prime housing market scare. We should note the magnitude of SWFs worldwide has grown dramatically over the past 10-15 years, and are expected to rise from \$2-3 trillion today to about

\$6-10, maybe \$12 trillion, within five years. At present, the United Arab Emirates, Norway, Saudi Arabia, China, Kuwait, Russia, and Singapore are among the countries that hold the world's largest SWFs (Europa, 2008).

We further suggest that, if the managers of the SWFs are so minded they could invest with ease in both the capital and the operational aspects of maglev. As well as investing in the Eurasia Landbridge they could include the China-US route under the Bering Straits (Humber & Cook, 2007). The total cost of building the tracks of the two routes would be about \$1.0 trillion, and adding adequate numbers of vehicles would cost maybe a further \$0.5 trillion. Even if the cost was \$2.0 trillion it is quite achievable under current conditions, and indeed far less costly than the Iraq war.

INFRASTRUCTURE FACTORS

We recognise that there are many infrastructure projects that compete for scarce human and financial resources in all countries. And perhaps, of greatest concern are the projects in nations with 'dynamic' political situations. For example in Central Asia through which the Eurasian Landbridge crosses. Kidd (2007) has presented arguments to illustrate that many of their infrastructure projects are interdependent, with transport being the key factor.

Multi-modal nodes- for people and for freight

Maglev is a new form of transportation, it will not incrementally link with nor extend existing transport systems. Therefore to use its vast potential we will have to build new tracks, new stations for passengers, and new handling systems in freight depots.

- a) Passenger stations could be built inside mall complexes in city centres. Maglev is almost silent at low speeds and does not emit any pollutants – liquid, gaseous or magnetic – so it is well fitted to merge with the urban needs of passengers and the built environment. Passengers would like to have their fast transit system close to offices or to shopping to whisk them home to the pleasant unpolluted distant countryside far faster than the current slow and crowded urban transit metros take to reach the suburbs. We note that even with these high speeds available to passengers there is a preference cut-off distance beyond which passengers will prefer flying. For the TGV this cut-off was about 800 kms (CIT, 2005); we presume for the faster maglev it will be ~1000 kilometres.
- b) Freight depots are usually located some distance from city centres where land has been made available to allow for the proliferation of quaysides, rail sidings, roads, warehouses and container stacks. The fact that a new logistics system needs to join this arena ought to be no problem. Whether the existing multi-modal area is at present serving some combination of sea (or other water system), rail, road or air services the new maglev will need only specialist hoists to be built for the rapid load/unloading of its containers. We note that entrepôt software are now frequently linked by mandate to the software of the US Homeland Security Act (2002) which pervades many of the globes' logistics operations if the goods are destined to enter US costal waters either for final delivery to the US or as transit goods. These software will aid the tracing & tracking of the fast maglev logistics.

DISCUSSION

This paper considers maglev to be the superior solution in three interconnected issues:

1. Global pinch points.

At present the great circle air routes between the US, Europe and Asia are very congested (thus dangerous) and highly polluting; and their land is restricted for the expansion or development of new airports. The global seaways have pinch points in the Suez and Panama canals and there are severe constrictions in the Malacca and Sunda channels as well as the English Channel. Any increase in size of transport vehicles will be hit by physical limitations (for instance, the A380F air freighters or the Malaccamax boats). And any increase in their delivery speed also face limitation due to the greater fuel used to achieve higher speeds with the greater propensity to pollute. Globally rail systems do not connect to each other effectively. We suggest that maglev could be the mode of choice to increase global trade while minimizing pollution. The perception of cost may be a psychological stumbling block: but maglev is cheaper than TGV to build, and national foreign reserves and Sovereign Wealth Funds are well able to fund maglev implementation - if their managers are willing.

2. Maintenance of global GDP.

We have shown that maglev can easily deliver 600,000 TEU per day per track. No other mode can approach that volume except perhaps greater numbers of deep-sea shipping. But each Malaccamax boat takes many days to travel from China to Rotterdam or the US, whereas maglev containers could do the trip in three days delivering a huge boat-load every one hour or so.

3. Concerns upon climate change.

Maglev, when substituted for the existing sea, air, road and rail transport modes will reduce the total pollution thereby aiding pollution control across the globe. This follows from three aspects (i) maglev is very much more electrically efficient than TGV or standard rail systems, and (ii) maglev generates no pollution, and as it uses less electricity than other systems, it causes less secondary pollution. Further, we presume the electricity production in all Nations will move away from coal dependency to nuclear, topped up by renewables if possible. This will reduce the total existing up-stream/down-stream emissions by moving from fossil or petrochemical fuels to 'clean' electricity.

4. The 'mind-set' of decision makers.

We have suggested a set of 'justifications' promoting the implementation of ecologically sound maglev systems, however there is little hope of 'magically' persuading the Presidents of China, Russia, Central Asia (indeed the G7+1) to come to an early agreement about climate change, global trade and GDP and thus install maglev as a 'saviour'. We may have to hope that (a) the clamour of the public may sway opinion, not just to reduce pollution but to substitute maglev as a better transport mode; and (b) the managers of SWFs might suggest investing in maglev for the good of the globe.

The managers of Sovereign Wealth Funds have ample funds, enough to build and operate the two maglev backbones from China to Europe and to the US, if they are so minded. This is an intriguing thought.

CONCLUSION

Maglev high speed transport systems “is the future” but the decision makers seem unconvinced – just as they have been for decades over ‘climate change’ issues.

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HOW TO IDENTIFY AND ANALYSE PROBLEMS IN GLOBAL SERVICE SUPPLY CHAINS? – CONCEPT OF A COMPETENCE-BASED TOOL FOR THE LOGISTICS CONTROLLING IN INTERNATIONAL NETWORK STRUCTURES OF THE SERVICE SECTOR

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ABSTRACT

The main contribution of this paper is to show a competence-based tool for the identification and analysis of problems in Global Service Supply Chains (GSSC). For GSSC-Management it is required to systematically identify and analyse logistic service problems occurring in its international network structures. For this reason, a comprehensive concept has been developed based on a sophisticated methodology, which will be applied to movie productions as a global acting reference industry.

NECESSITY FOR DEVELOPING A CONTROLLING TOOL FOR GSSC

International structures of logistics services have significantly evolved, especially during the last decade. Service companies are embedded in service supply chain networks, where they themselves could be service consumer of another service producer and vice versa. Therefore, Global Service Supply Chains (GSSC) have to be characterised by a structure of different service companies (SC) collaborating in a world-wide network (e.g. Hülsmann and Grapp 2007). However, these modern types of logistics structures are confronted with diverse management theoretical problems, e.g. hyper-turbulence, hyper-competition and especially hyper-linking (D'Aveni 1995; Tapscott 1999; Siegele 2002), due to international service logistic processes taking place in GSSC, e.g. increasing communication and data transfer processes. This leads to an increasing complexity as well as dynamics in GSSC (Hülsmann et al. 2008) and for its management.

However, under these current phenomena in GSSC-structures logistics management seems to be burdened with competence deficits to fulfil its competence-oriented task. GSSC notably depends on its own organisational competence and the competencies of service industry companies respectively, which they have to coordinate. In the international network structures of the service sector there exist many different and rapidly changing service needs GSSC-Management has to consider. This means, GSSC-Management has to cope with a two folded competence problem context. On the one hand, it has to focus on the performance of its own organisational competence and on the other hand it has to ensure, that adequate competencies are available to satisfy the needs of its worldwide customers.

But, how can GSSC-Management recognise such general supposed unmanageable competence problems in a more specific way? In the sense of Drucker competence problems are only manageable if they are measurable (Drucker 1954), which is meant here in a qualitative way of using a more systematic approach. To consider specific problems of GSSC, could not an intelligent tool be necessary to understand its typical problems for the design of its own structures and processes? A goal-oriented controlling of competencies in

GSSC definitely needs a sophisticated approach to fulfil its task to organise collaboration among its service partners. Otherwise this competence-oriented task would lack of the original logistic objective fulfilment to bundle, transform and allocate competencies at good quality, in the right quantity, at the exact point in time, at low cost.

According to the above named questions two main goals have to be considered in this paper. Firstly, a competence-based controlling tool due to identify and analyse substantial problems in logistics has to be developed (**Aim no.1**). Secondly, the developed tool has to be applied to the context of GSSC (**Aim no.2**). Therefore, in a first step a logistics controlling tool and its different functions to identify, analyse and evaluate competence problems in logistics will be described. In a second step, the developed controlling tool will be adopted to GSSC, especially to the context of movie production logistics as a typical, exemplifying GSSC environment.

CONCEPT OF A TOOL FOR LOGISTICS CONTROLLING

As area of interest, international acting movie productions as companies of the service sector have been chosen. Their specific GSSC-environment compared to ordinary service companies increase the relevance and confirm the need to chose movie production as research objective (Hülsmann and Grapp 2006). As stated before, GSSC-Management has to consider its hybrid role, on the one hand to reflect on the performance of its own organisational competence. On the other hand, GSSC-Management has to ensure availability of competencies to satisfy its own and the needs of its worldwide customers, which is a typical service logistics requirement. But why are movie productions so special and should be focused? Following the general GSSC-perspective, movie productions are service companies which produce movies together with worldwide situated partners. These service partners consist of many different companies or even whole studio complexes responsible for e.g. technical equipment, transportation or administration contributing to a movie production process (Gajic 2008). Locations for shooting a movie are often spread all over the world. Between different service partners or locations (im-) material exchange (i.e. equipment and staff as well as data transfer) processes take place which have to be coordinated in an efficient as well as effective way. However, the optimal fulfilment of this task becomes increasingly ambitious, corresponding to an accelerating internationalisation of the movie industry. It becomes more and more difficult to achieve temporal, spatial, quantitative and qualitative goals for movie productions. It can be stated that the vulnerability to management failures seems to increase (Clevé 2004) and it needs to be controlled in a systematic way. This chapter wants to describe a logistics controlling tool with different functions to identify, analyse and evaluate problems.

There are two main aims of such a tool. The first one is the systematic identification of practical problems by business economic criteria. But, which are relevant problems of the service sector that could be considered, i.e. in the movie industry in specific? To generate an overview of actual logistics problems statements of actors of the movie industry (e.g. of directors, producers, actors) have to be collected. They need to be scrutinised regarding the question if and how far they contain or represent problems of logistics. The second aim is to further examine the identified problems regarding their overarching character. However, on which basis could this analysis and characterization be executed? To gain cognitions from a theoretical perspective a methodology needs to be developed on the basis of an adequate theory. Therefore, the competence-based

view (CBV) as leading paradigm of strategic management has been chosen to analyse problems of GSSC. This management theory seems to enable a strategic analysis of logistics problems in international movie production structures such as GSSC. The management of GSSC organizes collaboration among its global service providers. This corresponds to a view of an organisational competence, which can be understood as „[...] the ability to sustain the coordinated deployment of assets in ways that help a firm achieve its goals“ (Sanchez and Heene, 1996; Sanchez, 2004b). GSSC-Management, representing an organisational competence (e.g. producer of a movie production company), is responsible for bundling and allocating competencies of its service companies (i.e. technical, transportation support etc.). This means in general, that logistics excellence is represented by an organisational competence and logistics management in the service sector is responsible for the bundling, transforming, allocating of individual/organisational competencies. Bouncken characterises this ability to coordinate as meta-competence (Bouncken 2003). After showing general conceptual aspects for a tool development its concrete design elements will be explicated.

Former research already generated an approach for a problem analysis in GSSC, focusing on the design of a framework containing first basic thoughts (Hülsmann and Grapp 2007). It is a general attempt for identifying and evaluating problems of GSSC on the one hand. On the other hand it includes a competence-based option analysis for identifying and evaluating new strategic options in GSSC-collaboration. The present paper wants to get beyond an abstract approach and enable a concrete problem identification (Tool Function no. 1) as well as analysis (Tool Function no. 2) for GSSC-Management. The term “tool” is often synonymously used instead of instrument, which is especially applied in the context of scientific analyses (Wahrig-Burfeind, 2004). Kromrey understands a tool as method for a systematic proceeding according to fixed rules (Kromrey 2000).

Problem Identification (Tool Function no. 1)

If it is assumed, that there are problems in GSSC which have to be controlled by its Management, it has to be asked how those deficits can be systematically identified. According to Früh a standardised proceeding for a general problem identification does not exist (Früh 1992). In consequence, a specific one has to be created here for the concrete research context of movie production understood as service logistics, taking place in the structures of GSSC. Out of a pool of statements problems have to be classified and will be clustered. Therefore, first of all statements from actors of the considered industry (e.g. movie production) are collected. The collection of statements could include statements from subject-related literature or could be generated from interviews of GSSC-Managers. The classification process of statements comprises six steps. Each step is based on certain classification rules, standing each for a question that aims at focusing on as well as reducing the pool of statements to the relevant ones that will be analysed later on (see Figure 1). Following the sequence of steps through the classification process every statement is identified regarding its specific problem character with a certain problem code understood as codification. A problem code consists of the different letters (e.g. “P” for problem, “M” for movie-related and so on) which are answers to the classification questions and rules.

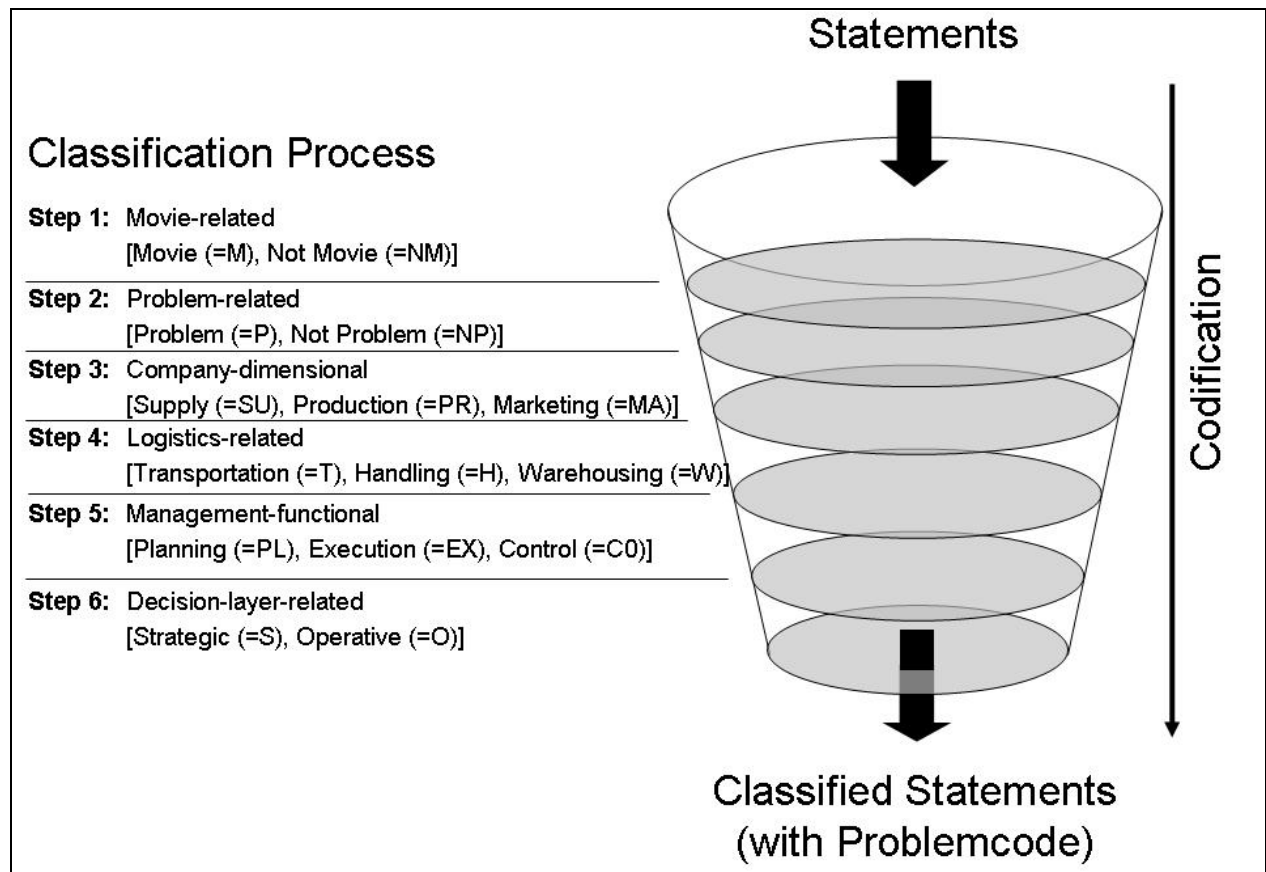


Figure 1. Statement Classification Process

After statements have been classified the question raises in how far the identified logistics problems feature characteristic commonalities and differences. According to Eckes so called cluster analyses could be a method to examine variables regarding their coaction and dependencies (Eckes, 1980). Backhaus et al. describe clustering as a method for group forming out of a multiplicity of objects (statements with different problem codes: e.g. statements with the code "M, P, PR, T, PL, S" meaning strategic movie production logistics related planning problems). Objects belonging to one group should feature the same characteristics, however between different clusters almost no commonalities should exist (Backhaus et al., 2006). The aim of the clustering process is to form problem clusters out of the identified problems from the classification process. Based on the mentioned problem codes for each statement containing a logistics problem, different groups can be build consisting of statements with the same problem character. One homogeneous group with the same problem character corresponds to one problem cluster which is the input for a further problem analysis by tool function no. 2 in the next research step.

Problem Analysis (Tool Function no. 2)

As it has been stated above GSSC-Management seems to be confronted with competence deficits. In how far this is the case will be examined by tool function no. 2 which stands for a competence-based problem analysis. For the intended analysis a framework has been developed that enables, according to Bronner, to explore the identified problem clusters (i.e. movie production logistics) as real facts on the basis of causal facts (i.e. competence-based view) (Bronner, 1999). Tool function no. 2 consists of three layers representing each a certain

framework component of analysis: localisation, characterisation and theoretical foundation (see Figure 2). Each layer consists of different analytical parts.

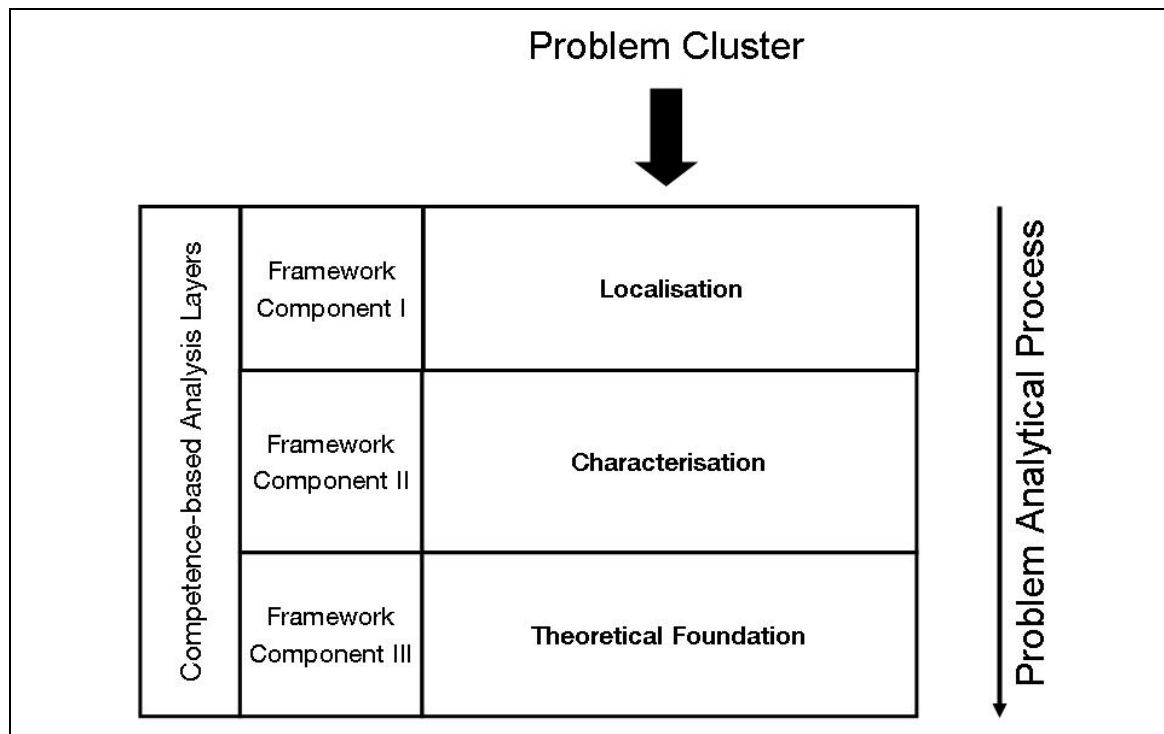


Figure 2. Competence-based Analysis

The purpose of **Framework Component I** is to locate where in movie productions competence problems could occur. Therefore, the open systems (OSV) view as a popular pattern of the CBV is used (Sanchez, 2004a, 2004b). As to Gersch et al. it is a model that allows a systematic and detailed analysis for designing and controlling input, resource as well as competence profiles of companies (Gersch et al., 2005). Amongst others it is examined if and how far for example strategic logic, management processes or operative processes represent spots of competence problems of GSSC. **Framework Component II** aims at examining GSSC problems regarding their competence-based character. As to Sanchez different criteria could be used to achieve this (Sanchez, 2004b). For example, it is examined if and how far a knowledge-related character of competencies ("knowledge basis") exists. As to Sanchez competencies are based on different forms of knowledge (Sanchez, 1997). On the basis of **Framework Component III**, consisting of essential competence-theoretical aspects it is intended to identify cause and effects of logistics problems in movie production. Therefore exist different sub-categories with analytical parts. One of them are the "4 cornerstones" (parts: e.g. dynamic, systemic) which explains competent organisations (Sanchez, 2004a, 2004b). This competence framework consists of 43 parts. Correspondingly, the result of its application is a catalogue of competence problems. As a competence analysis should intend to go beyond a simple listing of problems it is necessary to examine their (inter-)relations. This could be done by a causal net analysis (Bronner, 1989). In consequence, this last step of the developed analysis proceeding examines causes and effects between competence problems to consider their overarching relevance also contextually.

PROBLEM IDENTIFICATION & COMPETENCE-BASED ANALYSIS OF GSSC IN MOVIE PRODUCTIONS

Aim of this paragraph is to show the results of adopting the developed controlling tool to GSSC and especially to the context of movie production logistics as a typical and exemplifying GSSC-environment.

Results of Problem Identification (Tool Function no. 1): A classification of statements (350 qty.) resulted in three problem clusters: problems of (1) supply logistics, (2) production logistics and (3) marketing logistics. Most of the statements seem to belong to the second problem cluster (143 qty.). Besides operative problems especially strategic ones which overarchingly affect movie production processes of GSSC from the perspective of its top management have been identified. These logistics problems are (a) "conflicts" and (b) "communication process interruptions". They refer to information and knowledge flows among managers involved in GSSC-decision-making processes (Grapp and Hülsmann 2008). In general, information and knowledge is only available in a limited way for the management of GSSC processes. Conflicts result from the fact that persons have different interests (i.e. director: artistic realisation, producer: organisational aspects) and correspondingly differentiating information inventories. Through interactions such person-related deficits consequently result in conflicts. Thus, service companies (e.g. technical support) involved in GSSC have to cope with these opposing objectives. If such conflicts occur these service companies have to ask themselves about the effects on them: do conflicting interests of GSSC-Management affect their own goals and which interdependencies are there, e.g. is it still profitable to work for a movie production project that tends to focus on lowering costs and thereby limit options of efficient service production?

The mentioned communication process interruptions affect the technical process of communicating between managers of GSSC. Such problems describe a non-materialised or disconnected flow of information. This means that the transfer of information and knowledge does not function. For service companies this could for example cause severe problems if information about the movie production process is not available in time. Thereby, they maybe cannot offer their services in the needed quality as information as a basis for their internal planning is missing. Those strategic movie production logistical problems and correspondingly a strategic perspective (e.g. director, producer of a movie project) features dominance over an operative level of consideration (e.g. crew of a movie project). After Ulrich and Fluri the decisive influence of strategic problems on the whole justifies the focus on them (Ulrich and Fluri, 1995) for a further analysis.

Results of Problem Analysis (Tool Function no. 2): By every component of analysis diverse competence problems have been identified. Therefore, in the following just one example for each layer shall illustrate the results of the adoption of tool function no. 2. This will be shown for the above stated "conflicts" as problems for GSSC-Management in movie productions. **Localisation:** From a competence-based view "goal conflicts" between director and producer as GSSC-Managers can be assumed. They obviously are not able to balance them and finally build up a common framework for their managerial actions. This means, they have differentiating strategic logics. In consequence, it lacks a basis for decision-making in regard to the deployment of resource and competencies in GSSC-processes. Involved persons or service companies have to cope with diffuse guidelines for their own decisions. **Characterisation:** A further analysis shows that "conflicts" are caused by "competence asymmetry". Especially, in

movie productions it lacks of clear competence structures. This could be the reason why each person wants to enforce his own individual competence and no common interest can be found for the realisation of GSSC-Management processes in movie productions. **Theoretical Foundation:** Another cause could be a "learning deficit", because director and producer leave the structures of an only temporal movie production project. This is why learning curve effects cannot be generated. Mostly every project consists of a completely new team that has to build routines about how to cope with conflict afflicted situations. Therefore, it is much more difficult to use and transfer information about conflict situations from one project to another.

CONTRIBUTIONS & LIMITATIONS IN ANALYSING PROBLEMS OF GSSC

On the basis of competence science theoretical considerations GSSC-Management is provided with an intelligent logistics controlling tool. One of its decisive **contributions** is that it allows a systematic identification, analysis and evaluation of management problems (see Figure 1 and 2). Thereby, the developed proceeding is comprehensible and transparent, especially from a science theoretical point of view (**systematic**). Another contribution is the practice-related character of the tool. On the basis of statements of a certain industry, company or project in logistics it can be applied. This proceeding allows considering directly the existing, specific problems from the point of view of managers as here in GSSC (**practice-related**). However, also **limitations** of this tool have to be considered. One decisive difficulty is its context sensitivity. The tool could be transferred to different GSSC-contexts (e.g. movie production), but always needs the expertise of an expert coming from the specific industry or someone who has deeper knowledge about its coherences. Using the described logistics controlling tool does not completely function autonomously (**context sensitive**). A connected limitation is the huge quantity of data that has to be processed by the user of the tool. The methodology is not yet supported by a software or certain programme to process information which would accelerate the proceeding and finally getting a result (**complexity**).

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GENDER, SKILLS AND LOGISTICS PERFORMANCE

"The tyranny of the urgent makes gender issues appear a luxury"
(BRIDGE Project at the UK Institute of Development Studies)

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ABSTRACT

Purpose of the paper – The aim of this paper is to investigate the mutual links between logistical skills, gender, and logistics performance in the context of humanitarian logistics.

Design/methodology/approach – Based on a topical literature review, the paper evaluates the role of gender in the relation between logistics skills and logistics performance.

Findings – The paper recognises differences in the conceptualisation of logistics skills, in particular in the importance of relationship management skills for logistics performance. Gender in business logistics is conceptualised as part of the personal skills of logisticians, while in humanitarian logistics is linked directly to logistics performance.

Research limitations/implications – Based on a literature review the paper presents particular avenues for further research.

Originality / value – Literature on gender and logistics is scant, and it is not understood how gender issues impact on logistics effectiveness. The focus on humanitarian logistics also adds to the novelty of the paper.

Category: Conceptual paper

INTRODUCTION

In the aftermath of a disaster, be it natural or man-made, logistics is a cornerstone of the response of the humanitarian community. Indeed, some commentators have suggested that as much as 80% of an NGOs expenditure can be classified under the broad heading of logistics (van Wassenhove 2006) and, in that sense, a humanitarian organisation is a logistical organisation – albeit one with, typically, a specific mandate, and target set of beneficiaries.

Humanitarian logistics (or rather, its shortcomings) got into the media spotlight during a number of major natural disasters at the wake of the 21st century. This attention had significant implications for humanitarian organisations and the way they looked upon logistics, and logisticians. Whilst logistics efficiency as well as aid effectiveness had been under scrutiny in humanitarian organisations, the link between the two was not always established. This resulted in a number of studies on logistics performance, and performance indicators in humanitarian logistics (cf. de Brito *et al.* 2007).

As for humanitarian logisticians themselves, it implied a professionalisation of the field. There is an appreciation that training and most importantly, education, can provide tangible improvements to the effectiveness of humanitarian logistics, yet professionalisation led to the question of the skills and knowledge humanitarian logisticians would need to be "good". What is more, even on the larger scale of "logistics" at large, it is far from established which skills and knowledge a "good" logistician might need. Logistics skills literature has insofar built on the old engineering models of T-shaped people, listing a number of particular skills for the profession on one hand, and linking these to other knowledge areas of – in this case – management (see Mangan & Christopher 2005, for the discussion of the T-shaped skills model in logistics).

Whilst the T-shaped model has been developed for business (and engineering) logistics, other application areas (e.g. the humanitarian, or the military counterparts) emphasise a different mix of logistical skills and knowledge. As for humanitarian logistics, its aim is to meet the needs of end beneficiaries (Thomas & Mizushima 2005), thus logistics effectiveness in this area relates to meeting the needs of these beneficiaries. At the same time, "beneficiaries" is not a homogeneous group, rather, their needs depend on a number of demographical and cultural factors. One such factor that has been highlighted in the Millenium Development Goals is the special needs of women (United Nations 2005). Indeed, a beneficiary's gender is a key determining factor in her/his vulnerability (cf. Enarson 2002; Neumayer & Plümper 2007), and hence, her/his needs. More than just differentiating the targeting of female and male beneficiaries (ALNAP 2005; FAO 2001), humanitarian organisations have come to recognise that also the gender of the logistician matters in the delivery of aid. Yet the effects of gender on logistics performance have to date not yet been established.

The aim of this paper is, therefore, to investigate the mutual links between logistical skills, gender, and logistics performance. In the following, we will discuss each of these links in turn.

LOGISTICS SKILLS AND PERFORMANCE

The question of which skills and knowledge are important for logistics has been addressed from a number of different angles. The dominant approach is the educational angle, in which the main issue is to evaluate which areas of "competence" future logisticians would need, in order to develop educational programmes in logistics (Mangan *et al.* 2001). The reverse angle is to determine which skills are needed to educate future logisticians (Tracey & Smith-Doerflein, 2001). Skills for different levels of the profession are also investigated, e.g. skills needed to advance to senior positions in logistics (Murphy & Poist, 2007), or differences in skills needed between logistics and supply chain management (SCM) (Dischinger *et al.* 2006; Gammelgaard & Larson 2001). Here, the crucial difference in skills, however, boils down to the "personal skills", most importantly, the "relationship management skills" SCM would emphasise (Mangan & Christopher 2005; van Hoek *et al.* 2002), or, as Murphy and Poist (2007) put it, SCM requires other "business skills" than mere logistics skills. *Thus, further research is needed to evaluate the link between "SCM" and different sets of logistics skills, as opposed to "core" logistics skills.*

Thus, the emphasis of logistics skills literature is on training and education. Such an emphasis can also be found in humanitarian logistics literature, though from the perspective of criticising humanitarian logisticians for a lack of training (cf. Thomas & Mizushima 2005). But perceptions of what logistics, and the role of a logistician, is, colour which skills and knowledge are emphasised. Not only is logistics skills literature biased towards individual authors' definition of logistics, but also, future students, managers of logisticians, and the hiring organisations' definitions impact on the combination of skills required from logisticians (cf. Sohal & D'Netto 2004). Not only the differences between logistics vs. SCM are debated, but en large, logistics (still) suffers from a "truck driver image".

Other reasons to look at logistics skills are to link them to the logistics performance of an organisation (cf. Wouters & Wilderom 2008). Interestingly, the gender of a logistician has been highlighted as impacting on her/his set of skills (Min *et al.* 1995; CSCMP 2006), and gender relations are attributed an immense underestimated scope in supply networks (Broadbridge & Hearn 2008). Therefore gender should be taken into account when evaluating the links between the skills of a logistician and the logistics performance of an organisation.

GENDER AND LOGISTICS

Gender studies in logistics mostly focus on the under-representation of women in the profession, and emphasise differences between female and male career patterns in logistics (Lynagh *et al.* 1999; CSCMP 2006). Yet Trunick (2007) criticises such studies for being biased towards the logistics definition of the professional organisation they've been sent out to. There are indeed crucial differences between definitions when surveys are sent out to e.g. purchasing, warehousing, or freight forwarding associations. *Thus, as in skills literature, the issue of definitions, and logistics job descriptions, remains.*

The "truck driver image" of logistics can also be linked to gender. Logistics has been criticised for being a "male", engineering field, employing a "male language" (Allan and Loureiro-Koechlin 2007). Other barriers to women entering the profession are related to work-life balance, e.g. the needs of work-related travel in logistics jobs (Gustafson 2006), or consumer household logistics impacting on the lifestyle of women and men even in otherwise "westernised" cultures (Granzin 1990). Recognising such barriers led to the establishment of several projects that focus on promoting women logisticians. Examples of these is the Empathy net-works project at Hull University Business School; Women in Logistics at the Logistics Institute in Canada, or, in humanitarian logistics, the group of WISE, i.e. Women in Supply Chain Excellence. The focus of these projects range from encouraging women to study logistics, to designing logistics education targeting women, to coaching female logisticians at the workplace, to ultimately, advocating gender mainstreaming in logistics. What all of these projects have in common is a policy to counteract sex segregation in logistics.

Organisations might not see sex segregation as a problem, was it not that the gender of the logistician could in fact be linked to the logistics performance of the organisation. Just as Wouters and Wilderom (2008) discuss the link between the skills of the logistician and the logistics performance of the organisation, Min *et*

al. (1995) highlight the effects of gender on the outcome of purchasing negotiations. Links between gender and logistics skills are also discussed in literature, e.g. the latest version of the Ohio State survey on women in logistics evaluating the differences between female and male logistics leadership skills (CSCMP 2006). Just how this link can be conceptualised has not yet been clarified. Min *et al.* (1995) treat gender as a “noise” impacting on the negotiation skills of logisticians, just as the Ohio survey sees gender as impacting on logisticians’ leadership skills. *Further research is, however, needed to establish which logistics skills the gender of the logistician has a significant impact on.*

THE ROLE OF GENDER IN HUMANITARIAN LOGISTICS

The humanitarian context sees the effects of gender not just on the skills of the logistician, but also directly on logistics performance. Here, gender sensitivities come into play in (a) needs assessment, i.e. establishing the diverse needs of different groups of beneficiaries, (b) purchasing decisions, including where gender-insensitive purchasing may lead to sanitary and health problems, and (c) the last-mile delivery of relief items (Kovács and Tatham 2008). These are the gender issues in humanitarian logistics that relate to the gender of the logistician – while others stem from the areas of disasters, or from the nature of development aid. Yet there are obvious links between the two:

The reason to focus on *gender issues in needs assessment* is the appreciation of differences in disaster vulnerabilities between female and male beneficiaries (Enarson 2002). Firstly, beneficiary groups differ in their exposure to a disaster. This may depend on the very location of a person when the disaster strikes, i.e. who is in the fields vs. at home or in the city vs. in rural areas (Fordham 2002). A determining factor of disaster vulnerabilities is the (traditional) role of women and men in a particular society (Delica 2002; Weekes-Vagliani 1994). Also, war-related violence such as rape targets women in particular (FAO 2001). This establishes different needs of fe/male populations in a disaster. When it comes to the gender of the logistician, traditional roles of women and men in society may become an inhibiting factor in assessing their needs, particularly in cultures in which women are not allowed to speak to men outside of their families, and men cannot articulate the needs of their female family members. Such circumstances emphasise the need for women (as well as men) on needs assessment teams. However, while already in business logistics a lack of female logisticians has been criticised, humanitarian organisations also suffer from a lack of female humanitarian logisticians. What is more, humanitarian logisticians tend to be male even organisations that otherwise employ an 80-90% of female workforce (e.g. Médecins Sans Frontières).

Not surprisingly, *gender-insensitive purchasing* stems from male vs. female logisticians misjudging the needs of the other sex (of beneficiaries). Infamous examples here include not just gender- and culture-insensitive purchasing of clothing, but more strikingly, relief items being purchased that endanger women beneficiaries from a safety, or a health perspective (ALNAP 2005; Burki 2006).

Fe/male beneficiaries also differ in their possibilities to access relief. Access consists of several factors: the transport accessibility of aid (where wo/men have

to travel longer distances or cannot afford transportation to relief centres; Dayal 2008), but also, the way aid is distributed via e.g. male heads of households, where family units without a male head might have a disadvantage (Enarson 2002). Yet the gender of the logistician can delimit the access to such family units, as well as create additional problems where the people distributing relief items do not understand the diverse needs of different beneficiary groups. A crucial difference here between business and humanitarian logistics is the personal engagement of humanitarian logisticians in the *last mile delivery* of relief items. Gender issues in humanitarian logistics are not only magnified by arising from both sides (the logistician and the beneficiary), but also, situations in which the gender of the logistician is under scrutiny occur more often in humanitarian logistics. This is why in this context there is a direct link between the logistician's gender and the logistics performance of an organisation. *Further research here is needed to establish (a) the difference between the impact of gender attributes on logistics skills, and (b) the effects of gender attributes on logistics performance.*

CONCLUSIONS AND FURTHER RESEARCH

Clearly there are multiple ways through which gender attributes can be linked to logistics skills and, in turn, to logistics performance. Yet while different links have been established between logistics skills and logistics performance (Wouters and Wilderom 2008), and gender and logistics skills (Min *et al.* 1995; CSCMP 2006), interestingly, even studies on logistics performance in humanitarian logistics (de Brito *et al.* 2007) have not included gender as a dimension. Thus we propose that the links between gender, logistics skills, and logistics performance should be studied, evaluating not only how these three constructs relate to each other, but also, under which circumstances different sets of skills, or gender attributes, impact on logistics performance. Most interestingly, there is no consensus in literature in how gender, logistics skills, and logistics performance are linked to each other. Therefore, though it was originally planned, this paper could not construct an unambiguous model on gender, skills and logistics performance based on literature. In other words, further studies are needed in establishing the interrelation of different links, and in particular, to test whether gender has a direct impact on logistics skills, on logistics performance, or both. A working hypothesis here is that the difference in conceptualising gender in business logistics vs. humanitarian logistics will have an effect on the link between gender to skills, or gender to performance, in the different contexts.

Furthermore, previous surveys on women in logistics, and on logistics skills, have been criticised for being biased towards professional organisations, and thus, towards a specific definition of logistics. Therefore we propose a survey on gender and logistics skills not only to be sent out to logisticians, but also to their managers, in order to establish how logistics is perceived (and defined) in an organisation, and which implications this has for the emphasis of the organisation on different sets of logistics skills.

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THE IMPLICATIONS OF DEREGULATION & LIBERALIZATION ON THE LOGISTICS SERVICE INDUSTRY IN LAO PDR

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ABSTRACT

This study analyses the development of the Lao freight logistics sector with a special focus on domestic demand for freight logistics services. Based on empirical data, the study focuses on two main dimensions of the Lao freight logistics sector: (i) the development of a private freight logistics sector since the formulation of the New Economic Mechanism (NEM) that progressively opened the Lao economy to the world; (ii) the Lao freight logistics sector's awareness of opportunities and challenges arising from Lao PDR's participation in ASEAN, GMS and hopefully the WTO in the near future. The first part of the paper seek to map the development over time and provide a report of the current status the Lao freight logistics sector with special reference to the transition to towards market economy, whereas the second part will try to explore more long term consequences on the freight logistics sector as a consequence of increased integration with international markets.

KEYWORDS: LAO PDR, FREIGHT LOGISTICS,

Introduction

Since the launch of market reforms during the late 1980s, Lao PDR has shown a strong record of economic growth. Economic reforms in Lao PDR started at a major scale in November 1986, when the New Economic Mechanism (NEM) was adopted and major steps towards transition from a centrally planned economy to a market economy were taken. Under the NEM, the Lao government announced measures to promote the development of the private sector; it deregulated price and production controls, and granted managerial and financial autonomy to state-owned enterprises. These reforms, together with Lao's participation in ASEAN and its free trade area, the Greater Mekong Subregion (GMS) grouping and its willingness to become a member of the World Trade Organization (WTO), have created a challenging environment for all types of business activities.

The objective of this paper is to analyze the development of the Lao freight logistics sector with a special focus on demand for freight logistics services. Based on empirical data, the study focuses on two main dimensions of the Lao freight logistics sector: (i) the development of a private freight logistics sector since the formulation of the New Economic Mechanism (NEM) that progressively opened the Lao economy to the world; (ii) the Lao freight logistics sector's awareness of opportunities and challenges arising from Lao PDR's participation in ASEAN, GMS and hopefully the WTO in the near future. The first part of the paper seek to map the development over time and provide a report of the current status of the Lao freight logistics sector with special reference to the transition towards a market economy, whereas the second part will try to explore more long term consequences on the freight logistics sector as a consequence of increased integration with international markets.

The Importance of the Logistics Sector in a Transition Economy

The rationale behind the link between transport infrastructure investment and transition to market economy is that transport investments reduce transport costs, thus providing better scope for higher market efficiency (Jacoby 2000). The immediate benefit of infrastructure investment is the fall in unit costs for each type of traffic using the infrastructure in question, multiplied by the amount of traffic. This would represent the costs saving for existing traffic, and is believed to encourage economic performance in various ways (Banister & Berechman 2001). Logistics services, as one factor in the production of goods and services, represents a cost to individual businesses. Greater efficiency in the logistics sector can help stimulates greater demand, so that firms may enjoy enhanced scale economies, a virtuous circle of further cost reductions and sales growth is set in motion.

A critical component for the successful integration of the local economy into regional and global markets and to achieve an efficient transmission of benefits from trade to the domestic economy is an efficient and well functioning national transport logistics system. The performance of the national logistics system is an important facilitator for the export and import trade, but also for domestic distribution (Sadoulet & de Janvry 1995). Efficient distribution systems with low transaction costs are expected to transfer goods produced elsewhere to the local consumer at a competitive price, at the same time as local producers can get a competitive price for their commodities (Pelton et al 2002). Geographical factors such as location, distance to markets, and road accessibility naturally have a significant impact on the costs of intermediate and final goods. This means that transaction costs—including transport costs and costs for retrieving information about prices and market conditions—can have a direct effect on firms opportunities to increase their earning (Gannon & Liu 1997).

Increased economic interaction with neighboring economies

Expanding trade is an important part of market-oriented policy reforms. Successful outward oriented development will require not only trade reforms, but also improvements in both the hard and soft infrastructure of trade such as ports, customs administration, insurance, finance, and related institutional structure governing logistics services. Increasingly congested ports and insufficient transport facilities, as well as institutions focused on control rather than on trade facilitation and the lack of access to trade financing have become obstacles to business development. During the period 1992-2005, exports of Lao PDR to the other five GMS¹ countries grew by 16%, on a compounded annual average basis, from US\$48 million to US\$314 million, accounting for almost half of its total exports, which similarly grew by an average of 16% (IMF-DOTS). Overall, the growth of Lao PDR intra-GMS trade has been very rapid and in line with the process of economic integration to regional and global markets. Trade has not only increased between the capital Vientiane and through major transit routes with Thailand but there has also been an increased interaction between provincial centres and Vientiane (Andersson et al, 2006).

¹ The GMS member countries are: Cambodia, People's Republic of China (Yunnan & Guangxi province) Lao PDR, Myanmar, Thailand and Vietnam

Current Status of the Logistics sector in Lao PDR

There are four key elements that influence the transport and logistics system in Lao PDR: (1) landlockedness which creates a dependency on transit traffic through neighboring countries; (2) a geographically scattered population; (3) high dependence on subsistence agriculture; and (4) weak transport infrastructure that impedes the integration of scattered local and provincial markets.

Large investments in transport infrastructure have been carried out with the purpose to alleviate the negative impact of these characteristics on national economic development and integration both within the country and with neighboring countries. The rapid increase in trade together with the specific characteristics of Lao PDR raises the importance of capable logistics services.

Surface Type	Administrative Classification						
	National	Provincial	District	Rural	Urban	Special	Total
Paved	3,771	198	31	14	429	54	4,497
Gravel	2,244	3,038	1,826	1,815	871	304	10,097
Earth	1,126	3,240	2,008	9,527	465	249	16,615
Total	7,141	6,476	3,865	11,356	1,765	607	31,210

Table 1. Total Road Length

Source: UNESCAP (2007)

There are now 4,500 km of paved roads in Lao PDR, 10,100 km of gravel road, and 16,600 km of earth road. Much of the network is not ready for all weather traffic thus not accessible all year around. The development of the road system has concentrated on improving major links and enhancing maintenance capacity. Major transport corridors have been upgraded, with links restored between the northern and southern parts of the country, and all provincial capitals are to be joined to the national network with all weather roads. About half of the 21 ports on the Mekong River have been rehabilitated in the last 15 years. The road network carries the dominant share of passenger and freight movement in Laos. National statistics indicate that road transport has a share of 70% of the freight transport in 2002, with almost all of the remainder being carried by river transport (NSC 2003).

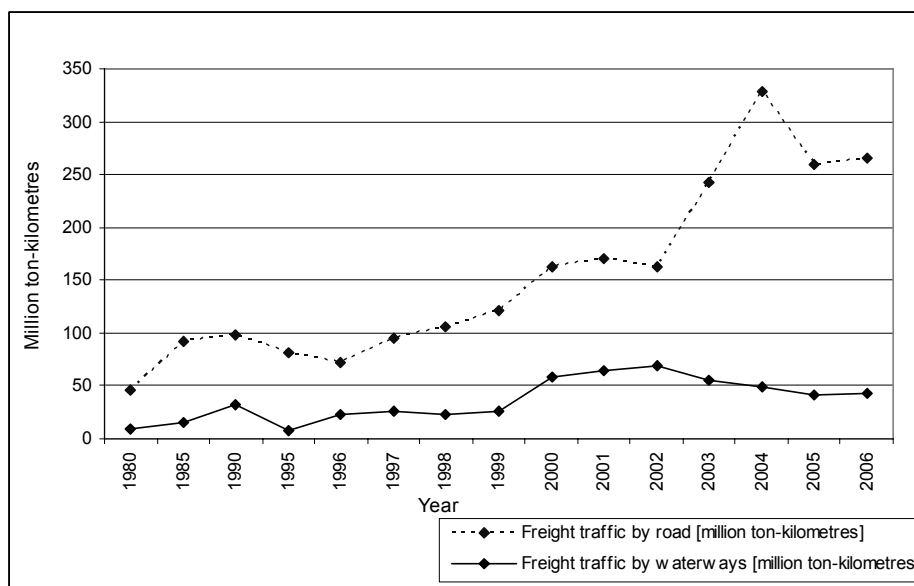


Figure 1. Modal share of domestic freight movements Source: MCTPC

The Ministry of Communication, Transport, Post and Construction (MCTPC) is responsible for the planning, construction and macro-management of roads, waterways, civil aviation, transport, communication, housing and urban planning for urban and rural areas nationwide (Decree, May 12 1999). The various provincial Departments of Communication, Transport, Post and Construction (DCTPC) are responsible for the implementation, the construction and maintenance of road within their respective province or municipality as delegated by the MCTPC (Agreement, 1993). Offices of Communication, Transport, Post and Construction (OCTPCs) are located at the district level and are responsible for the maintenance of roads under its jurisdiction as delegated by the provincial DCTPC in compliance with the communication management guidelines developed by MCTPC (Agreement, 1993).

Freight services in Lao PDR are provided by private companies under regulations governed by the MCTPC and provincial DCTPC. Figure 2 illustrate the growth of added value provided by logistics services in Lao PDR since 1995. The numbers fit well with the overall increase in economic activity.

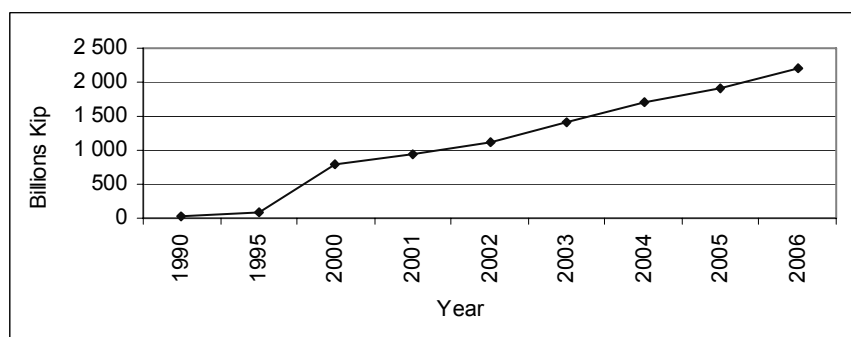


Figure 2. Value-added of transport, storage and communications

Source: UNESCAP 2007

The Lao International Freight Forwarders Association (LIFFA) was established by ministerial decree in 2001. LIFFA currently has around 20 members composed of freight forwarders, trucking companies and customs brokers. The majority of their members are based in Vientiane where most of the transit traffic is concentrated. Under the 1999 road transport agreement with Thailand, Lao trucks are able to deliver and collect Lao import or export goods to and from Bangkok or Laem Chabang port. However, to date none have been able to do so. The reason may be partly because Thai authorities are still reticent about having Lao trucks on Thai road for numerous safety reasons but also because it is difficult for Lao trucks to get return traffic. This makes the transit cost high compared to just transloading the goods on Thai trucks in Nongkhai (just across the friendship bridge) and getting return traffic into Lao from the same location.

Trucking associations at district levels have been existence since the late 1980s. Many of them act as freight brokers as well as schedule co-ordinators between members. Provincial trucking associations have now been established in 7 provinces and there are plans to expand to other provinces. The MCTPC is working on organizing a national association of trucking operators which may come under the umbrella of LIFFA.

In Vientiane, the capital, there are 14 trucking companies and 6 associations, with a total fleet of 1,211 trucks in number. This includes 605, 6-8 tons trucks; 363, 10-12 tons trucks; and 243, 18-22 tons trucks². Around 50% of the trucks are old Soviet trucks and rest are used 2nd hand Japanese and Korean trucks. The average truck age is more than 10 years. Trucking companies are usually family businesses with staff that learned "on the job" the trucking business. There exist foreign-owned freight forwarders in Lao PDR but there is no foreign owned or joint-venture truck operator. Truck tariffs are subject to negotiation between individual shippers and operators, but an estimated figure of US\$5 to 6 cents/ton/km was quoted by one operator.

Savannakhet Province is the 2nd most important province in Lao PDR located in the southern part of the country. The province has in total 738 trucks. This includes 280, 1-6 tons trucks; 347, 8-12 tons trucks; and 101, 14-23 tons trucks. The current truck fleet is a mixture of used Japanese/Korean trucks (10-15 years old) and Soviet era trucks (more than 20 years old). In Savannakhet, Lao trucks have access to Vietnamese roads. Some Lao trucks move freight between Savannakhet and Hue, Danang and Hanoi. In 2005, truck traffic from Vietnam was 14,361 in number and carried 37,433 tons; the traffic to Vietnam was 14,475 in number and with a cargo volume of 264,562 tons. It was reported that Vietnamese carried up to 95% of the total Lao PDR-Vietnam traffic. Truck traffic from Thailand in 2005 was 9,845 in number and in 146,124 tons in volume; truck traffic to Thailand was 6,238 in number and 131,946 tons in volume. Lao trucks can deliver goods to Mukdahan in Thailand by crossing the second international bridge over Mekong. Major difficulties of the Lao trucking operators on these international transport routes were aged trucks, high oil price, lack of return load and insufficient skills of trucking management and drivers.

² Interview data from the Department of Roads, MCTPC

Current issues faced by the Lao logistics industry include: a relatively (compared to adjacent countries) low weight limits for trucks which result in higher transport costs for operators (and consumers) compared to other ASEAN countries; the extent of vehicle overloading by some freight operators to reduce their costs (requiring more rigorous enforcement); regulations on the use of containers in Lao PDR; transit fees for freight services using Lao PDR as a 'land-link' between neighboring countries; the high costs for (imported) parts; the lack of professional knowledge in the truck management and operations.

A changing institutional setting for Lao PDRs' logistics sector

Two major strategic economic groupings provide the framework for improved regional transport integration in the region: the Association of South East Asian Nations³ (ASEAN) framework agreements and the ADB led Greater Mekong Subregion initiatives. Acceding to United Nations agreements on international trade and transport would also be of benefit the Lao capability to reach global markets.

There are ASEAN framework agreements that directly impact on the Lao logistics industry. The first one is the ASEAN framework on the facilitation of goods in transit signed in 1998 and the second is the ASEAN framework agreement on multimodal transport signed in 2005. However, their implementation is still lacking due to difficulties in negotiating implantation protocols. The third ASEAN initiative is the endorsement of the ASEAN roadmap for the integration of the ASEAN logistics sector in 2007. This roadmap calls for enhanced liberalization of logistics service within member countries and have set the target date to 2013.

The GMS countries have also signed the GMS Cross Border Transport Agreement (CBTA) in 2007. The objective of the CBTA is to facilitate the movement of people, freight and vehicles within the GMS. In the agreement there are provisions related to exchange of traffic rights and the number of designated transit licenses per country.

The proliferation of such agreements hinders rather than helps Lao PDR. The Lao government is drowning in bilateral, trilateral and multilateral agreements covering international and transit trade, which have different operational modalities according to their respective aims.

The Lao logistics industry is faced with numerous challenges. Their market will be liberalized by 2013 under ASEAN and their government has acceded to some controversial ASEAN protocols such as the one limiting the number of transit trucks to 60 per member country while the CBTA permits up to 500 designated transit vehicles. The fear is that the local logistics industry is not even aware of the development that will occur and have no response to such development. This emerging local industry may disappear even before it is strong enough to survive in its market.

³ Members of ASEAN are Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Singapore, Philippines, Thailand, and Vietnam

Conclusion and future outlook

Private freight operators provided an interesting perspective to the MCTPC and DCTPCs capacity to formulate transport or logistics related policy and regulations. There is a strong “gap” in terms of understanding and trust between government institutions and the private operators. This “gap” also exists within the private freight operators themselves based on the level where they operate i.e. international, national, provincial, and district level. Competition and low levels of coordination between trucking companies on national and provincial levels are weak and thus strongly affect final delivered price.

There is another “gap” between clients and the local service providers. The Lao Chamber of Commerce (representing the local clients) does not consider that the industry is very competitive because it is a very small market, with a limited number of players who know each other and collude on prices. In contrast, truck operators argue that the domestic trucking industry is very competitive and that tariffs relatively low - barely covering fuel cost. The larger operators complain that small operators with limited numbers of trucks are able to compete on the basis of paying lower taxes as a consequence of operating in areas where the tax collecting authorities are weak.

These “gaps” do not support the sustainability of the Lao freight logistics industry. There are pressures to open up the domestic Lao freight market based on regional agreements when in reality the industry is at an infant stage and still needs to be developed. This infant industry is not trusted by its local clients while the overseeing governmental agencies lack the capacity to understand what their current needs are. The future looks very uncertain for the local freight logistics industry.

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EXPLAINING COMPETITIVE ADVANTAGE OF LOGISTICS SERVICE PROVIDERS: A RESOURCE-BASED VIEW APPROACH

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ABSTRACT

Logistics service industry has experienced tremendous growths via a mixture of organic expansion, merger, acquisition and alliance. According to resource-based theory, firms achieve growth because they are competitive; and firms achieve competitiveness by accessing and exploiting unique resources. This research applies resource-based theory to explain the competitive advantage of fifteen global logistics service providers (LSPs). The research explains what resources these LSPs acquired, and how they have acquired and bundled these resources together to achieve competitive advantages.

INTRODUCTION

Logistics service became a separate industry only in the late 1980s (Sheffi, 1990). The logistics service industry has been experiencing growth, but not all logistics service providers (LSPs) achieve the same rates of growth - some with decline growth (Min & Foo, 2006). Furthermore, a recent survey indicates that many buyers are overall dissatisfied with the services provided by their LSPs (Langley & Gaggemini, 2007). Thus, logistics service contracts are still mostly limited to transport and warehouse and changes of LSPs occur every two years.

What logistics service industry needs are theories and solutions that lead to sustainable competitive advantage but the literature of third party logistics (3PL) has not addressed these needs. There is some literature that explores success and failure factors of logistics outsourcing but we need more understanding of the means for LSPs to achieve competitive advantages. Furthermore, much of the 3PL literature has been exploratory in nature; it has largely lacked the development of theoretical-driven models and hypothesis, not to mention its application to the practitioners (Maloni & Carter, 2006).

In reality, the growths of LSPs have been achieved via a mixture of organic expansion, merger, acquisition and alliance in the recent years. These attempts represent a way to acquire resources to achieve growth. According to resource-based view (RBV), firms gain sustainable competitive advantages by ensuring appropriate access to a bundle of valuable, rare, non-imitable and non-substitutable resources (Penrose, 1959; Wernerfelt, 1984; Barney, 1991). Thus, RBV provides a key theoretical foundation for the LSPs' competitive advantages. This research attempts to collect empirical evidences which explain the competitiveness of LSPs' based on RBV. Based on a database of 15 LSPs, this research investigates what and how logistics resources are accessed by these LSPs and how different resources are managed or bundled together to achieve competitive advantage.

LITERATURE REVIEW

One of the less explored research areas in the logistics service industry is the growth and competitiveness of logistics providers. The logistics service industry

is growing due to increased outsourcing. Literature which focuses on the outcomes of logistics sourcing has suggested the following competitive factors for the LSPs, i.e., price, frequency, capacity, schedule service, ability to track packages, extent of geographic coverage, reliability, and innovative service offerings (Rafiq & Jaafar, 2007). Research has to explain how these competitive factors come about. The study by Daugherty *et al.* (1998) indicated that logistics service ability was indirectly related to firm's market share through customer satisfaction and loyalty. Murphy and Poist (1998) further pointed out that some LSPs choose to light-asset while others choose asset-based strategies but there is inadequate empirical evidence which relates the two strategies to competitive advantage.

Somehow the asset-based strategy indicates that some LSPs purposely acquire certain resources for achieving competitive advantages. According to resource-based view (RBV), resources are defined as those tangible and intangible assets which are tied semi-permanently to a firm (Wernerfelt, 1984). The term "tied semi-permanently" is loosely refers to the acquisition, access, or possession of "unique resources" so that they can be exploited to achieve competitive advantage (Penrose, 1959; Wernerfelt, 1984; Prahalad and Hamel, 1990; Barney, 1991). Physical plant, equipment, finance, human, organisation, stock, land, debtor can be classified as tangible resources; while intangible resources are for example information, knowledge, competence, trademark, patent, and relationship (Lewis, 1995; Hunt, 2001; Mills *et al.*, 2003).

RBV can provide valuable understanding of the competitiveness of LSPs. Two of its assumptions reflect the business environment of logistics service industry. Firstly, resources are distributed heterogeneously across LSPs. Secondly, critical resources cannot be transferred from a LSP to another without cost (i.e., resources are sticky). Even though RBV is not a prescriptive theory, it is useful in explaining how a firm may sustain its competitive advantage by acquiring and exploiting the "right" resources (Priem and Butler, 2001). RBV can also be used to explain the growth or diversification of LSPs; driven by the desire to growth LSPs usually acquire new resources or diversify especially when it has reached a satisfactory and reasonably secure position (Penrose, 1959).

RBV has actually been applied in the logistics literature. Much literature has direct or indirectly related resources to LSPs' performances or competitive advantages. Technology, especially information technology has been regarded as one of the success factors of the LSPs (Chiu, 1995; Hammant 1995; Myers *et al.*, 1999; Alshawi 2001; Gunasakeran & Ngai, 2003; Aldin, 2004; Lai *et al.*, 2005; Sanders & Premus, 2005; Brah & Lim, 2006). The other often cited resource is knowledge, which is reflected from the management practice (Myers *et al.*, 1999; Mentzer *et al.*, 2004; Brah & Lim, 2006) and human resource since logistics is a "people" oriented business (Novack *et al.*, 1992; Drew & Smith 1998; Zineldin, 2004). Other more recent literature argues that relationship is the key to LSPs' success (Panayides & So, 2005; Panayides, 2007). This literature provides the basis for further investigation of the relationship between resources and competitive advantages of LSPs.

Research has also looked into how different resources are "bundled" together. For example, it is important to integrate IT with logistics management concepts

(Chiu, 1995); and logistics people should be trained to use technology and tools Larson & Kulchitsky (1999). Such a literature indicates that it is not just necessarily to understand what resources are required but also how these resources are “bundled” together to achieve competitiveness.

RESEARCH METHODOLOGY

This research set out to answer the three questions: (1) what logistics resources are accessed by these LSPs? (2) How are these resources accessed? And (3) how are different resources bundled together to achieve competitive advantage? The research is based on databases of 15 LSPs (Schenker AG, Ryder System, Inc., Kuehne+Nagel, FedEx Corporation, TNT NV, United Parcel Service, Inc., DHL, Exel PLC, Yamato Holdings Co. Ltd., Panalpina World Transport (Holding) Ltd., Kuehne+Nagel (K+N), Expeditors International of Washington, Inc., Penske Corporation, Wincanton plc, Kintetsu World Express). They are selected because they have been trying to become successful global LSPs. They vary in organisation sizes (from about 6,000 employees to 428,000 employees) and their operations cover from 15 to 220 countries.

The databases provide updated company profiles (year 2007) for the above LSPs; they are published by Datamonitor (www.datamonitor.com). Datamonitor is a leading business information company specialized in industry analysis. The databases provide accurate financial data, strategic decisions, announcements, key events (such as merger, acquisition, joint-venture, disposal, financial crisis, etc.), product segmentation, and new product development. This research particularly looked for activities which provide access to critical resources and competitive advantages. Datamonitor also claims to provide unbiased expert analyses and forecast of the related industries, which include SWOT analyses and market forecasts. However, data for this research are based only on facts and reported events from the databases, not from any of these analyses.

The limitation of performing analysis based on such databases (secondary data) is that there is no chance to seek further explanation to the data. Furthermore, no all required information is available. Thus, the contribution of this research is limited to the collection of more empirical evidences to support the RBV theory.

FINDINGS

The following are the key findings from this research.

Question 1: What logistics resources are accessed by these LSPs?

The research found plenty of evidences of the application of resource-based theory by the LSPs in practice. Logistics resources are divided into: physical resources, information/knowledge resources and relational resources.

Physical resources: Most LSPs have acquired physical resources such as aircraft, vessels, vehicles, logistics hubs, warehouses, lands, and etc. Expeditors, Wincanton and Panalpina have acquired less physical resources because they have chosen the light-asset strategy. Most LSPs perceived physical resources as one of the most important resources because they are required to support the “network coverage” advantage (DHL called this “global reach”), without which no LSP could offer a wide selection of service portfolio at both global and domestic levels. Lack of access to physical resources could be a hurdle to revenue growth.

For example, K+N's generated its revenues from mainly sea freight, but due to limited physical resources (vessels and terminals) it experienced disadvantages against other larger sea freight operators such as A.P. Moeller-Maersk.

Information resources: Every LSP has attempted to access to information technology and continuously upgrading their information resources such as "Easyship Professional" (DHL), a shipping tool for eBay marketplace (UPS), "KN Login" (K+N), and "Logistar" (K+N). One of the reasons for K+N's acquisition of ACR logistics was the access to "Logistar" (a SCM software). Another effort in strengthening information resources is the integration of radio frequency identification (RFID) technology to warehouse management systems and transportation management systems by Ryders System.

Knowledge resources: Many LSPs have also attempted to acquire human resources with expert knowledge in certain industries. DHL and FedEx admitted that knowledge of the customer is the key to success. DHL and UPS have hired supply chain experts and acquired or designed supply chain software in order to perform complicated logistics network and supply chain analysis. UPS even established a "logistics campus" in Ontario to support the development of knowledge resources for its supply chain solution division. Wincanton with relatively low physical resource relied heavily on knowledge resources which provide customized one-stop management solution.

Relational resources: Many LSPs have attempted to build up collaborative relationships with their customers. UPS was able to become the official logistics provider for eBay marketplace because of its close relationship with eBay. Wincanton's 6-year relationship with Comet (an electrical retailer) led to another 3-year contract. This relationship is further strengthened by Wincanton's expertise in the retail sector and their understanding of Comet's business. Relational resources are also established between LSPs horizontally. For example, K+N collaborated with Wincanton to form "KNW Retail Solutions" which jointly competes with other competitors in the retail sector. The acquisition of relational resources is not just for the purpose of accessing to customers, it is also another quick means to access to physical, information and knowledge resources with low financial investment.

The above evidences show that LSPs have been busy acquiring a wide variety of resources including physical, information, knowledge and relational resources, especially in the emerging or new markets. UPS and DHL have been successfully in acquiring these resources; they are also the market leaders in the logistics service industry. However, some LSPs failed to access some of the above resources. For example, TNT attempted to acquire new resources via establishing horizontal alliances (with a Chinese and another Turkish logistics companies). Despite this effort, TNT still lacked scale in its logistics networks and did not have wide network coverage in Asia and America. Eventually, TNT saw no success and sold its logistics and freight management divisions.

Question 2: How are these resources accessed?

The results show that merger and acquisition peaked during 2002-04 but slowed down in the recent years. Most US and European LSPs had been aggressively acquired vertically (buying up customers' logistics companies) as well as

horizontally (buying up other LSPs), while Japanese LSPs have been relying on vertical strategic alliances and horizontal partnership. Since the Japanese LSPs confined themselves to Japanese partners and customers, their growth rate is not as high as some of the US's and European's LSPs.

Acquisition is a common strategy especially for accessing to a particular new market previously inaccessible. For example, K+N acquired a Norwegian forwarding firm "Speditoren" to strengthen its custom clearance competence in Norway. Furthermore, K+N could access to customers from many different industries by acquiring ACR logistics, a logistic service provider in Europe. Joint venture is another alternate strategy to access to unique resources. For example, Wincanton (UK-based) established a joint venture with Kerry Logistics (China-based) to provide logistics service for manufacturing plants in the Far East until the retails across Europe and vice versa. Before this joint venture, both LSPs had physical, relational, information and knowledge resources suitable for two different continents and they could not provide a single contact point to either the manufacturers in the Far East or the customers in Europe.

Contract (or outsource) is a popular means of acquiring resources by the asset-light LSPs. Expeditors provided air and sea freight by buying cargo space from airliners and ocean shipping liners. Agreement of cargo space is made in advanced in terms of volume, time and rate. With this access to physical resources (the cargo spaces), Expeditors managed to provide competitive rates to smaller customers with lower annual shipping volume. This example explains that it is not necessarily for all LSPs to own physical resources; in some cases, a non-vessel operating common carrier (NVOCC) such as Expeditors can gain competitive advantages by outsourcing. Freight operators who own substantial physical resources will not necessarily gain competitive advantages with respect to smaller customers. Ownership is not the only means to access to resources.

Question 3: How are different resources bundled together?

LSPs have typically bundled their resources by the following strategies.

Acquire resources and integrated them quickly. Some LSPs (such as DHL, K+N, Wincanton) acquired resources and then quickly integrated them with the existing resources to provide better services. Resources from express, freight, forwarding and warehouse businesses are integrated together to offer customized logistics solutions. For example DHL utilised its extensive express network (with 33 parcel centres and more than 720 pack-stations in 220 countries) for some of its logistics businesses. These new capabilities have allowed some logistics service providers (such as DHL, K+N) to secure new logistics service contracts. Conversely, other evidences suggest that the lack of integrated resources could hinder competitiveness - one of the reasons why DHL could not compete in the US market is that DHL could not offer both FTL and LTL to the customers due to limited network coverage.

Develop IT to integrate internal resources and activities with customers and suppliers. Software such "Easyship Professional" (DHL) and "KN-Login" (KN) are developed for customers to order shipping services and connect these orders to their systems easily.

Establish an asset (resource) management unit. To provide the best service in the contract logistics segment, many LSPs established new divisions to manage their real estates (physical resources such as warehouses, distribution centres, hubs, cross-docking facilities, and offices). For example, K+N's real-estate division acted as landlords and leased logistics facilities to the contract logistics division. This real-estate division has been continuously acquiring lands close to sea and airports or major international logistics hubs. This arrangement assisted K+N to focus on doing what they are good at, and avoid from being burdened by low-liquidity assets especially during economy downturn.

Supplement the value of a resource with another resource. Sometime investment in knowledge resources leads to the building up relational resources. Wincanton and Comet's relationship was further extended mainly because of Wincanton's exclusive knowledge of Comet's business. Closer and longer-term relationship will further allow Wincanton to further understand Comet's business.

Though this research discovered various ways to bundle logistics resources, there are evidences suggesting that most LSPs are struggling in this aspect. Most LSPs are struggling with integrating the various resources in a wide geographical area. The division of resources into separate units such as freight, forwarding, and supply chain solution could be useful but integration sometimes become difficult.

DISCUSSION & IMPLICATIONS

The logistics market is still highly fragmented and highly competitive. LSPs compete by offering a comprehensive range of services in a global marketing and network coverage. The continuous proliferation of value adding services demanded by the buyers have induced LSPs to acquire a wide variety of resources, including physical, information, knowledge and relational resources. Consequently, most LSPs continue to expand their resource-based assets.

A further analysis found out that most LSPs had positive revenue and profit growths except Nippon Express and COSCO Pacific. The analysis ascertains that asset-light strategy did not always warrant high revenue growth. Panalpina is asset-light but it achieved relatively lower revenue growth in the recent years (10% CARG over 2002-06) compare to K+N (21% CARG). Instead, another asset-light LSP (Expeditors) achieved relative high revenue growth (18% CARG). This means the level of resource "possession" might not be the right explanatory factor for financial performance.

In addition to financial performance, long-term contracts or continuity of contracts can be another measure for competitive advantage. For example, K+N won several multi-year contracts during 2006/07 from many customers, and Wincanton further secured a 10-year contract with GlaxoSmithKline. These long-term contracts are secured due to high levels of knowledge in supply chain solutions or customer, short lead time and the offers of extended services.

Furthermore, LSP's financial performances are highly dependent on the economies of the geographical regions they operate in. Economic slowdown in the US and Europe has affected the revenue growths of most of the LSPs operated in these regions. Furthermore, entering to the emerging markets such as Asia and Eastern European countries is extremely difficult without the

acquisition of new resources. Some of the physical, information, knowledge, human resources and relational resources are simply not transferable. Therefore, some LSPs disposed their resources in the US and Europe and invested new facilities in countries such as China, India, Brazil, and Eastern European countries.

CONCLUSION

Overall, this research extends the resource-based view theory by introducing constructs for classifying logistics resources and means to assess resources. This helps to explain LSPs' competitive advantages. The empirical evidences collected so far indicated that there are linkages between logistics resources and LSPs' performances and competitive advantages, and most LSPs have been trying to acquire these resources by various means with different degree of success. The unanswered question is still how different logistics resources should be "combined" or "bundled" together to achieve competitiveness.

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A STUDY ON READINESS AND ADJUSTMENT OF THAI LOGISTICS SERVICES SECTORS TOWARDS TRADE IN SERVICES LIBERALISATION

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ABSTRACT

Nowadays, the global logistics services industry is increasingly playing an important role to international trade and investment. Effective logistics systems can reduce total costs and also improve service levels, so products can sell at competitive prices in global markets. Logistics services involve a complex web of activities designed to ensure the efficient movement of materials, intermediate inputs, finished goods and reversed products between exporters and importers. Countries (e.g. Japan, Chile, South Korea, Hong Kong, and Australia) have now requested that the Thai government open itself to logistics service liberalisation. However, literature reveals interesting issues related to international logistics service liberalisation and logistics service providers (LSPs). For example, countries can have different definitions of the terms and scope of logistics, as well as different understandings of "major industry players," the readiness and adaptability of LSPs that are in the small-to-mid-sized enterprise (SME) category, and international non-tariff barriers. To prepare and facilitate Thai stakeholders (LSPs, logistics users, and regulators) to assess their capabilities for logistics service liberalisation, Thailand needs to assess the current capabilities of its LSPs, including examining their readiness for logistics liberalisation. The main objective of this study is to examine the current capacities of Thai LSPs, including an assessment of their readiness and adaptability to services liberalisation with international trade partners. This study also examines issues related to the benefits and costs of logistics services liberalisation in Thailand. In the literature review for this study, a problematic issue was discovered. Countries now maintain varying definitions of the terms (and scope of) "logistics" and "supply chain." Therefore, this study applied the World Trade Organisation (WTO) definitions for scope and meaning. Under the WTO definition of scope, logistics services cover activities in seven sectors: 1. transportation; 2. storage and warehousing services; 3. express mails/parcels; 4. packaging; 5. custom [broker] clearances; 6. information technology for logistics, and; 7. freight forwarding companies. To examine these sectors among Thai LSPs, survey research and in-depth interviews were conducted via 558 and 105 respondents respectively. Research processes were designed to ensure that validity and reliability were carefully maintained. Data collected was systematically edited and coded before processing and analysis by SPSS version 11.0.5. The results show that within each sector, Thai LSPs have varying, (but relatively low), degrees of readiness and adaptability to service liberalisation. Most of them still lack understanding of logistics service liberalisation and its effects. Within each logistics sector, competitive capabilities were found to be at medium to low levels. Outdated national laws and regulations, as well as unstable political and economic situations, were found to be impeding the growth of the national logistics service industry. This study also assesses the benefits and costs of liberalisation, and shows that LSPs in the small-to-mid-sized enterprise (SME) category have the most potential for adverse effects. On the other hand,

liberalisation can offer logistics users (importers and exporters) greater capabilities for achieving better market responsiveness and cost reductions. The study points out problematic issues to growth within Thai logistics sectors, issues that are impeding international trade flow. It also provides recommendations on how to facilitate Thai LSPs to adapt and respond to the rapid changes of international logistics liberalisation.

Keywords: Liberalization, free trade, services, Logistics services provider, Logistics, Thailand

1.0 INTRODUCTION

In recent years, Thailand's government has placed a high priority on the logistics services industry, identifying it as a driving force for improving service levels and reducing the costs of international trade. This priority has come about due to the current atmosphere of intense competition among Thai and foreign logistics services providers (LSPs) within Thai markets. Countries have asked and tried to pressure the Thai government to open trade via services liberalisation, especially by logistics services liberalisation. However, there is no current data to support critical decision-making, especially in regards to capacity levels or the competitive position of Thai LSPs as compared to foreign LSPs.

The objective of this study is to explore the current capabilities of Thai LSPs, including an assessment of their readiness and adaptability to services liberalisation with international trade partners. This study also examines issues related to the benefits and costs of logistics services liberalisation in Thailand.

In the literature review for this study, a problematic issue was discovered. Countries now maintain varying definitions of the terms (and scope of) "logistics" and "supply chain." This, of course, causes confusion and impedes the growth of logistics services liberalisation. This study applied the World Trade Organisation (WTO) definitions for scope and meaning. Under the WTO definition of scope, logistics services cover activities in seven sectors: 1. transportation; 2. storage and warehousing services; 3. express mails/parcels; 4. packaging; 5. custom [broker] clearances; 6. information technology for logistics, and; 7. freight forwarding companies.

2.0 LITERATURE REVIEW

The global logistics service industry is increasingly playing an important role to international trade and investment (5). Effective logistics systems can reduce total costs and improve service levels so that products can be sold with lower prices and higher responsiveness to global markets (8, 9). Logistics services involve a complex web of activities designed to ensure the efficient movement of materials, intermediate inputs, finished goods and reversed products between exporters and importers (1). Countries (e.g. Japan, Chile, South Korea, Hong Kong, and Australia) have now requested that the Thai government open itself to logistics service liberalisation. However, literature (8, 9, 10) reveals interesting issues related to international logistics service liberalisation and logistics service providers (LSPs). For example, countries can have different definitions of the terms and scope of logistics, as well as different understandings of "major industry players," the readiness and adaptability of LSPs that are in the small-to-mid-sized enterprise (SME) category, and international non-tariff barriers (11). To prepare and facilitate Thai stakeholders (LSPs, logistics users, and regulators) to assess their capabilities for logistics service liberalisation, Thailand needs to

assess the current capabilities of its LSPs, including examining their readiness for logistics liberalisation. This literature review searched the various international definitions (by terminology and scope) of logistics. The results showed that even though countries may have different definitions and perspectives (9, 11), their basic logistics concepts are similar and consistent in that they focus on the two major trade flow activities of physical goods and information flow. This issue of common definitions of terms and scope as it relates to logistics liberalisation is becoming a challenging issue for negotiators and governments. Countries (9, 10, 11) assessed the capabilities of their logistics players before negotiating free trade agreements or establishing service liberalisation. Most of them examined readiness and adaptability within their service sectors before opening logistics services liberalisation. The literature review pointed out trade benefits and cost reductions attributable to logistics services liberalisation. However, it also identified problematic issues. For example, how does one assess readiness for logistics liberalisation within the categories of LSP size (i.e., small to large) and sector (i.e., transport or freight-forwarding companies)? What is the role of government to LSPs: facilitator or regulator? To avoid confusion, this study applies the World Trade Organisation (WTO) scope of logistics activities (9,10) within seven major sectors: transportation; storage and distribution; express mails and parcels; packaging; custom broker; information technology for logistics; and freight forwarding companies (11). The literature pointed to the conclusion that a preparatory evaluation of the readiness of stakeholders within the logistics industry is essential before considering or negotiating the establishment of logistics liberalisation. The potential success of logistics liberalisation is based on a win-win approach to negotiations that always takes into consideration the readiness and adaptability of stakeholders. The literature also pointed out that there is a relationship between capacity level and readiness to activating logistics liberalisation, as well as to its success. It also pointed to the unique characteristics of each sector. Within Thai LSPs, there were varying low degrees of readiness and adaptability to logistics service liberalisation. Most of them still lack understanding and effects of opening logistics service liberalisation. Each sector showed a competitive capability at medium to low levels.

3.0 RESEARCH METHODOLOGY

To achieve the research objective, this study developed its research data through two sources. First, a literature review was conducted. The literature reviewed was related to logistics management, trade services, logistics businesses in Thai firms, and services liberalisation. This data source provided a broad view about the benefits and costs that occur from opening free trade agreements and other forms of trade services liberalisation. Secondly, relevant data was collected by questionnaire surveys and in-depth interviews. This part of the research focused on exploring the current status and capacity level of Thai LSPs. In-depth-interviews were used specifically to obtain deeper insight into the relevant opinions and concerns of executives and managers at Thai LSPs. To obtain the full scope of data, the research analysis covered seven LSP sectors (as defined by the WTO): transportation; storage and warehousing services; express courier and parcels; packaging; custom clearance; information technology for logistics; and freight forwarding companies. As shown in Table 3-1, a number of samplings were taken from each sector.

Table 3-1 Numbers of sampling sizes

No	Type of LSPs	Targeting sampling	Actual Sampling	Rate of Response
1	Transportation	150	140	0.93
2	Storage and warehousing services	145	128	0.88
3	Express courier and parcels	50	47	0.94
4	Packaging	50	42	0.84
5	Custom clearance	95	70	0.74
6	Information technology for logistics	50	30	0.60
7	Freight forwarding companies	200	128	0.64
	Total	740	585	0.79

Table 3-1 shows numbers of targets and sampling sizes. After having developed sampling sizes for each logistics sector, this study gathered data by questionnaire survey. The 740 questionnaires were distributed by various methods, e.g., face-to-face, postal and e-mail. The rate of response generated was very good with 585 respondents or 79.0 percent in total. The data collection period took four months. The study also conducted in-depth interview with 105 respondents, covering all sectors of Thai LSPs. All interviews were conducted in Thai language, using a tape-recorder, in one to three hour sessions. Notes were also taken at each interview to supplement the recordings and instill an air of professionalism and importance at each interview. The semi-structured questions were developed based on research questions and these same questions were repeatedly asked of all respondents. After all data from the in-depth interviews was transcribed and tabulated in appropriate formats, content analysis (2) was performed. Research processes were structured to ensure that validity and reliability were carefully maintained. The research tools, i.e., questionnaires and interview questions, were designed to fit properly with targeting groups. The questionnaires used perceptual Likert scales (1), where targeted samples were asked to rate each item on a five-point scale, ranging from strongly disagree to strongly agree. If a variable was related to a complex concept (2), it was covered by multiple queries and its value corresponded to the mean value of the scale. In determining the measurement properties of the constructs used in the statistical analysis, reliability and validity were assessed respectively (1, 2) using Cronbach's alpha. The alpha value of overall questionnaire was 0.82. The authors (7) suggested that a value of reliability of 0.70 is acceptable, while over 0.80 is considered good (2). After questionnaires were returned, they were classified by sources (type of LSP) and coded and edited to make them ready for data entry (7). The SPSS was used to analyse the data. The survey results were incorporated with information from the in-depth interviews.

4.0 RESEARCH RESULTS AND DISCUSSION

This study offers results covering four major issues. First, the demographic data of respondents was utilized to identify targeted groups and their characteristics. Secondly, there was an examination of the capacity levels and readiness of major

players in Thai logistics industry as compared with foreign LSPs. Thirdly, there was an examination of other issues related to negotiation and establishment of logistics liberalisation between Thailand and countries. Finally, this study analysed the benefits and costs to Thai LSPs and other stakeholders (logistics users and regulators) when activating logistics liberalisation.

Table 4-1 Types of respondents

Kind of Business	No. of Respondent	Percent
1. Freight forwarding	130	23.0
2. Warehousing and storage facilities	128	21.0
3. Information technology for logistics	30	5.0
4. Transportation	141	24.0
5. Express and courier parcels	45	8.0
6. Customs broker	70	12.0
7. Packaging	41	7.0
Total:	585	100.0

Table 4-1 shows types of respondents. The greatest number of respondents (by sector) came from transporting companies in all modes at 23.0 percent, followed by freight forwarding, and warehousing and storage companies at 23.0 and 21.0 percent respectively. These results reflect a reality within the Thai logistics industry, indicating that transports (land, water, and air) are playing a major role. This study identified companies by size. It revealed that most Thai LSP companies (84 percent) have less than 200 employees. It also shows that most are small companies (at 49 percent; with medium-sized enterprises at 35 percent). These results also identified the real major players of Thai LSP. When considering size of business firms by value of fixed assets, this study referred to the definitions of Ministry of Industry, Thailand. Firms with fixed assets of less than 50 million baht or 50 employees or less are considered small-sized companies. Firms with fixed assets between 50-200 million baht are defined as medium-sized companies. The results in this area of the study are consistent with the result in Table 4-2, revealing that most Thai LSP companies have a value of fixed assets at less than 200 million baht. An overarching conclusion is that most Thai logistics companies are SMEs. In considering the shareholder (ownership) structure of respondents, the result revealed that most companies, 93 percent, were Thai-owned companies. This was followed by joint ventures between Thai and foreign companies, at just 6 percent. The low percentage of joint ventures reflects a major problematic issue: foreign logistics service providers have impeded entry into Thai logistics markets because of current Thai laws.

Table 4-5 reveals capability levels of Thai LSPs as compared to foreign LSPs. The results reveal that most of Thai LSPs rated their performance and capacities of conducting businesses at lower than the standard level (3.0). They identified that they had higher service quality than foreign competitors (2.85), maintained strong, competent staff to handle customer problems (2.72), and had the capability of local access to target markets (2.71). However, the results also showed that some issues were becoming weak points. Those issues included: lack of resources and capitals (2.25); weak management talents and competencies (2.20), and; low availability of IT for logistics (2.03). Particularly telling was the lack of global business networks (1.92).

Table 4-5 Capability levels of Thai LSPs as compared to foreign LSPs

Capability levels	Mean
Providing excellent service quality	2.85
Achieving higher performance through logistics staff	2.72
Ability to effectively access local target markets	2.71
Maintaining vision in dynamic business environments	2.70
Effectively managing operating costs	2.68
Providing services via one-stop service centre	2.51
An organisational culture that responds well in a dynamic business environment	2.49
Excellent logistics knowledge and understanding	2.28
Ready access to resources and capital	2.25
Strong management	2.20
Sufficient resources of information technology (hardware, software and "people-ware")	2.03
Having a strong global business network	1.92

This study identified problems and opportunities for Thai LSPs in establishing logistics services liberalisation. Targeted respondents were asked about problems or opportunities which could be expected to occur if Thailand established logistics services liberalisation. Most of them strongly agreed that the Thai logistics industry is experiencing intense competition (3.91). They believed Thai LSPs would have to increasingly use price strategies (3.78). They saw foreign LSPs expanding more and more into Thailand markets (3.68).

As far as benefits for Thai LSPs from logistics services liberalisation, the results reveal that most of the respondents (54 percent) believed that if Thailand established logistics services liberalisation it would not negatively affect Thai LSPs in any way. Some of them (25 percent) pointed that it might affect Thai LSPs to a small degree, but without major affect, since foreign LSPs were already operating logistics businesses in Thailand in the form of agencies or nominees (e.g. TNT, Linfox, Fedex and NYK Logistics).

When examining the attitudes of respondents to Thai governmental supports and incentives to entry into foreign markets through logistics services liberalisation, the result showed that a large percentage of respondents (44.0 percent) agreed that the Thai government should actively support Thai LSPs' entry into foreign markets. Some of them (34 percent) were not sure that the Thai government would support Thai LSPs investing in foreign markets, because of high risks and uncertainties. Unfortunately, the results also revealed that LSPs think the Thai government currently provides insufficient support in policy, resources or capital for effective entry into foreign markets. In an evaluation of positive affects for Thai LSPs through logistics service liberalisation between Thailand and partners, the study asked respondents to identify such affects. Most respondents (56 percent) identified that liberalisation did provide positive effects to Thai logistics industry. These benefits included better utilization of resources and capital, plus the transfer of valuable technology and know-how from developed countries. As the result, liberalisation would enhance Thai LSP business development, increase

trade capabilities, and improve competitive positions over foreign LSPs. On the other hand, some of the respondents (23 percent) were concerned about negative affects to their operations. They worried that activating logistics liberalisation could increase competition and eventually destroy their business.

When considering costs and benefits of activating logistics service liberalisation, the study revealed that most respondents (67 percent) identified that Thailand would not reap benefits sufficient to the costs. They indicated that they believed foreign LSPs have high competencies, strong financial support, and wide global networks. Some respondents (12 percent) pointed out that liberalisation would not be any different for them, in term of operations, since foreign LSPs (e.g. TNT, and Linfox) have already established businesses in Thailand. They indicated it might change some business practices. However, a larger percentage (21 percent) thought that activating logistics liberalisation in Thailand would reap more benefits than costs. They think liberalisation would facilitate importers and exporters to sell more products in global markets with lower costs and higher service levels.

In this study, Thai LSPs were asked if they agreed with and supported logistics liberalisation negotiations by the Thai government with foreign partners. The result revealed that most respondents (56 percent) do support such negotiations, but qualified that by indicating that the government should negotiate carefully by considering and analysing the benefits and costs involved. Further, the government should formulate policies and strategies to develop capacity among Thai LSPs, especially the SMEs. Some respondents (22 percent) felt that there would be no difference if Thailand negotiated logistics services liberalisation, since even without such negotiations, there were already many foreign LSPs investing in Thailand. Lastly, 22 percent of respondents indicated that they did not agree with nor support negotiations.

5.0 RESEARCH DISCUSSION AND IMPLICATIONS

As indicated by this study, Thai logistics players come from various sectors. The literature revealed that countries define logistics and its scope differently. Thailand, for example defines logistics as transport and warehouse activities. On the other hand, Australia defines logistics as activities related to core or non-core logistics. This is a problematic issue when a country wants to negotiate to open logistics services liberalisation with another country. In essence, they will be speaking different languages. Therefore, the Thai government should develop certain definitions of logistics and its scope for negotiating in international forums. The definitions and scope of logistics would be handled consistently within an international context. Further, the Thai government should define the scope of logistics activities and size of logistics businesses. This definition should be different than other industries due to the unique nature and operations of LSP businesses. The Ministry of Industry, Thailand, defines firms with fixed assets of less than 50 million baht, or 50 employees or less, as so-called small-sized companies. A company with 50-200 million baht in fixed assets is considered a medium-sized company. But, look at TNT, for example. TNT is a world class company operating in Thailand with only 80 employees. The company effectively operates a wide network across many countries. This shows how business size within the logistics industry is unique and needs to be defined more in relation to business management and operations.

This study pointed out that most of Thai LSPs were small-to-mid-sized enterprises (SMEs). It identified that their strengths as commitments to: higher service quality than foreign competitors; strong and competent staffs for handling customer problems, and; a capacity to access local target markets. It also identified the Thai LSP weak points within the global logistics industry. Those weak points included: availability of resources and capital; strong management talents and competencies; availability of IT for logistics, and especially; a lack of global business networks. These weaknesses indicated that the Thai government should assist Thai LSPs by helping eliminate, or at least, reduce these shortcomings and increase their competitive advantage. Most Thai LSPs in each sector had a low degree of readiness and adaptability to logistics service liberalisation. This was particularly true within SME sectors. They needed capital, technology and know-how to improve their competitiveness. Accordingly, larger Thai logistics companies had a higher capacity level and readiness for activation of logistics liberalisation than the SMEs. Most of them still lacked understanding regarding the affects of logistics service liberalisation. The competitive capabilities within all sectors were at relatively medium to low levels. There were other mitigating factors, e.g., outdated national laws and regulations, and unstable political and economic climates, impeding the growth of the Thai logistics service industry. In relation to Thai government agencies and their role in facilitating logistics operations, it was indicated they lacked understanding and knowledge on how to effectively encourage, facilitate and offer incentives to Thai LSPs so that they can better contribute and compete in the global logistics markets.

After analysing the benefits and costs to liberalisation, LSPs in SME sectors have the most potential for adverse affects. On the other hand, logistics users (Thai importers and exporters) can reap the greatest benefits through higher responsiveness and lower costs. The study points out problematic issues to growth within Thai logistics sectors, issues that are impeding international trade flow. It also provides recommendations on how to facilitate Thai LSPs to adapt and respond to the rapid changes of international logistics liberalisation.

6.0 CONCLUSION

The study examined the capability levels of Thai logistics service providers (LSPs), including an assessment of their readiness and adaptability to international trade services liberalisation between Thailand and outside trade partners. It concluded that Thai LSPs, in particular SMEs, had a lesser degree of capacity to compete with foreign LSPs. They also lacked readiness to contribute to the establishment of logistics liberalisation. A timeframe for developing LSP readiness before activating logistics liberalisation would be unique to each sector, depending on types and sizes of logistics activities, but should range between 3-8 years. The study examined issues related to the benefits and costs of logistics services liberalisation in Thailand. It concluded that by opening logistics liberalisation between Thailand and outside partners, Thai LSPs would be at a disadvantage to foreign LSPs. However, liberalisation would benefit Thai importers and exporters in trading their products into global markets through lower costs and higher responsiveness. Confusion over definitions of logistics terminology and scope were found to be problematic to negotiations within international forums. This study pointed out that the Thai logistics industry

should define the terms and scope of logistics, consistent to an international context. Another issue was governmental support and facilitation of Thai LSPs. In particular, SMEs should be focused on to enhance their sustainable competitive capabilities and encourage the overall growth of the Thai logistics industry.

The study led to a conclusion that most of today's Thai logistics players effectively lacked critical capacity levels for logistics liberalisation. They have also been negatively impacted by the lack of definition of the terms and conditions required for effective logistics liberalisation negotiation. In the final analysis of the benefits and costs to activating logistics liberalisation, growth of international trade within Thailand would certainly expand. The SMEs in the Thai logistics industry would be adversely affected in term of operations, resource utilization, and capital. Finally, Thai logistics users (importers and exporters) would reap the highest benefits through higher responsiveness and lower costs.

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SERVICE LOGISTICS AND THE EVOLVING COMPETITIVE LANDSCAPE: A CASE STUDY OF THE INDIAN IT SERVICES INDUSTRY

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ABSTRACT

The leading Indian IT service providers are actively expanding their operations around the world. While this development translates into new demands and threats for many Western technology and professional services companies, it also provides them with new business opportunities. The main objective of this case study is to help Western technology and professional services companies, especially SMEs, analyse the situation and develop competitive and co-operation strategies vis-à-vis the Indian IT majors. To pursue this objective, the paper describes how IT services are actually exported from India. In addition, it identifies the major strengths, weaknesses and coping strategies of the Indian IT services export industry. Our findings suggest that while Western technology and professional services companies can often enhance their competitiveness by investing in customer intimacy and IPR development, they should also explore the prospects of establishing partnerships with the Indian IT majors. The biggest Indian IT service providers have got ample resources and a global reach, but they are not that good in applied research or in the traditional product business. Since the situation of many smaller Western technology companies is somewhat reversed, the opportunities to build on each other's comparative strengths are obvious.

INTRODUCTION

The major Indian IT and business process outsourcing (BPO) companies have been very competitive in the global IT services market. IT-related exports from India have grown from USD 12.9 billion in the financial year 2003–04 to USD 31.4 billion in 2006–07. The major export market is the USA, which accounts for around 70% of all export revenues, followed by Europe (around 20%) and Asia (around 10%). Over the period 2001–2006, India's share of the global sourcing market has been estimated to have grown from 62% to 65% for IT, and from 39% to 45% for BPO. (NASSCOM 2007.)

India's foray into the IT arena began in the mid 1980s, mainly through some lower-end software development and hardware maintenance activities. The key break for the industry came in the form of the Y2K crisis. Since then the global demand for IT and BPO services has been strong, and the Indians have taken advantage of this unique opportunity. This has enabled the Indian ICT sector to grow at a CAGR of 27–30% over a number of years. Its share of the Indian GDP has correspondingly risen from 1.2% in 1997–98 to 5.2% in 2006–07 (NASSCOM-Deloitte 2008).

The situation means different things for different actors. On the one hand, it translates into new opportunities for many private and public organisations in the need for affordable partners in IT and IT-enabled services. It has been

estimated, for example, that more than 50% of the Fortune 500 companies are outsourcing to India (CIO 2003). Leading product and professional services companies, such as IBM, General Electric and American Express, have also established their own development and service centres in the country. These 'captive units' often serve the dual purpose of providing the parent company with cost-effective services and of developing the local market.

At the same time, many Western technology and service firms that compete for the same clientele with their Indian rivals will have to cope with mounting cost pressures and efficiency requirements. Many of their employees have lost their jobs and many more are likely to lose them in the future. According to some estimates, US companies have been shipping in the order of 200,000 service and engineering jobs abroad every year since the beginning of the century, of which around 70% have gone to India (Wired 2004). Western IT companies and professionals alike need to pay increasing attention to identifying and developing the basis of their competitiveness. The ability to differentiate and to utilise one's comparative advantages has become crucial.

This paper is concerned with the evolving competitive landscape in technology and professional services. The paper is based on a case study within the Indian IT services industry. The main objective of the paper is to help Western technology and professional services companies analyse the situation and develop competitive and co-operation strategies vis-à-vis the Indian IT majors. Our underlying assumption is that while effective service logistics provides the Indian IT majors with a strong competitive advantage, thus making them competitors to be reckoned with, it may also provide the rationale for establishing business partnerships between rival companies. What this means – or could mean – in practice is the primary concern of this paper.

METHODS

In total, 14 semi-structured interviews were carried out with top and mid-level executives at four major IT services companies in August 2005 in India. Three of the case companies were of Indian origin, while one was an Indian subsidiary of a major multinational corporation. In addition, six interviews were conducted at Indian Institute of Management Bangalore with academics possessing applicable areas of expertise. Apart from these interviews, various sources of secondary information were used, including data and reports from industry associations and research organisations, business periodicals and academic publications.

THE GLOBAL DELIVERY MODEL

One of the important aspects of the Indian success story has been the offshore model of resource deployment, or 'global delivery model' as it is often referred to in India (Figure 1). It is based on the good-old principles of distributed manufacturing, and it takes advantage of India's lower labour costs. The model entails a large part of the development and maintenance work being carried out in India, while such parts of the service that cannot be transferred abroad, e.g. requirements specification, are carried out locally with the customer.

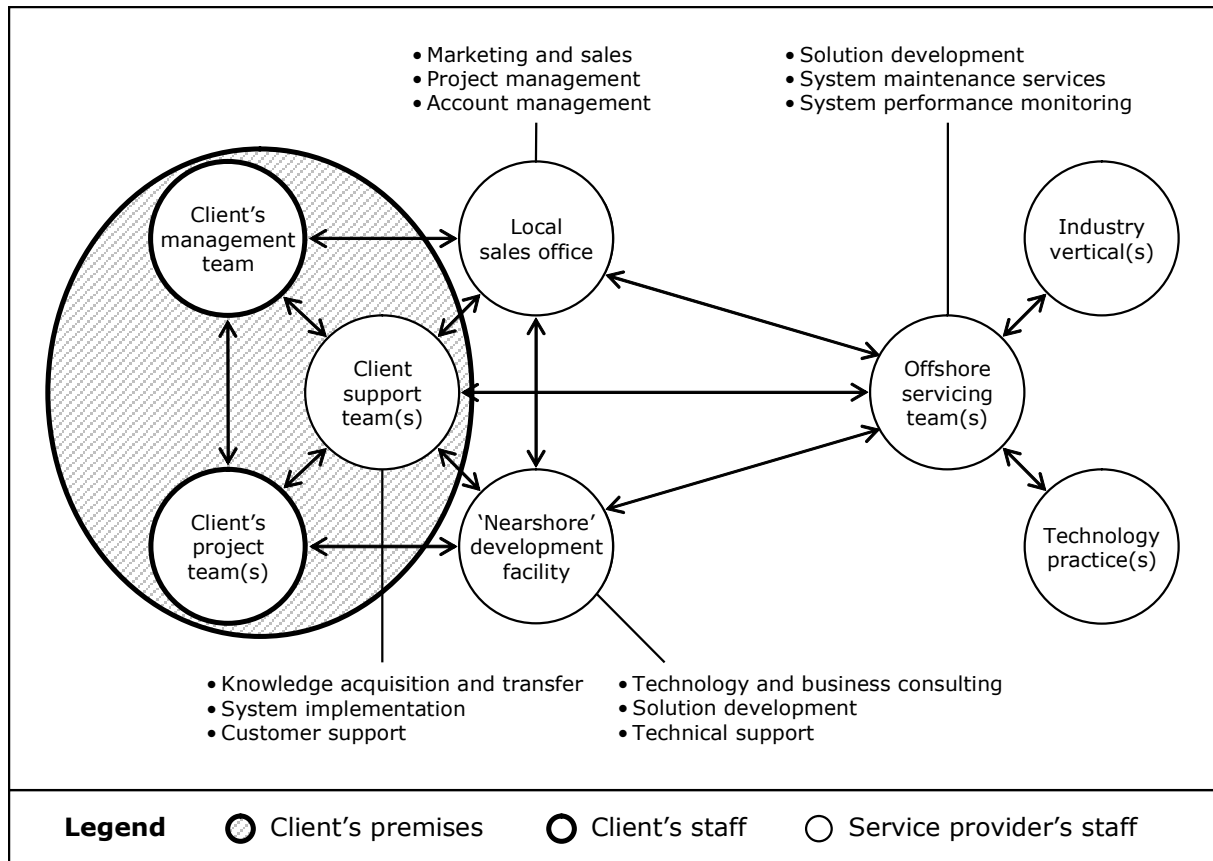


Figure 1. The global delivery model: Key actors and examples of related tasks.

Local sales offices are responsible for generating new business. Following the formal signing of the contract, knowledge acquisition and transfer commences with the deployment of a task force to the client's site. The service provider sets up client support teams that start working under the client's management and with the client's project teams. At the same time, an offshore client servicing team is assembled in India on the basis of required skills (industry expertise, service line, technology platforms used, etc.). At this stage, the transfer of knowledge and the role of domain experts are paramount.

The bulk of the related development work, the nature and extent of which depends on the content of the assignment, takes place in India. It is conducted by the offshore servicing team in close association with the local client support teams. Depending on the case, some parts of the development work can be assigned to the service provider's 'nearshore' development facilities. These facilities are typically located in the same or a nearby country, and their main task is to provide technical support for local customers and sales offices. The service provider's project management team looks after the integration of the work packages.

Following the completion of the development work, the knowledge transfer process is reversed: the client support teams introduce the solution to the customer and provide hands-on support during the implementation process. Depending on the level of complexity and the nature of the agreement between the client and the service provider, a dedicated team may stay stationed at the client's premises for a designated period of time. However, if a long-term

outsourcing deal is involved, the service provider will gradually assume full responsibility for running the service or practice concerned. This is usually the case with system administration services. In such a case, the contract will include a clear description of the expected service level and related metrics, as well as performance-related compensation and penalty clauses.

Each company has, of course, developed its own version of the model and uses its own distinctive terms and concepts when talking about the model. However, on a general level, their purpose is the same: to support flexible and cost-effective servicing of customers. This objective applies to all phases and aspects of project and customer relationship management.

OTHER SOURCES OF COMPETITIVE ADVANTAGE

While the global delivery model provides the frame for effective international operations, much more is needed. The model could not be applied without significant human resources and a wide array of complementary capabilities. According to our analysis, the following factors are of special importance to the competitiveness of the Indian IT services sector.

Supply of fresh graduates. One important prerequisite for the fast expansion of the Indian IT and BPO services sector has been the availability of large numbers of suitably qualified engineers and other professionals at low cost. More than 200,000 students graduate each year from India's first-level engineering programs (Wadhwa et al. 2005). Recruitment has been relatively easy for many of the leading IT service companies. This ability of being able to ramp up 'production capacity' fast during projects is a key factor in India's success.

Accumulating domain expertise. Initially, a large part of poorly-paid development and maintenance work was taken up by fledgling companies. They needed to generate volume to sustain the low-cost model, which gradually resulted in the accumulation of a large experience base across various industries. The previous mundane work of managing legacy systems and the development of smaller modules for large software products has increased their understanding of a wide range of industry requirements. This learning has enabled these companies in turn to offer their services across a wide spectrum of industries.

A wide range of services offered. A large part of the business that the Indian IT majors undertake appears to come from repeat customers. Regardless of many outsourcing-related challenges, a topic that has been extensively discussed e.g. in the English-language business press, many customers have nevertheless felt confident in the Indian service providers' capabilities. As a result, they have also been willing to offer them more work in related areas. The Indian IT majors are currently offering a range of services for their clients, including application development and maintenance, packaged software, infrastructure services, technology consulting and business process management. In addition, they provide turnkey deliveries and can commit to strict service level agreements. Studies indicate that for both US and European companies the most preferred relationship between service purchaser and service provider is that of a single provider who can assume responsibility for a range of applications and services (Kakabadse & Kakabadse 2002). The Indian IT majors are well positioned and experienced to take full advantage of the situation.

Process development investments. To address the perception among many potential Western clients that Indian companies may lack the necessary discipline or process focus when implementing demanding software projects, most of the companies in the field, including all major players, have invested in acquiring various certifications. As of December 2006, over 440 Indian companies had acquired some quality certifications, with 90 companies certified at SEI CMM Level 5 – higher than any other country in the world (NASSCOM 2007). Although there are different views on the practical value of such certificates, Indians themselves seem to value them and are clearly proud of their achievements.

NOBODY IS PERFECT

The Indian IT majors are also facing many challenges. Some of the challenges have been recognised and are being actively acted upon, while others have proved to be more demanding to cope with. The following three topics have been selected on the basis of their relevance for the European market and companies.

Declining cost advantage. There is a growing concern among industry players about the long-term viability of the prevailing cost advantage (or wage-arbitrage) model. Indian IT service companies are currently witnessing significant pressures on pricing and profitability – for a number of reasons. First of all, employment costs are rising fast in India. Salaries for technologists are currently increasing by around 12% annually. Indian IT service and BPO companies also suffer from high attrition rates among employees. While the largest IT service companies have managed to keep their annual attrition rates at around 10-14%, the average figure within IT services is around 18-20%. In non-voice BPO the attrition rate is around 20-30%, while in voice-based BPO it appears to exceed 50% (NASSCOM press releases 2005-08). These figures translate into huge recruitment and training costs. Also other countries are gradually entering the game. Companies operating out of cheaper destinations, such as the Philippines, are expanding their business.

Insufficient focus on applied research, innovation and IPR. The primary focus of most Indian IT companies has been on creating growth, while incentives for the deployment of resources into risky research and development activities have been relatively low. As a result, Indian IT companies do not generally excel in the traditional product business. In 2004 India's share of the USD 180 billion global software product market was a mere 0.2% (CIOL 2004). This problem of under-resourced R&D concerns also other lines of business. Currently India's R&D spending as percentage of GDP is only 0.8%. Of that 0.8%, India's public sector accounts for 80%. In China and the USA, the share of the public sector is 30%, and in Japan it is as low as 18% (Livemint 2008). It remains to be seen how the Indian IT majors will cope with mounting pressures on profitability in the future. The lack of strong IPR will nevertheless make it more difficult to sustain good profit margins in the midst of tightening international competition. In addition, since most IT service providers are very 'bottom heavy' as a result of the fast growth rate and the incessant recruitment of fresh graduates (mostly with a Bachelor's degree in some engineering discipline), the proportion of employees with a Master's or PhD degree is relatively low. Also the limited amount of universities and educational institutes with world-class Master's and PhD

programmes has hampered India's innovation capabilities. In particular, a greater emphasis on applied R&D has been demanded (FEER 2007).

Diverging languages and cultures of Continental Europe. Currently, the share of revenues generated in Europe is relatively low for both Indian IT service and BPO companies. Most major players admit that the European market has huge potential and that it should not be any different from catering to the US and UK markets. The commonly cited issue concerning the Continental European BPO sector is the range of languages. While India has a large number of professionals with high proficiency in English, such numbers are not available in other European languages. To tackle the issue, the biggest Indian IT and BPO firms have been recruiting locally and have invested in their nearshore operations centres in Central and Eastern Europe (e.g. Hungary and Czech Republic) to serve their non-English speaking customers. Some of the IT majors have also set up operations in Mauritius with a view to catering to their French-speaking clients. These investments are expensive and take time to develop. Also national cultures and their openness to the very idea of sourcing services from abroad affect the equation. Some countries like France have been considered difficult in this respect for many socio-political reasons, while the Scandinavian countries appear to be more flexible about the issue.

TO COMPETE OR NOT TO COMPETE

What could form the basis for developing competitive advantage within those small and medium-sized technology and professional services companies that compete with the major Indian IT service providers on their own turf? At least two factors are worth further investigation: customer intimacy and strong IPR.

Customer intimacy involves in-depth understanding of the customer's business requirements and expectations, and a history of joint effort and achievement. Also the common language and cultural background may count a lot, especially within the SME sector. In such a situation the threshold for abandoning a reliable partner, for example a technology or IT services provider, even in exchange for a theoretically more value-adding offering, can be very high. A reliable and long-standing service provider can often charge a substantial premium – especially if the service provided is complex and of strategic importance.

On the other hand, well-known trademarks and patents to widely-used or new, promising technologies can retain their value quite well irrespective of the evolution of industry structures and value chains. They can be used to protect one's position in a particular market or, alternatively, licensed to other companies that could benefit from applying the same technology in their own products. There are many companies like Qualcomm – companies that do not have well-known consumer products or trademarks of their own – that can nevertheless generate significant revenues from their patent portfolios. Strong IPR is also a good remedy against salary inflation, if it can be used to reduce one's dependence on more labour-intensive work as a source of sales revenue. It is important to remember, however, that IPR does not last forever and that a resourceful competitor can often develop its own technology and solutions.

What SMEs can do in practice is, above all, a question of resources. If, for example, an increasing number of one's existing customers want to expand or

are already operating internationally, and/or are looking for more comprehensive enterprise solutions with 24/7 user support and strict service level agreements, the requirements may get difficult to cope with for a small or medium-sized product company. International market development calls for a sustainable financial position or a great deal of investor trust. Also, the required investments in new technology or product development may easily exceed the investors' risk bearing capacity. In such a case, one obvious alternative to be considered is partnering. This is where large, globally operating Indian IT firms can come in.

One way to proceed is to agree upon R&D and marketing co-operation. The responsibilities should be defined in such a way that both parties can benefit from each others' comparative advantages. A smaller European technology firm may, for example, have developed and patented unique technology, manufactured a well-functioning prototype, and perhaps also provided a handful of local customers with tailor-made solutions, but lacks the necessary funds to move forward. On the other hand, a large Indian player with a corresponding 'hole' in its product and service portfolio is likely to possess the necessary funds and other means to support further development work and to assume responsibility for managing global marketing, sales and customer support operations. To make such an arrangement work, however, many things need to be checked and agreed upon. Among the most important ones are the division of tasks, responsibilities and expenses, the ownership and use right of the results of the joint development work, trademarks and branding, pricing and revenue-sharing models, and of course billing, reporting and money transfer procedures.

The large Indian IT service and BPO companies are also willing to expand their business through inorganic growth and have been scouting for attractive targets. Since most of these companies' forays into product development have not been particularly successful, their current focus appears to be on the acquisition of (foreign) product companies with an existing client case (Table 1). One possibility to capitalise on the ongoing development trend, therefore, is to put one's business up for sale. Although the deal sizes have been small in comparison with the largest acquisitions in the manufacturing and metals sectors, it is entirely possible that the amounts may go up to hundreds of millions of dollars. The liquid assets of the five top Indian IT service and BPO companies totalled around EUR 2.8 billion in financial year 2006-07 (CMIE 2007).

Table 1. Some acquisitions made by Indian IT service and BPO companies in 2006 (source: articles in business press).

Acquiring company	Target company			Investment USD million
	Name	Country	Line of business	
HOV Services	Lason	USA	BPO	148
Subex Systems	Azure	UK	Revenue assurance	140
TransWorks	Minacs	Canada	BPO	125
TCS	TKS-Teknosoft	Switzerland	Banking solutions	80
Wipro	Enabler	Portugal	IT services	52
NIIT	Element K	USA	Learning solutions	40
Wipro	Saraware	Finland	Telecom software	32
NIIT	Room Solutions	UK	Insurance	25
Wipro	cMango	USA	IT services	20
TCS	TCS Management	Australia	Consulting	12

SUMMARY AND CONCLUSIONS

The major Indian IT and BPO service providers have proved their ability to compete globally. An important success factor has been the application of the global delivery model. Many smaller, locally-operating Western technology and professional services firms have been forced to face the fact that services can be exported, including those that require local presence. On the other hand, the Indian success story is not that definitive as it may first appear. Employment costs in India are rapidly increasing. The development of well-known product brands and IPR has also proved difficult for most Indian IT and BPO companies. These two factors erode the Indian cost advantage and add to the challenge of maintaining good profit margins in the future.

The results suggest that especially Western SMEs should better explore the prospects of utilising the financial, logistical and marketing capabilities of big Indian players for mutual business benefit. Such co-operation may involve, for example, technology licensing, joint solution building and international marketing. The key is to identify each others' comparative advantages and to assess the potential benefits of establishing strategic co-operation against related investment, counterfeit and defection risks. The biggest Indian players are also keen to acquire foreign product companies with an existing clientele. Whether this is seen as an opportunity or threat, at least the owners need to keep this clearly in mind when dealing with the Indian players.

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SECTION 9

ENVIRONMENTAL LOGISTICS

THE ENVIRONMENTAL IMPACT OF ROAD FREIGHT TRANSPORT IN THE UK IN 2020 – IDENTIFICATION OF THE KEY DETERMINANTS

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ABSTRACT

This paper reports on research undertaken to determine the baseline trends in logistics and supply chain management and associated environmental effects up to 2020. The factors affecting freight transport demand and thus fuel consumption are classified into six categories in relation to different levels of logistical decision-making. Their potential impact on CO₂ emission levels is discussed and the complexity of the problem is highlighted.

INTRODUCTION

Concern has been mounting over the environmental impact of freight transport operations. Although tightening vehicle emission standards have been reducing exhaust emissions of noxious gasses, attention has shifted to the growth in carbon emissions from the freight sector. National governments and the EU have set targets for reducing all these emissions and devised policy measures to cut the external costs of freight transport. To assess the net impact of these policy measures, however, it is necessary to establish what the 'business-as-usual' (BAU) trends would be in the absence of any new initiatives. The aim of this paper is to report on research undertaken in the UK to determine the baseline trends in logistics and supply chain management and associated environmental effects of road freight transport up to 2020. The research has been conducted as part of a multi-university project funded by the UK EPSRC, called Green Logistics.

Globally, according to the Stern report, transport accounts for 14% of total greenhouse gas emissions, with three-quarters of these emissions from road transport (Stern, 2006). In the UK, road freight traffic is responsible for 22% of all CO₂ emissions from the transport sector and roughly 6% of total domestic CO₂ emissions (Department for Transport, 2006). It is estimated that in 2004 the UK freight transport sector emitted 33.7 million tonnes of CO₂ with HGVs constituting 78.5 % of this total (McKinnon, 2007).

Improvements in key supply chain variables such as the average length of haul, modal split or vehicle utilisation levels could produce significant economic and environmental benefits (McKinnon, 2003) but there is a great degree of uncertainty about the likelihood of this occurring by 2020. Additionally, it is possible that factors and processes influencing trends in road freight tonne-kilometres, fuel consumption and thus CO₂ emissions will change in future years,

making it very unwise simply to extrapolate past trends. The forecast of CO₂ emission trends should be rooted in a detailed understanding of the underlying causes of freight traffic growth and its carbon intensity.

An analytical framework has been constructed to map the complex interdependence between economic performance, a series of logistics parameters and freight transport-related externalities. The key factors affecting freight transport intensity, supply chain structure, modal split, vehicle utilisation and fuel efficiency have been investigated and verified during a series of seven focus group discussions. The issues identified by the participants were categorised into six classes on the basis of their relationship to different levels of logistical decision-making within a company and its environment. An online Delphi questionnaire has been developed and sent out to a large sample of logistics and supply chain experts to measure the direction and intensity of future developments likely to determine the environmental performance of supply chains. This paper presents the interim results from the first round of the questionnaire and points out directions for future research.

METHODOLOGY

This research aims to forecast a series of baseline trends in logistics and supply chain management and associated environmental effects of road freight transport up to 2020. Saaty and Boone (1990) list four approaches to forecasting: extrapolating past trends, analysing past relationships and analogies, constructing future scenarios along with developing trajectories and building a consensus of expert opinion. As recently there has been a discontinuity in the statistical trends in the key logistics parameters, extrapolation of past data or analysis of past interdependencies is likely to yield unreliable results. As the main objective of this research is to construct a baseline BAU scenario of freight transport futures, forecasting based on expert opinion has been identified as the most appropriate of the four approaches. Focus group research followed by a Delphi survey have been chosen as formal means of capturing and consolidating expert judgment. This concept of methodological triangulation, where both qualitative and quantitative techniques are applied to gain insight into the research problem, offers the greatest potential for an in-depth exploration of future freight transport and supply chain trends (Dunn et al., 1993, Kent et al., 1997). Mangan et al. (2004) and Frankel et al. (2005) argue that the use of both qualitative and quantitative methods is necessary to advance logistics research and to gain a "real-world" perspective on the subject. This "real-world" expert outlook on the future developments in logistics and supply chain trends is believed to maximise the credibility and accuracy of the forecast.

In the first stage of the research project, in order to gain in-depth understanding of future logistics and supply chain trends and their underlying causes a series of seven focus group discussions were run in four locations in the UK involving a total of 58 freight and logistics specialists from broad range of organisations. They expressed their views on the key factors affecting supply chain structure, modal split, vehicle utilisation and fuel efficiency. The summary of this research is presented in Piecyk et al. (2007). The discussions helped to identify key drivers, processes and trends and provided valuable input into the development of an online Delphi questionnaire for distribution to a much larger panel of industry representatives.

A stratified sample was drawn from a large database to reflect the shares of different types of organisations involved in logistics e.g. manufacturers, retailers or carriers. An invitation to take part in an online survey was emailed to 347 potential participants. In the first round 100 invitees filled in the questionnaire giving an overall response rate of 29%. The composition of the sample was: logistics service providers (LSPs) 27%, enablers 17%, manufacturers 15%, academics 14%, trade bodies 11%, retailers 10% and policy makers 6%.

The main objective of the Delphi study is to produce a reliable forecast based on expert judgement, thus the main criteria in drawing a sample were knowledge and experience of potential participants. The analysis uses statistical measures of central tendency and variability to summarise the experts' speculations (McKinnon et al., 2000). The respondents were asked to express their opinion on a particular variable on a five point scale. The mean values indicate both the direction of trends and their relative strength. Standard deviation measures how widely spread the values in the data set are.

After analysis of the first round of responses, a second round questionnaire will be circulated to the participants showing the mean scores for each question on the first round. The respondents will be given the option of modifying their initial response or to explain why they do not agree with the rest of the panel. In this way a greater degree of consensus will be reached. The final analysis will be based on the results of the two-round Delphi survey. This paper regards the results of the first round of the survey.

FACTORS DETERMINING THE ENVIRONMENTAL IMPACT OF ROAD FREIGHT TRANSPORT IN 2020

Air pollution from road freight transport is a function of the quantity and type of fuel used. The quantity of fuel used is directly related to the underlying demand for road freight. McKinnon and Woodburn (1993, 1996) divide the variables affecting road freight demand into four categories in relation to different levels of logistical decision-making within a company:

- Structural factors determining number, location and capacity of factories, warehouses and other facilities in the logistics system;
- Commercial factors related to companies' sourcing and distribution strategies and policies;
- Operational factors affecting the scheduling of product flow;
- Tactical factors relating to the management of transport resources – usually regarding the choice of vehicle, planning of loads and routing of deliveries.

This framework has been extended to include the following factors:

- External regulations and constraints imposed on companies by the entities like governments, regulatory bodies or international agencies, as well as other outside influences caused by wider macroeconomic factors and market dynamics.
- Product-related factors affecting product and packaging design and handling equipment requirements.

The first part of the questionnaire was designed to investigate future trends in factors belonging to the above categories. The type of fuel used is partly

influenced by pressures from the governments, customers and other external entities as well as companies' internal policies. However, the potential for use of alternative fuels, particularly biofuels was investigated in the later part of the questionnaire and due to limited space available it will not be discussed in this paper.

STRUCTURAL FACTORS

There was a general agreement that in 2020 the UK market will be predominantly supplied with goods produced overseas and then distributed through centralised logistics networks within the country. The majority of respondents believed that for production and inventory centralising tendencies will remain much stronger than any pressure to decentralise. This will probably lengthen the distances over which goods are transported. Hub & spoke networks, consolidation initiatives and port-/ airport- centric logistics are likely to gain in significance, potentially leading to better vehicle utilisation and reduced emissions. In the retail sector, the storage area in the shops is going to be reduced, forcing more frequent but smaller deliveries and increasing the negative environmental impact of the transport operation.

Q1: To what extent will the following changes to logistics and supply chain systems occur within UK by 2020? (Please rate where 0 = not at all and 4 = large extent)	Mean	Standard deviation
Centralisation of production	2.2	1.1
Decentralisation of production	1.5	1.1
Centralisation of inventory	2.3	1.1
Decentralisation of inventory	1.5	1.1
Relocation of production capacity to other countries	3.0	1.0
Relocation of warehousing to other countries	1.6	1.0
Concentration of trade through hub ports / airports	2.7	0.9
Growth of hub & spoke networks	2.6	0.9
Development of urban consolidation centres	2.6	1.0
Primary consolidation of inbound loads to distribution centres / factories	2.8	0.9
Increasing the storage area at retail outlets	1.1	1.1
Reducing the storage area at retail outlets	2.4	1.2

Table 1. Structural factors affecting road freight demand

COMMERCIAL FACTORS

Increase in volumes of goods and services traded online and more products being returned for recycling or reuse were identified as two of the main commercial factors impacting on freight transport demand in 2020. Although possible increase in local sourcing, particularly in case of food produce, was indicated earlier by focus group participants (Piecyk et al., 2007), Delphi panellists felt that across all sectors this will occur only to a limited extent. Additionally, some goods are still likely to be sourced from further afield contributing to higher CO₂ emissions from freight transport. Expansion of the market areas of UK businesses is likely to have a similar impact.

Retailers' control over supply chains is going to strengthen even further, increasing their responsibility for improving the environmental performance across the chains. Growing demand for "green" products and services may give

the retailers an incentive to involve other partners in joint efficiency initiatives yielding an overall economic and environmental benefit across the supply chain. Panellists also anticipated a significant further increase in vertical disintegration with more non-core processes being subcontracted and, presumably, extra links being added to supply chains.

Q2: How are the following commercial practices likely to change by 2020? (Please rate where -2 = much less important than now and 2 = much more important than now)	Mean	Standard deviation
Online retailing	1.6	0.6
Return of products for reuse / recycling	1.6	0.6
Global sourcing of supplies	0.9	1.0
Localised sourcing of supplies	0.4	0.9
Expansion of the market areas of UK businesses	0.8	0.8
Retailer control of the supply chain	0.8	0.9
Subcontracting of non-core processes	1.0	0.8

Table 2. Commercial factors affecting road freight demand

OPERATIONAL FACTORS

Panel members expected further reduction of order lead times, tightening of the delivery windows, need for more frequent of deliveries to the retail outlets and even greater application of the Just-In-Time (JIT) principle. Variability of order sizes will make it difficult for companies to match load and vehicle capacity efficiently. These trends are likely to make it difficult for companies to improve or even maintain current levels of vehicle utilisation. On the other hand, growth in night-time operations should help managers to optimise the use of delivery vehicles, potentially helping to reduce the negative environmental impact.

Q3: Relative to today how are the following logistics and supply chain operations likely to change by 2020? (Please rate where -2 = large reduction and 2 = large increase)	Mean	Standard deviation
Order lead times	-0.4	1.0
Width of delivery time windows	-0.2	1.1
Frequency of delivery to shops	0.3	1.0
Application of JIT principle	0.5	1.0
Variability of order size	0.8	0.8
Night-time delivery to retail outlets	1.1	0.7

Table 3. Operational factors affecting road freight demand

TACTICAL FACTORS

Within a logistics system managers can optimise the resources and their use to achieve greater efficiency of operation. Use of telematics and computerised vehicle routing and scheduling systems (CVRS) were predicted to significantly gain in importance by 2020. In order to improve efficiency of distribution and to seek further cost reductions companies are also predicted to get more heavily involved in various collaboration initiatives. Within organisational structures, production and distribution operations are likely to be more integrated than they are now. Better matching of vehicle fleet to transport demands may lead to better resource planning like, for instance, investment in double-deck / high-

cube vehicles for efficient trunking or/and in smaller vehicles for the last leg deliveries in the distribution network.

Almost all of the tactical factors rated by the respondents are likely to bring significant savings in fuel consumption and emissions levels in the short to medium term. This is due to the fact that these determinants can be easily optimised in the short term with relatively low investment and risk. As they are applied at the lowest and most flexible level in the decision-making hierarchy, they help companies to improve their performance within often fixed logistics structures or where commercial and operational requirements are imposed by a more powerful partner in the supply chain.

Q4: What will be the uptake of the following management practices by 2020 relative to today? (Please rate where -2 = much less and 2 = much more)	Mean	Standard deviation
Use of telematics	1.4	0.7
Use of vehicle routing and scheduling systems	1.3	0.7
Logistical collaboration between companies	1.3	0.6
Integration of production and distribution	0.8	0.8
Matching of vehicle fleet to transport demands	1.0	0.8
Investment in double-deck / high-cube vehicles	1.2	0.7
Use of vans for deliveries	0.7	1.0
Backloading of vehicles	1.2	0.6
Focus on service quality rather than costs	0.5	0.9

Table 4. Tactical factors affecting road freight demand

EXTERNAL FACTORS

External factors will have an effect on all the key freight transport variables. Fuel prices were perceived as the biggest threat to transport operations. However, increasing fuel prices are likely to reinforce fuel efficiency initiatives amongst road freight users. Combined with potential extension of emission trading scheme to transport and growth in use of some types of alternative fuel this may yield significant reductions in freight related CO₂ emissions. (Since the survey was completed, new scientific evidence has been publicised which suggests that, on a life-cycle basis, many biofuels are more carbon-intensive than conventional fossil fuels). Infrastructure charges on the national road network were judged as beneficial for the UK freight transport sector, whereas the opposite was predicted for congestion charging in urban areas. From the environmental perspective, fiscal measures reducing traffic congestion on both urban and rural roads are definitely beneficial despite imposing an additional economic burden on road transport operators using road infrastructure at busy times.

Restrictions on drivers' time and the potential shortage of qualified workforce are likely to make management of delivery operations more difficult resulting in potential loss of flexibility and sub-optimal performance. On the other hand, panellists envisaged a significant more development of online freight exchanges / load matching services by 2020, which will be likely to promote further reductions in empty running and exhaust emission levels.

Q5: What will be the impact of the following external factors on the UK road freight transport by 2020? (Please rate where -2 = large negative impact and 2 = large positive impact)	Mean	Standard deviation
Fuel prices	-0.9	1.3
Extension of emission trading scheme to freight transport	0.2	1.1
Use of alternative fuels	0.7	0.9
Introduction of user charging on the national road network	-0.2	1.2
Congestion charging in urban areas	-0.2	1.2
Quality of road infrastructure	-0.5	1.2
Availability of drivers	-0.6	1.1
Restrictions on drivers' time	-0.5	1.1
Development of online freight exchanges / load matching services	0.7	0.7
Polarisation of the road freight market	0.2	0.8
Competition from foreign operators	-0.4	1.1

Table 5. External factors affecting road freight demand

PRODUCT-RELATED FACTORS

Design of products and packaging can impact on vehicle utilisation and thus on the environmental performance of logistics. Two contradicting trends were identified by panel members. Greater use of space-efficient packaging and handling equipment as well as more attention given to logistical requirements at the design stage of product development process, should support effective utilisation of transport resources and lead to lower emissions. On the other hand, the projected increase in the use of shelf-ready packaging and imports of goods in store-ready format can undermine efforts to optimise vehicle utilisation and lead to increased fuel consumption and emissions.

Further miniaturisation of products and an increase in their value-density can also have a double effect. If products are smaller and lighter, more of them can be transported in one vehicle and so fewer journeys are needed. Nevertheless, if goods are more valuable, offering a higher level of customer service may be considered more important than optimising logistical efficiency and result in under-utilisation of available vehicle capacity.

Q6: To what extent will the following changes in product and packaging design occur within UK by 2020? (Please rate where 0 = not at all and 4 = large extent)	Mean	Standard deviation
Greater use of space-efficient packaging / handling equipment	2.9	0.8
Design of products more sensitive to logistical requirements	2.1	1.1
Increase in the use of shelf-ready packaging	2.6	1.0
Import of goods in store-ready format	2.6	0.9
Miniaturisation of products	2.1	1.1
Increase in the value-density of products	2.3	1.0

Table 6. Product-related factors affecting road freight demand

CONCLUSIONS AND NEXT STEPS

Some long-established production and logistics trends which exert a strong influence on road freight demand, such as the centralisation of manufacturing and inventory, the adoption of JIT replenishment and the outsourcing of non-core activities, cannot continue indefinitely. The preliminary results of the Delphi survey reported in this paper, however, suggest that these trends are likely to continue at least until 2020. They also show how complex the inter-relationships are between the broad range of business trends which interact to determine freight traffic levels and related emissions. While some of the trends predicted by the panel of experts will increase the environmental footprint of road freight operations, others will have the opposite effect. Broadly speaking, many of the trends anticipated at the upper strategic, commercial and operational levels in the decision-making hierarchy are likely to increase the environmental impact, while those projected to occur at a tactical level in the management of transport resources will have an offsetting effect. The net impact on energy consumption and emissions is thus difficult to forecast. The standard deviation values also reveal significant differences of opinion on some key variables, which may narrow in the second round of the Delphi survey. Further analysis will be required to evaluate the relative contribution of all factors discussed in this paper to the emission trends and to disaggregate the responses of different stakeholder groups. When the final Delphi results are available, they will be used to calibrate a spreadsheet model linking macro-economic variables to freight-related emissions via a series of key freight and logistics parameters. This model will be used to project the future BAU trends in these major parameters. In this way it will be possible to construct a quantitative forecast of the environmental and social impacts of freight transport in 2020 on the basis of expert opinion.

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ENVIRONMENTAL LOGISTICS IN THE THAI BATTERY SECTOR

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ABSTRACT:

An importance of reverse logistics topic has gradually increased over the past few years. Some researchers have considered reverse logistics to be similar to green logistics, in particular when related to product recycling or re-use. This paper primarily focuses on another facet of reverse logistics, which involves the return of used products that need to be remanufactured or recycled or disposed by the manufacturer. This study aims to explore which environmental logistics framework is utilised in Thai mobile telephone battery sector.

Environmental stewardship and reverse logistics concepts are selected as a generic model on environmental logistics. The environmental stewardship concept is based on recognition that the environmental effects of an organisation encompass environmental impacts of goods and processes from extraction of raw materials to usage of goods produced; to the final disposal of those goods. On the one hand, reverse logistics concept is based on roles of logistics in product recycling, waste disposal, and management of hazardous materials from the end-users or manufacturing. The model is adapted to Thai used mobile telephone battery sector for assessing the utilised environmental logistic framework on its remanufacturing or recycling or disposal.

Nokia's and Sony Ericsson's used battery returns systems are selected as a representative of reverse logistics in the Thai market because of their market shares and the use of local firms. It was discovered that the two companies hereover use a similar environmental logistics framework. Used batteries were handed over to retailers which can be either Nokia's or Sony Ericsson's dealers or other mobile telephone shops and then they were delivered to a collection centre for recycling or remanufacturing or disposal abroad. It was found that apparently the environmental logistics framework in the Thai mobile telephone battery sector was different from the generic model on environmental logistics especially in term of used product returns flow from end-customers to re-manufacturing or re-use point.

Keywords: Mobile telephone in Thailand; Battery, Reverse logistics, Recycling and Environmental logistics.

INTRODUCTION:

Environmental regulations are changing the way how supply chains are designed and managed. Rules, regulations and different consumers' requirement have increased the complexity of global trade for firms active in numerous markets. Even though environmental issues are having significant impact on businesses and their supply chain; an understanding of nature of product returns provides a valuable insight into the changing needs of marketing and logistics requirement over the life of a product (Stonebraker and Liao 2006; Mollenkopf and Closs 2005; Tibben-Lembke 2002).

In Thailand, there are approximately twelve millions registered mobile telephone users in 2006 (The Thailand Pollution Control Department, 2007) and the growth of registered mobile telephone user increases in parallel with the demand for accessories such as portable batteries. Most of these batteries are Nickel-Cadmium Li-ion batteries which have a direct impact on the environment if they are not disposed of carefully due to the nature of the hazardous materials contained inside. Moreover, the life cycle of mobile telephone battery is short due to its derived demand of fashionable nature of mobile telephone and rapidly changed in mobile telephone used technology. Used mobile telephone batteries will negatively impact to environment if lack of proper management system is a case. This means that a better understanding of the utilised environmental logistics framework in Thai mobile telephone battery sector can help businesses understand the environmental impact of used batteries and its movement. In this paper, the system of returns of mobile telephone batteries in Thailand is selected as an illustrative case study.

LITERATURE:

The concept of reverse logistics is not new. Agreed upon definitions have only started since the 1990s. The Council of Logistics Management (CLM) published the first known definition of Reverse logistics in the early nineties (Stock, 1992):

"...the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials: a broader perspective includes all relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal."

The European Working Group on Reverse Logistics, RevLog (1998), puts forward the following definition:

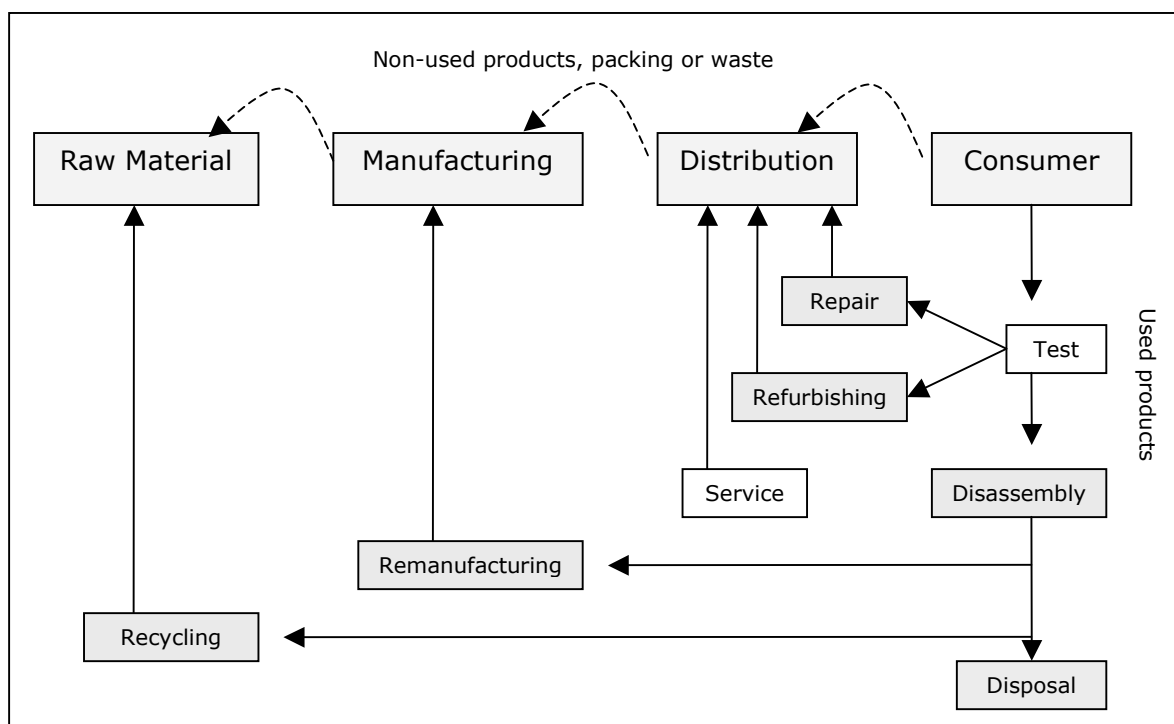
"The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point to the point of recovery or point of proper disposal".

Brito (2002) defined the returns in reverse logistics to three dimensions as manufacturing returns, distribution returns and customer or user returns. Firstly, manufacturing returns is all those cases where components or products have to be recovered in the production phase. This includes raw materials surplus, quality-control returns, and production leftovers. Secondly, distribution returns

refers to all those returns that are initiated by a supply chain actor during distribution after the product has been made. It refers to product recalls, commercial returns, stock adjustment, and functional returns. Lastly, customer or user returns consist of reimbursement guarantees, warranty returns, service returns, end-of-use, and end-of-life.

Figure 1 shows the basic flow diagram of reverse logistics activities. The complexity of operations and the value recovered increase from bottom-left to top-right in the figure. The pattern of quantity, quality and time of arrival of returns is of paramount importance in reverse logistics network design. The location of facilities relative to process inputs, customer markets or waste disposal locations has been considered both analytically and empirically in literature (Giannikos, 1998; Pushchak and Rocha, 1998).

Figure 1 Flow diagram of reverse logistics activities



Source: Krumwiede and Sheu (2002)

Collection is the first and a very important stage in the recovery process, where product types are selected and products are located, collected, and, if required, transported to facilities for rework and remanufacturing. Used products originate from multiple sources and are brought to a product recovery facility, resulting in a converging process.

Inspection/Sorting may be carried out either at the point/time of collection itself or afterwards (at collection points or at rework facilities). Collected items generally need sorting. Inspection/sorting illustrates the need for skill in the sorting of used products (Ferrer and Whybark, 2000). This may or may not be

combined with pre-processing. Jahre (1995) found that the converse to sorting complexity is collection complexity. Pre-processing may be in the form of sorting, segregation, partial or complete disassembly or minor repair and refurbishing activities. It may be carried out either at collection centres or at rework facility depending upon the technological and economic factors. Louwers et al. (1999) discuss it in detail while developing a facility location allocation model for reusing carpet materials. They include the operational costs related to energy, labor, maintenance costs and the loss of interest related to the facilities.

Location and Distribution (Network Design) are the most important and critical area of reverse logistics that is assuming greater importance day by day. In many cases, recovery networks are not set up independently "from scratch" but are intertwined with existing logistics structures. In particular, this is true if the OEM recovers products. Location and configuration of facilities frequently affect and are affected by the external natural environment, mainly the estimated returns.

Distribution is a typical concern, and one of the first functions targeted to minimise environmental costs. Firms have sought to reduce raw material use by modifying packaging, which can directly and indirectly lower distribution costs as well. Some concentrated laundry detergents come in smaller packages, weigh less than regular ones, and use less energy and raw material for equal cleaning performance.

The environmental stewardship concept is based on the recognition that the environmental effects of an organisation include the environmental impacts of goods and processes from the extraction of raw materials, to the use of goods produced, to the final disposal of those goods (Lamming and Hampson, 1996). The evolution of manufacturing enterprises from traditional, problem-solving environmental management techniques to fully integrated environmental management. Thus, in the earliest evolutionary stages of environmental management, organisations separate environmental performance from operational performance.

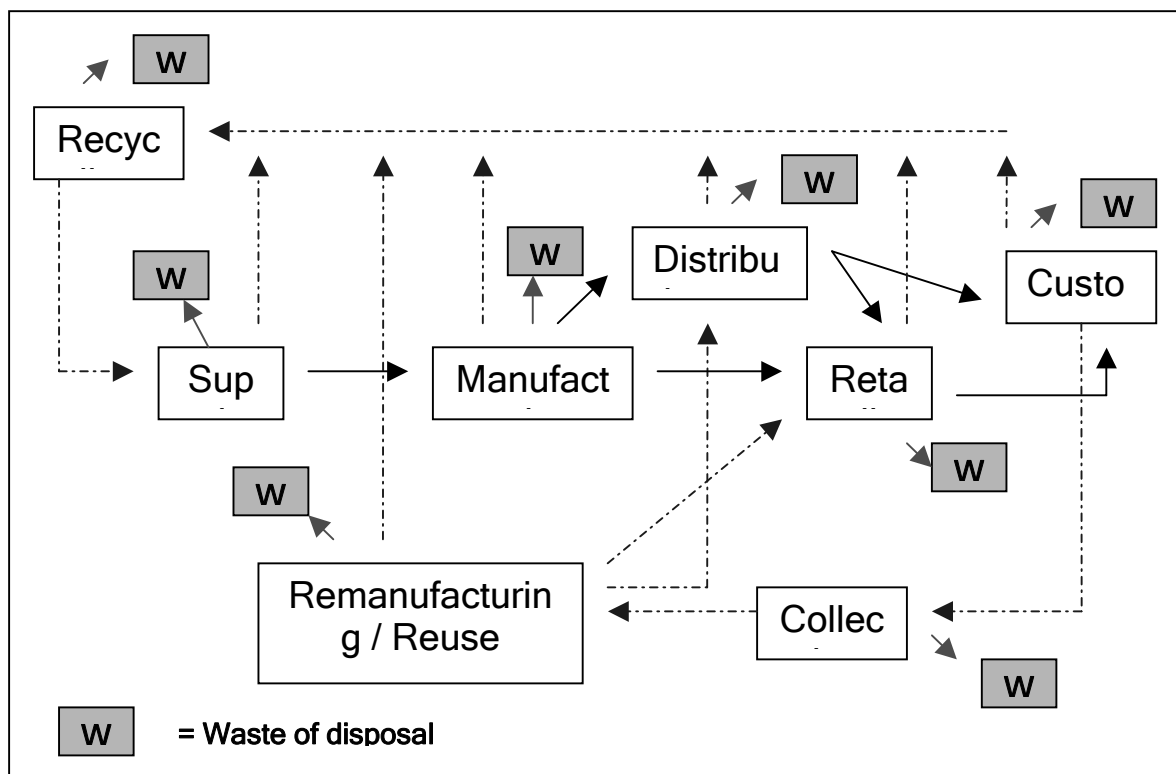
Combining the reverse logistics and environmental stewardship concepts, Figure 2 represents the traditional supply chain links as solid lines, and the links corresponding to the extended supply chain as dashed lines. The "W"s enclosed by diamonds represent waste (or disposed) materials.

Recycling is the process of collecting used products, components, and/or materials from the field, disassembling them (when necessary), separating them into categories of like materials (e.g. specific plastic types, glass, etc.), and processing into recycled products, components, and/or materials. Beamon (1999) explained that the success of recycling depends on: (1) whether or not there is a market for the recycled materials; and (2) the quality of the recycled materials (since most recycling processes actually reduce the value of the material from its original value, as the material itself has degraded). Re-use is the process of collecting used materials, products, or components from the field, and distributing or selling them as used.

The process of remanufacturing consists of collecting a used product or component from the field, assessing its condition, and replacing worn, broken, or obsolete parts with new or refurbished parts. In this case, the identity and functionality of the original product is retained. The resulting (remanufactured) product is then inspected and tested, with the goal of meeting or exceeding the quality standards of brand new products. Thus, in some cases, the remanufactured product can exceed the original product in quality and/or function. This is due to the fact that during the remanufacturing process, the design of the replaced parts and/or components may have been improved since the original product was manufactured. The unique advantage of remanufacturing is that, unlike recycling and re-use, the process of remanufacturing does not degrade the overall value of the materials used (Beamon, 1999).

As in the general concept of environmental logistics above, this study will use the stewardship and reverse logistics concepts to be the basic framework as shown in figure 2. It shown that flow of return products will be from customers to collection centre, remanufacturing or re-use centre respectively as seen in the spot line. In this case the collection centre will take responsibilities on wastes from customer returns directly.

Figure 2 Generic framework on environmental logistics



Source: Beamon B (1999)

METHODOLOGY:

This paper is a case study that providing an exploration of environmental logistics framework in Thai mobile telephone battery sector. The results presented are derived from empirical data. A scope of study is focuses on Nokia's and Sony Ericsson's used mobile telephone batteries as a representative of reverse logistics in the Thai market because of their market shares and the use of local firms. The semi-structured interview is used as a research tool from the end-customers to manufacturing.

Due to limitation of time and sample size, this study does not focus on the depth of environmental logistics framework and its process mapping which will help businesses better understand the environmental impact and the returns management system.

FINDINGS:

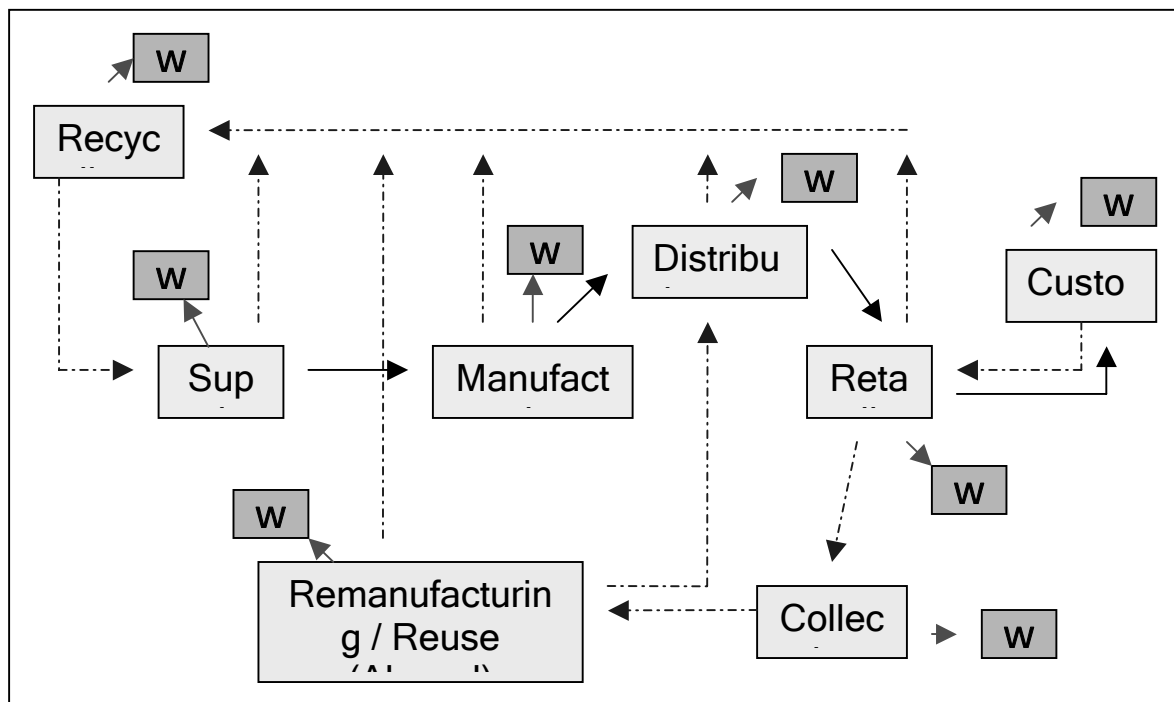
In Thailand 65 per cent of total registered mobile telephone users choose the brand Nokia, followed by Sony Ericsson, Motorola, Samsung, LG and some local brands respectively (MCOT, 2008). Therefore, this case study focuses on Nokia's and Sony Ericsson's used battery returns as a representative of the Thai market. Survey is conducted in the study by interviewing all concerned parties through supply chain.

It is found that in Thailand the trial initially provided for the return of used batteries through the general mobile telephone shops or the dealers. This study discovers that both of the alternatives returns the used batteries to the collection centre which further delivers them to Nokia's and Sony Ericsson's factories abroad for re-manufacturing or re-use of the used batteries.

In general, the impact of manufacturing operations on the environment may be categorised as follows: (1) waste; (2) energy used; and (3) resource used (material consumption). These are considered in term of environmental logistics in Thai mobile telephone batteries sector as shown in the movement of used mobile telephone batteries. It shows that apparently the environmental logistics framework in Thai mobile telephone batteries sector was different from the generic model on environmental logistics especially in term of used product returns flow from end-customers to re-manufacturing or re-use point as shown in figure 3. These mean that the retail parties composing of the mobile telephone shops and the dealers of Nokia and Sony Ericsson will take responsibilities on the wastes coming from the returns of used batteries. Hence quantity of wastes at the collection centre may be reduced or at the same level. This differs from the generic model because in the generic model the products returns from end-customers are delivered to the collection centre directly whereas in Thai mobile telephone market, the end-customers hand over used mobile telephone batteries to retail parties instead and then these batteries are delivered to the collection centre. Comparing with the generic framework in Figure 2, the environmental impacts will affect retail and collection parties most significantly due to the difference of the used mobile telephone batteries returns flow. As the results show, retail parties in the used batteries sector are facing more negative

environmental impact than other parties. Furthermore, the difference in customer returns flow shows that there is a lack of proper returns management system because manufacturing, Nokia and Sony Ericsson, do not yet set up return management system for collecting the used mobile telephone batteries from end-customers. These used mobile telephone batteries will be delivered directly by the mobile telephone shops and the dealers of Nokia and Sony Ericsson to manufacturing.

Figure 3 Environmental logistics framework in Thai battery sector



Source: Survey by Authors (2008)

CONCLUSION:

In summary, this paper does not only make a contribution to the literature on environmental logistics and reverse logistics concepts but also conduct a certain of empirical work on the movement of used mobile telephone batteries. Even though this study is only to explore which environmental logistics framework is utilised in Thai mobile telephone battery sector, it was found that the Nokia and Sony Ericsson companies use a similar environmental logistics framework. Used batteries were handed over to retailer parties which can be either Nokia's and Sony Ericsson's dealers or other mobile telephone shops and then used mobile telephone batteries were delivered to the collection centre for recycling or remanufacturing or disposal abroad. Moreover, it shows this is room to improve in term of a proper management logistics system for the used battery sector in Thailand. A well-constructed environmental logistics system to control or eradicate wastes from used batteries returns would be an important issue for businesses and organisations' resource allocations.

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THE ECO-SUPPLY CHAIN: FINDINGS OF A GLOBAL COMPARATIVE SURVEY

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INTRODUCTION

Environmental seems to be part of every debate and trends demonstrate an increasing awareness of the matter in the business world. Indeed, many companies now are considering the incorporation of the environmental factor in the various phases of their Supply Chain: sourcing, manufacturing, forward and reverse logistics, and transportation. This reconsideration of the existing processes is done with the aim of minimizing the environmental footprint of a product or service (green¹ supply chain).

Many authors are exploring environmental initiatives within each of the different phases of the supply chain, focusing predominantly on only one functional area (Sarkis, 1999 and 2006). More recent contributions (Rao and Holt, 2005) have encompassed the entire supply chain, since it has been widely acknowledged that the critical step for integrating sustainable principles within operations is the examination of the interaction between sustainability (or environmental principles) and supply chains (Linton et al. 2007). However, sustainability seems to be dealt with in generic ways, as if a single form of sustainability could be achieved and implemented in all types of supply chains. Alternatively, sustainability is sometimes reduced to a fragmented approach based on anecdotic best practices for the different phases of the supply chain. In both of these approaches, it is difficult for companies to understand that sustainable supply chains could be much more than an obligation, a cost, a constraint, or a charitable deed.

Therefore, the identification of specific sustainable initiatives which best suit different contexts (type of product, characteristics of demand, societal concern, etc.) could be beneficial for companies to recognize that sustainable supply chains can become a source of competitive advantage and at the same time, a lever for reducing environmental externalities. In other words, as has been recently argued in the strategic management literature (Porter and Kramer, 2006), it is important to establish a link between competitive advantage and sustainable behaviour. This connection could also contribute to the transformation of *cosmetic* actions (CSR reports, media campaigns, etc.) into concrete initiatives along the supply chain, thus reducing the current widespread phenomenon, known as *greenwashing*.

It is worth noting that sustainable strategies evolve in accordance with the evolution of the competitive context. Hence, the implementation of a sustainable supply chain has to be intended as a dynamic process which regularly updates the *sustainable agenda* for supply chain managers.

With these preliminary remarks in mind, we have initiated a research project aimed at achieving two complementary objectives. First, drawing on the stream

¹In this paper we use “green” and “sustainable” supply chains as synonymous. We neglect the social pillar which is often included in the sustainable concept, along with the economic and environmental ones.

of supply chain literature arguing that each product *needs a specific supply chain* (Fisher, 1997), we intend to show that different types of supply chain strategies call for different types of sustainable strategies. More precisely, it is our intention to verify if *lean* and *agile* supply chains integrate sustainability in their strategic and operational issues in different ways. We refer to Christopher and Towill (2001) segmentation of supply chains in terms of a lean or an agile approach. A key characteristic of an agile approach is flexibility, whereas lean means doing more with less. Agility is pursued in a volatile marketplace. Leanness makes sense when demand is predictable and the requirements for variety are low and volume is high.

Second, as the search for an alignment between supply chain and sustainable strategies is a dynamic process, sustainable supply chain strategies change over time. We presume that the older the sustainable supply chain strategy is, the more mature the company is in this field. Thus, we aim at classifying companies according to their different maturity level in the practice of sustainable supply chain initiatives. Beyond the age of the approach, other managerial variables, such as the number of functions and external partners involved, the presence of a dedicated service, the performance and the follow up measures are taken into account in order to produce a *mapping* of companies in terms of sustainable supply chain strategies.

We have carried out a global survey. However, as data gathering has been concluded very recently and the data-analysis phase is on-going, in this paper, we would rather provide the reader with the first empirical evidences discussing motivations, constraints and main results relating to the green supply chain. Our discussion will focus on the elements which will be used for the classification aim and those supporting our presumptions about the existence of a link between supply chain strategies and different forms of sustainability.

METHODOLOGY

The survey on the eco-supply chain was conducted in two phases. The quantitative phase took the form of an online questionnaire sent to decision makers involved in the supply chain. Overall, almost two thirds of the respondents (64% excluding and 68% including quality managers) hold positions associated with the management of a core part of the Supply Chain (production, procurement, logistics). About 600 questionnaires have been collected. The sample is mainly represented by companies located in the United Kingdom (43% of the sample), France (26%), the United States (12%) and Japan (7%). It includes companies of different sizes, from a turnover exceeding 1 billion dollars (40%) to less than 100 millions dollars (26%). The spread of sectors represented in this study is very broad. However 57% of the sample is accounting for by the following five sectors: consumer goods (16%), large-scale distribution (13%), transport (10%), electronics/IT (10%) and pharmaceuticals (8%).

The qualitative phase took the form of face-to-face interviews. About twenty interviews were conducted with supply chain and environment directors of companies directly involved in green supply chain operations.

The structure of the questionnaire reflects the different phases of a product life cycle (product design, sourcing, manufacturing, distribution product recovery), with the aim of analysing each supply chain phase through the sustainability *augmenting glass*.

We are going to carry out a cluster analysis aiming at proposing a "mapping" of the surveyed companies according to their different "maturity levels" in terms of

sustainable supply chain strategies. The analysis of the link between the specific supply chain strategy and the corresponding form of sustainability will be carried out in a supplementary step.

PRELIMINARY SURVEY KEY FINDINGS

The survey reveals that 83% of companies claim to take into account environmental concerns into their strategic decisions. This high general level of consideration reveals an increasing awareness for environment which is clearly claimed by companies while not always transformed into action. At the same time, half of the companies which claim not to consider environmental concerns plan to do so in the near future. Companies are motivated to take environmental concerns into consideration by compliance with regulatory constraints (73% of the companies surveyed) and a desire to improve the company's brand image (60% of them). Despite the important role played by environmental concerns in strategic decision, overall, only 35% of companies declare that they have established a green supply chain or a part of it. This result seems to corroborate the prevalent beliefs that companies hardly go beyond *greenwashing*, when dealing with sustainable issues.

The bigger the company the greater the level of involvement in the green supply chain: 54% of companies with turnover in excess of 1 billion dollars claim to be involved in a green supply chain, but this percentage drops to 29% for companies with turnover of less than 100 million dollars. The picture is different country by country: 100% of the surveyed companies in Japan have adopted a green supply chain strategy, the percentage of companies that have implemented a green supply chain strategy is just 38% for Europe, and significant gaps exist between the UK (45%), France (30%) and the United States (with just 24%).

Regarding the drivers and the hampering factors to green supply chains, the main results are in line with the literature and can be summarised as follows. Four main drivers have emerged. First, regulation (compliance with relevant laws and anticipation of future requirements) received 22% of responses. Brand image received 19% of responses, mainly by companies operating in the mass market/large-scale distribution sectors, which tend to implement measures that are "more visible" to the final customer. The remaining two drivers are linked to innovation (product/processes) and cost reduction (via process and flow optimisation), which accounted respectively for 15% and 13% of the responses. The optimisation driver is cited mainly by companies operating in the B2B and industrial sectors.

About the different phases of the supply chain, diverse orientations to sustainability have emerged. 81% of companies that are implementing a green supply chain, have made changes to their transport/ logistics operations. The most common environmental measure (41%) involves restructuring logistics flows to reduce the number of journeys. 66% have adopted an eco-sourcing approach, i.e. an approach which favours purchases of less polluting products/materials. 65% have changed their production operations. The two main courses of action are modifying production processes (35%) and using less polluting manufacturing materials/ equipment (24%). 59% have implemented an eco-design approach for products and/or manufacturing procedures. 59% have implemented a reverse logistics initiative in order to recover products. Half of reverse logistics operations (50%) involve finished products.

Summarising the survey preliminary results, significant differences exist among sectors and countries in terms of the age of the green approach, in terms of number of partners involved (both upstream and downstream in the supply chain), of functions affected and in terms of measuring tools set up for the follow up. The following table (table 1) reveals different levels of maturity among companies, with regards to green supply chain.


	Motivation	Age of the approach	Presence of a dedicated function	Functions affected	Partners involved	Follow-up/ Control system
	None or regulation	Less than 3 years	No	No function entirely affected	None	None
	Regulation Optimisation	More than 3 & less than 5 years	Yes but limited in scope and no corporate alignment	At least one (transport)	None	None
	Brand image Innovation	More than 5 & less than 10 years	Yes but limited in scope, with corporate alignment	At least two (transport & manufacturing)	One partner (in general a supplier)	Currently being set up Transactional
	Part of the company's <i>raison d'être</i>	More than 10 years	Yes, heavily institutionalised Wide in scope Alignment along divisions	All (from design, to recycling...)	Collaborative involvement of third parties along the SC	Already in place, incorporates in reward system

Table 1: Different maturity levels towards a green supply chain

CONCLUSION

In conclusion, even if most companies take into account the environment when making strategic decision, significantly fewer have pursued or initiated a green supply chain strategy and they show different levels of maturity with respect to this approach. Starting from these preliminary results, several research directions are being explored. First, we are going to develop a finer classification of companies in terms of maturity level in the establishment of a sustainable supply chain, illustrating possible common behaviours per sectors, countries, and company's size. Second, having acknowledged that a variety of motivations and actions exist in the green supply chain, we are going to link different corporate strategies to different sustainable supply chain strategies.

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A STUDY ON STRATEGY FOR IMPROVEMENT OF CUSTOMER PURCHASING QUANTITY TO REALIZE EFFICIENT GREEN LOGISTICS IN HOME DELIVERY BUSINESS

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ABSTRACT

The purpose of this research is to propose a strategy to attract excellent customers and evaluate the improvement of the green logistics system through improving the customer's order amount and purchase price. We analyze what kind of logistics service is attractive to excellent customers but unattractive to bad customers from the marketing viewpoints, and propose a way to improve the delivery efficiency by increasing the average amount of purchase price per order.

Key words: Environmental Logistics, Environmental Efficiency, CO2 Emission

INTRODUCTION

Recently, the home delivery business is growing in Japan as a result of social aging and access to high quality services. Japanese Cooperatives (COOPs) are regarded as one of the most well-known associations running a home delivery business. Although the customers (known as "Coop members") are increasing, the average quantity of each order per member is decreasing. The main reason for this is the tendency for new members to make small orders. This problem causes an inefficient logistics system for home delivery. This fact has been verified from the data of sales results in COOPs. In the home delivery business, drivers have to stop their trucks in front of each member's residence, unload the delivery goods, catalogs, and order sheets and collect used containers and bottles for recycling. Therefore, the amount of energy consumed in the delivery is basically proportional to the number of contractors (customers). Thus, the lower the order and delivery quantities per member, the less efficient the delivery system is. Therefore, one of the most important goals for COOPs is to increase the order quantity per member, leading to a more efficient logistics.

In addition, most companies have to care about environmental issues these days. CO2 emissions are caused by the consumption of fuel or electric energy in the process of transportation, stock holding, loading, etc. COOPs also have been making efforts to reduce the environmental load caused by logistics activities. They are recognizing that improvement in the efficiency of home deliveries will lessen the environmental load. Currently, however, the influence of the decrease in the purchasing price is stronger than their efforts. In the logistics of COOPs, it is of critical importance to improve delivery efficiency by increasing the number of new excellent customers who will buy a lot of goods in a single order.

In this paper, we propose a sales and delivery system, in other words "a strategy", to reduce the CO2 emissions and to increase the sales amount. We analyze what kind of logistics service is attractive to excellent customers but unattractive to bad customers from the marketing viewpoints, and propose a way to improve the delivery efficiency by increasing the average amount of purchase price per order.

We analyze the difference in characteristics between excellent customers and other customers, based on the Conjoint Analysis with stratification, and prove that services exist which give us the possibility to attract only the excellent customers. A delivery service system with incentives is proposed to discourage the participation of customers who make small orders leading to environmental inefficiency. In addition, we evaluate the impact of improving the purchase amount of price for efficiency of the home delivery system. By considering the results based on the Conjoint Analysis, it is efficacious to show the effect of reductions of the environmental load, i.e., CO2 emissions, quantitatively with its price.

Through this process, we propose a strategy to attract excellent customers and evaluate the improvement of the green logistics system through improving the customer's order amount and purchase price.

CUSTOMER SURVEY QUESTIONNAIRE

In this paper, we analyze the home delivery services which are attractive to excellent customers through a customer survey using a questionnaire. The questionnaire contains both selective questions about customer characteristics and questions for the Conjoint Analysis. Here, the Conjoint Analysis is a statistical technique used in market research to evaluate how customers value different features of products or services. For the Conjoint Analysis, a virtual home delivery service is described in terms of a number of attributes. A list of these several prototypes of virtual home delivery services is shown to questionnaire respondents and they are asked to choose from and rank the virtual home delivery service in the order they like.

In this study, the difference of ranking between excellent and bad customers is examined and the services excellent customers like are revealed.

The process to make the questionnaire is as follows:

Step 1. Developing items for the questionnaire for inquiry into the customers' attribution

Step 2. Creating questions for the Conjoint Analysis

<1> Listing all the attributes of home delivery services

<2> Extracting important items from the list of all attributes.

<3> Deciding the level of extracted attributes.

<4> Profiles of virtual home delivery services are constructed by the Fractional factorial design.

Step 3. Making the questionnaire by combining both questions of Step 1 and 2.

1) Making items of questionnaire about customers' attribution

In order to analyze the differences between excellent and bad customers, the expected purchase price per order should be evaluated for all questionnaire respondents. In this study, we use the following question to get this information: "How much would you purchase per week in case if you use home delivery service (having conditions similar to COOPs)?"

Moreover, in order to investigate customers attributes related to the purchase unit price per order, we also ask the following profiles of the respondents in the questionnaire:

- Age
- Sex
- Occupation
- Resident status
- Family
- Experience of home delivery service

2) Making questions for the Conjoint Analysis

As the result of investigation of important attributes of home delivery services, we reached the conclusion that interim services are important because they lead new customers to participate in COOPs. Thus, the following four attributes are extracted:

1. A free delivery service

The delivery charge is a very important attribute in the home delivery service. Two types of charge free service can be showed to new customers.

- In case of ordering items more than 5000yen, the delivery charge is free.

- If a new customer joins the home delivery service, free charge service will be available for an initial 8 weeks.

2. A trial service

Many companies which is running the home delivery business are using marketing strategies using the services of supply of trial goods to customers. In this study, the

following two trial goods are considered by investigation of real cases in practice:

- Vegetables in season
- Frozen food

3. Discount and point services

Discount service is popular for consumers and it is used as an important price strategy in marketing to get many customers. On the other hand, the point service is also attractive to Japanese people. Customers can get various services by accumulating points they get proportional to the purchase price. The answer for the question, "Which service prefer to excellent customers?" is interesting for marketers and the following two services are considered as service attributes.

- In the case of ordering more than 5000yen, 5% OFF of the price ordered.
- In the case of ordering more than 5000yen, the points are increases by 20 times.

4. Penalty of stopping the catalog distribution

Inordertoremovebadcustomersmakingverysmallorders,somepenaltyforcustomer members may be introduced as a possibility. In this study, we evaluate the penalty of catalog distribution as a way to stop the bad customers.

- In the case of ordering less than 1000yen, the next catalog delivery is stopped
- No penalty.

Here, the eight interim services can be made by combining the above-mentioned four attributes with two levels based on the orthogonal table L_8 . However, it is difficult for respondents to rank eight virtual services. Therefore, the above four attributes are divided into two portions with three attributes each in this study and we make two sets of 4 interim services by using the orthogonal table L_4 of three attributed with two levels.

The four virtual services from services A to D are made by using attributes 1, 2, and 3 in the above list as shown in Table 1. The other four virtual services from services E to H are made by including the penalty of catalog distribution instead of the discount or point services as shown in Table 2. Then, we analyze the two sets of four virtual services by the Conjoint Analysis.

3 attributes combined in the virtual services A, B, C, and D

- The free service of the delivery charge.
- Trial service
- Discount or point services

3 attributes combined in the virtual services E, F, G, and H

- The free service of the delivery charge.
- Trial service
- Penalty of catalog distribution

Table1 Virtual services A,B,C, and D

	A free delivery service	Trial service	In case of ordering more than 5000 yen
A	In case of ordering items more than 5000yen	Vegetable in season	5% OFF of the price ordered.
B	In case of ordering items more than 5000yen	Frozen food	Thepointsareincreasesby 20 times.
C	Anyone can receive free delivery service for the initial 8 weeks.	Vegetable in season	Thepointsareincreasesby 20 times.
D	Anyone can receive free delivery service for the initial 8 weeks.	Frozen food	5%OFF of the price ordered.

Table2 Virtual services E, F, G, and H

	The delivery charge is free.	Trial service	The penalty
E	In case of ordering items more than 5000yen	Vegetable in season	The case of ordering less than1000yen, the catalog delivery is stopped.
F	In case of ordering items more than 5000yen	Frozen food	No penalty.
G	Anyone can receive free delivery service for the initial 8 weeks.	Vegetable in season	No penalty.
H	Anyone can receive free delivery service for the initial 8 weeks.	Frozen food	The case of ordering less than1000yen, the catalog delivery is stopped.

3) Making and distribution of the questionnaire

- Execution period: January, 2008
- Target: Men and women from teenage years to seventies
- Number of distributions: 330 people
- Distribution method: Handing or E-mail
- Number of collections: 267 people (rate 81%)
- Collection method: Handing, E-mail, or mailing

RESULT OF QUESTIONNAIRE

1) Attributes of respondents

At first, we show the attributes of respondents.

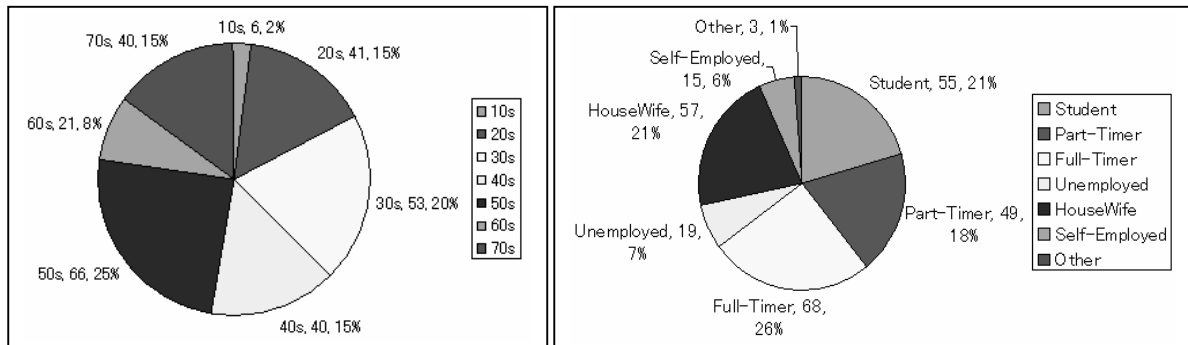


Figure 1 Composition ratio of age layer Figure 2 Composition ratio of occupation

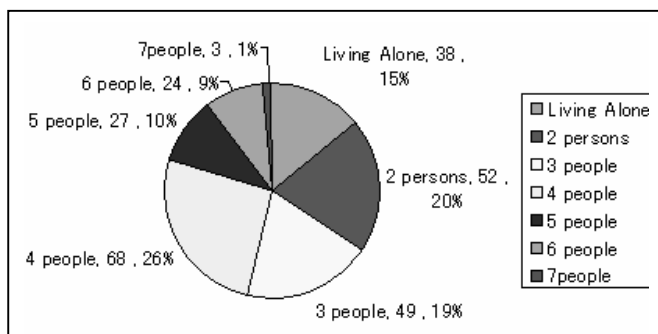


Figure 3 Composition ratio of number of families

2) Relation between respondent's attributes and the purchase price

It is important to pay attention to the purchase unit price and the answer result of the selection order of the virtual service in order to find the home delivery service that excellent customers like.

Then, we use the question "How much would you purchase per week in the case of using home delivery service (having conditions similar to COOPs),?" and using the answer for this question as the base of judgment for purchase price per order. Then, the choices in the 12 question concerning the purchase unit price are classified into 3 layers.

"Less than 3000 yen"

"From 3000 yen to less than 7000 yen"

"More than 7000 yen "

About the purchase unit price and age layer

Table 3 shows the relation between ages and purchase price per order of respondents.

Table 3 Purchase unit price ratio of each age layer

Unit price Age	Less than 3000 yen	3000 - 7000 yen	More than 7000 yen	Total
10's	0.667	0.333	0.000	1.000
20's	0.591	0.273	0.136	1.000
30's	0.550	0.325	0.125	1.000
40's	0.340	0.453	0.208	1.000
50's	0.195	0.512	0.293	1.000
60's	0.350	0.450	0.200	1.000
70's	0.381	0.286	0.333	1.000
Total	0.423	0.382	0.195	1.000

From Table 3, the purchase price per order by the ages from 40's to 60's is higher than other ages. On the other hand, the purchase price per order of the ages from 10's to 30's is the lowest.

As mentioned above, people from 40's to 60's years by age may be excellent customers who will buy a lot of goods in a single order. Perhaps their incomes are higher than other ages and they have many family members including their growing children.

About purchase price per order and the number of family members

Table 4 shows the relation between the number of family members and purchase price per order of respondents.

Table 4 Ratio of the purchase price per number of family members

Unit Price Number	Less than 3000 yen	3000 - 7000yen	More than 7000yen	Total
1	0.684	0.211	0.105	1.000
2	0.423	0.423	0.154	1.000
3	0.388	0.531	0.082	1.000
4	0.279	0.426	0.294	1.000
5	0.481	0.259	0.259	1.000
6	0.417	0.292	0.292	1.000
7	0.667	0.000	0.333	1.000
Total	0.425	0.380	0.195	1.000

This table shows the tendency for the customers with the highest purchase price per order having 3 or 4 family members on average. On the other hand, purchase price per order of people living alone is the lowest of all ages.

3) Conjoint Analysis: the relation between purchase price and popular service

The respondents make the orders they like for both two sets of the virtual delivery services, ABCD and EFGH. Figure 4 shows the result of the Conjoint Analysis for services

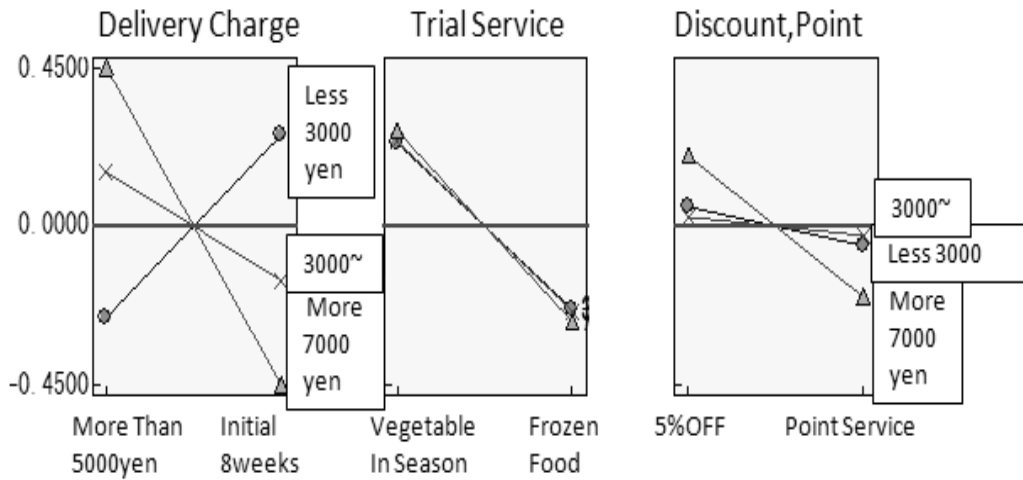


Figure4 Part effect of value per purchase price in the services ABCD

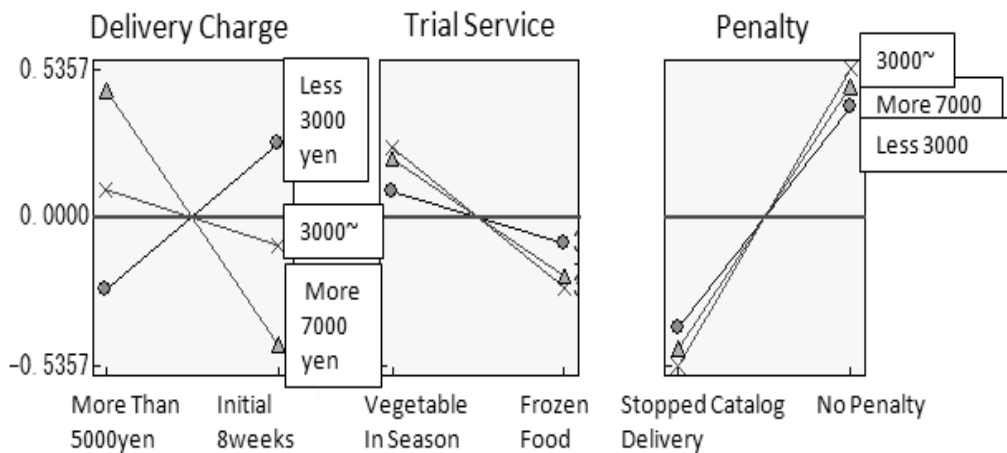


Figure5 Part effect of value per purchase price in the services EFGH

From Figure 4 which is the result for ABCD, the respondents with the highest purchase price per order (many of whom are in their 40s and 50s) tend to like the free delivery charge service in case of ordering items more than 5000yen. On the other hand, people with lower purchase price per order (many of whom are in their 20s and 30s) tend to prefer to receive the free delivery charge service for the initial 8 weeks. Therefore, the free delivery charge services are important to attract the excellent customers. This tendency is the same in the result of Figure 5. This result shows that excellent customers and bad customers tend to like different delivery services. Because the excellent customers often buy many items and spend a lot of money, they tend to like the services which can be received whenever they order items more than 5000yen. On the other hand, the bad customers tend to like the free services that anyone can receive. The free delivery charge service for the initial 8 weeks is attractive not only to the excellent customers, but also to the bad customers.

However in the result in EFGH, it is proved that the penalty has a strong influence on choice in comparison with the other service. That is to say, regardless of purchase price per order, all customers attach most importance to the penalty of stopping the

catalog distribution. Although the penalty is the way to remove the bad customers who make small orders, it may disturb the excellent customers who are going to join as a COOP member.

Moreover, the customers tend to like the "Vegetable in season" more than "Frozen food" as the "Trial service", regardless of the purchase price. The fact may be useful to get new customers in Japanese market.

CONSIDERATION OF RESULT OF THE SURVEY

1) Relationship of purchase price and customer attribute

When ages are compared from the viewpoint of purchase price per order, it is shown that those in their 40's and 50's have a high average. This result may be dependent on family structure.

People in their 40's could have families with parents, school children, junior high school students, or high school students. For people in their 50's, there exists the tendency that most of the family members are adults. Therefore, it is thought that purchase price tends to be high because they need to buy a lot of food.

2) The results of the Conjoint Analysis

The customers tend to like the "Vegetable in season" more than the "Frozen food". This tendency is not depending on the segment of customers by the purchase price. In Japan, people look for safety in food as they grow older. The trial service is not directly related to the price, it is especially popular to housewives. The fact is useful to get new customers in Japanese market. Because the trial service depends on customers' selection, it is meaningful to investigate what kind of trial service is attractive to customers.

3) The differences of favorite service between excellent and bad customers

From the results of stratification in the Conjoint Analysis, the interesting result was obtained in free delivery service. Several types of the discount delivery charge service can be introduced in home delivery service. We evaluated two types of the free delivery charge services from the viewpoint of the difference of conditions when customers can receive the free delivery charge.

As for the discount service of delivery charge, favorite services are greatly different by the purchase price per order between the high (40's and 50's groups) and low (20's and 30's groups).

People with a high purchase price per order tend to like the delivery free service they can receive in the case of ordering items more than 5000yen. The customers with the low purchase price tend to like the delivery free service that anyone can receive for the initial 8 weeks. The bad customers tend to prefer only their profit in the viewpoint of price. The reason of this result can be considered as follows: Usually, the customers with low purchase price cannot receive the benefits of the delivery free service in the case of ordering more than 5000yen because their purchase price per order is under 5000yen. On the other hand, the excellent customer with a high purchase price per order can usually receive the free delivery charge. The advantage for the excellent customers and the disadvantage for the bad customers might be influenced by their choice. The bad customers tend to like the services that they can receive even if they make small orders.

Then it is necessary to provide the free delivery charge in the case of ordering over some amount of purchase price (for example 5000yen) to guarantee the excellent customers. By the introduction of the delivery charge free service that customers can receive when they order many items, we can have the delivery service which is attractive for the excellent customers but unattractive to the bad customers. If the business company can get only the excellent new customers, the average delivery amount per member increases and the efficiency of home delivery can be improved.

In addition, it has been shown that people with high purchase price per order tend to like the discount service of "5% OFF of the price ordered" more than "the point service which is increased by 20 times in the case of ordering more than 5000yen". This fact is also meaningful to work out a strategy to get the excellent customers.

4) The point customers attach importance

The service that greatly influences all categories of customers is a penalty item of "In case of ordering less than 1000yen, the catalog delivery is stopped" without relation to the unit price. Therefore, the advantages of home delivery services with high quality services may be canceled in the case of combining the penalty condition even if the service quality is so attractive. Though the penalty may be effective to remove the bad customers, it is thought that the excellent customers are also kept away. Therefore, if the penalty is considered as a strategy to stop the delivery for bad customers and improve the efficiency of distribution, its influence has to be examined closely carefully.

CONCLUSION

In this research, the relation between preferable delivery services and the purchase price per order is examined. Regarding the purchase price per order as the amount of materials, the possibility of increase of purchase price of new customers is studied. As a result, we clarified the delivery service the excellent customers like by analyzing from the marketing viewpoint. In COOPs, the initial (free service of delivery charge) – free delivery service is being introduced for the initial eight weeks for every new customer as a joining privilege. However, the result in this study suggests the need of a careful reexamination because it is also attractive to bad customers.

Moreover, it is effective to introduce the free delivery service (service of delivery charge) in the case of ordering over some amount of the purchase price. This service gives good customers the advantage. The service which is attractive to only excellent consumers with a high purchase price can be introduced from the result and consideration. Because the excellent customers also dislike the penalty as "in the case of ordering less than 1000yen, the catalog delivery is stopped", it is necessary to carefully examine the disadvantage of the penalty.

By considering the results based on the Conjoint Analysis, it is efficacious to show the effect of the reduction of the environmental load, i.e., CO₂ emissions, quantitatively with its price. Therefore, we have to identify the CO₂ emissions correctly. In this paper, this evaluation cannot be addressed. The future work is to present the calculation method of CO₂ emissions exhausted by all processes of logistics, show the impact of the customer's order unit price for CO₂ emissions by using this CO₂ model, and discuss the effectiveness of the strategy.

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INFORMATION MODELLING TO CALCULATE CO₂ EMISSIONS CAUSED BY DISTRIBUTION AND ITS ALLOCATIONS

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ABSTRACT

The purpose of this research is to consider the structure of information management system for environmental logistics to measure CO₂ emission caused by distribution activities with high accuracy. The conducted research technique develops information model consisting of "The information system to get the data of fuel consumptions" and "Radio Frequency Identification (RFID)-Tag information system". Basically, this paper proposes new concept which makes it possible to grasp the CO₂ emissions by each transported goods unit. This system contributes to show how amount is loaded by owner in their transportation activities. Finally we propose the new paradigm in which the customers can choice the goods based on the information not only its prices but its environmental loads per goods or owners.

Key words: Environmental Logistics, Environmental Activities, RFID, CO₂ Allocation, Fuel Consumption

INTRODUCTION

In recent years, it has been one of the most important problems to improve the efficiency of the truck transportation in logistics from the viewpoints of the environment and economics. Especially in Japan, the "Revision Law Concerning Rational Use of Energy" requests transportation and owner companies to make efforts to decrease Carbon-dioxide (CO₂) emissions in their logistics processes. To realize this direction, it is necessary to grasp the volume of CO₂ emissions caused by their delivery or transportation activities (Figure 1).

However, many of the transportation companies cannot increase their workload practically, because most of them are small or medium-sized companies in Japan. In addition, under the current situation of rising oil prices and demand for excessive services, it has been more difficult for them to make enough profit and to also make efforts to reduce the CO₂ emissions. It is necessary to construct a framework of CO₂ monitoring system which doesn't need unacceptable many efforts.

Therefore, this study aims to develop the information model of the system in order to collect the data automatically in daily activities, calculate the CO₂ emissions, and allocate the total emissions to owners of goods. The system proposed in this study consists of the following three sub systems:

- 1) "The information system" to collect the data of fuel consumptions of truck and driving status.
- 2) "The RFID-Tag information system" to get the data of loads transported by trucks.
- 3) "The calculation system and database" to unify all information and to allocate the total CO₂ emissions to owners or shippers of goods.

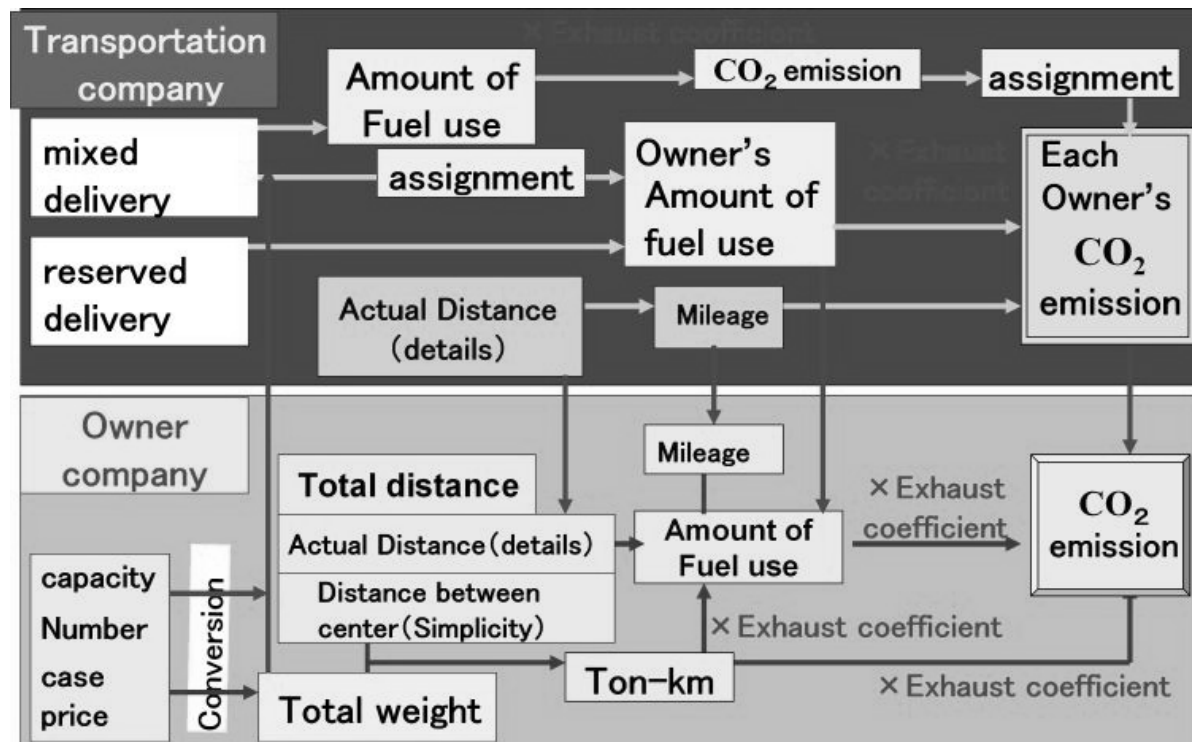


Figure1: Intelligence sharing between transportation company and owner company
(ref.1: "Manual for introducing the environmental logistics management system"p.29, JILS)

THREE SUB SYSTEMS

1) "The information system" to get the data of fuel consumptions of truck and driving status

In this research, the delivery route is divided into the some running sections defined as intervals between stopping and unloading points.

First of all, this system grasps the information such as the delivery route and fuel consumption of the truck for each section (Figure 2) in real-time and calculates the CO₂ emissions by using the advanced fuel gauge. For this system, we introduce the existing advanced fuel gauge named "TRU-SUM" (Figure 3) (*1) in this study. We develop and improve the TRU-SUM system to measure the fuel consumption in more details and in real-time. This system clearly distinguishes running-time and stop-time with a manual operation by a driver or deliverer (Figure 4). In the future, we are going to make the functions to the fuel gauge where the both times can be automatically distinguished and recorded.

*1: The TRU-SUM is one of the systems to calculate the fuel consumption of trucks what provided by Toward Logistics Ltd. This is "Run analysis software" made for administration, cost management and security management of distribution activities.

The travel information obtained in Table 1 is as follows: Truck Number, Time Stamp, and Fuel Consumptions. This system clarifies the data of fuel consumptions of truck and driving status which enables to acquire the necessary information to grasp CO₂ emissions by the owner.

Moreover, in the case of the route delivery, it is expected that the environmental impacts allocated to the owners change depending on the round route. Therefore, another

information processing should be considered for allocating the fuel consumption by each delivery methods and contracts.

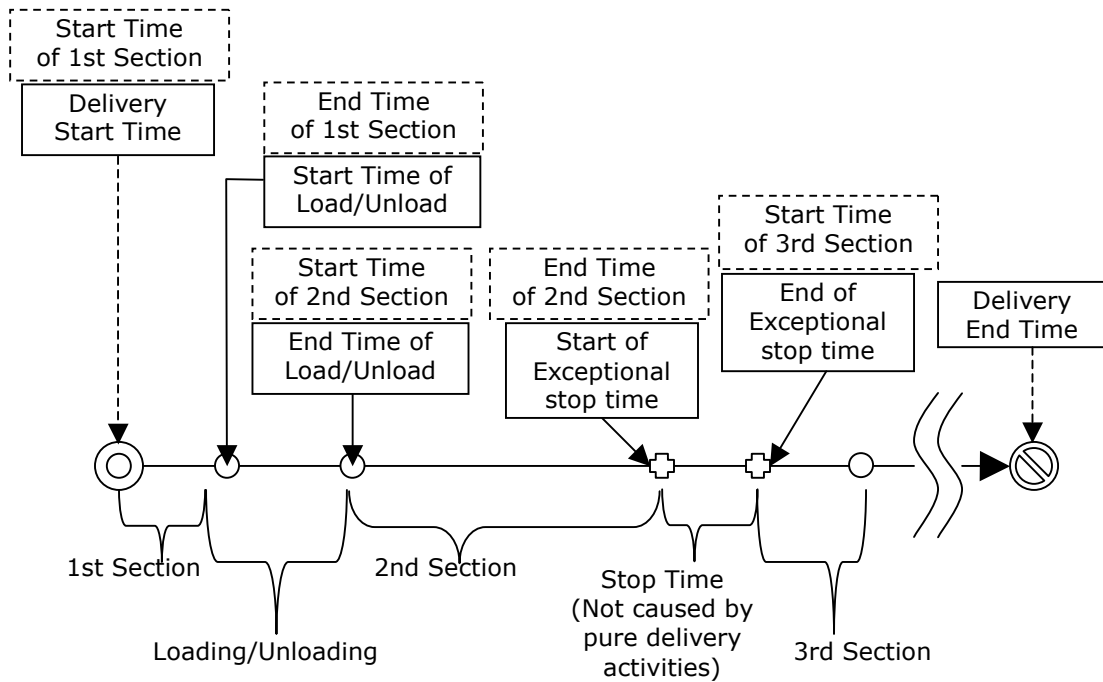


Figure 2 Timing to get the data of fuel consumptions of truck and driving status (Case: Direct sending)

Table 1: The list of information that we grasp first

Label	Explanation
Truck Number	Identification number of truck
Sequence No.	Sequence No. for calculation
Time Stamp	"yyyy/mm/dd hh:mm:ss"
Event No.	Classification number of each event (start/stop)
Latitude	Latitude (GPS) of loading/unloading point
Longitude	Longitude (GPS) of loading/unloading point
Deliverer ID	Deliverer (Driver)'s ID number
Mileage (km)	Accumulation Mileage delimited by event
Volume of Fuel Consumption	Accumulation fuel consumption delimited by event
Trip ID	ID number allocated each trip on delivery
Section ID	ID number allocated each section on trip

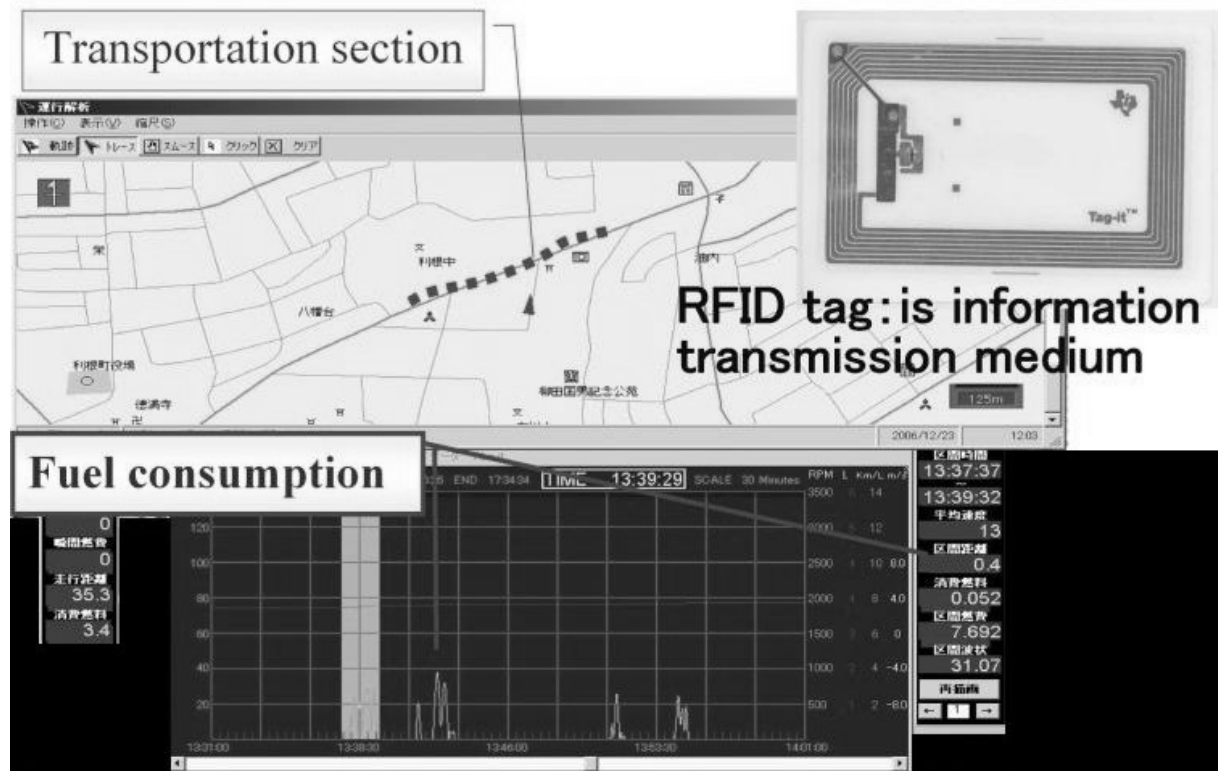


Figure3: Run analysis software (TRU-SAM)

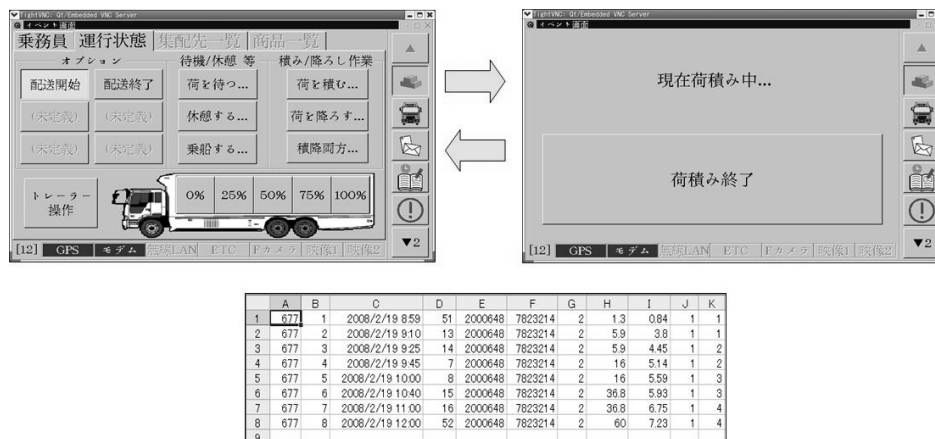


Figure 4: User Interface for Driver

2) "The RFID-Tag information system" to get the data of loads transported by trucks

This system grasps clearly the loading and unloading goods by using RFID-Tag system with IC-Tags and antenna. It works by sticking the RFID-Tag on goods, and setting up an antenna and reader/writer on the vehicle as shown in Figure 5. By reading the owner information and goods ID, each loading/unloading information is grasped in real time according to a timing of loading/unloading. We examine the two types of RFID systems of 950MHz and 2.45GHz belts. The appropriate frequency belt has to be chosen in consideration of the communication range, its accuracy and other characteristics. By the practical experiments, we'll propose how to choose the optimal frequency belt of the RFID-Tag system in the future.

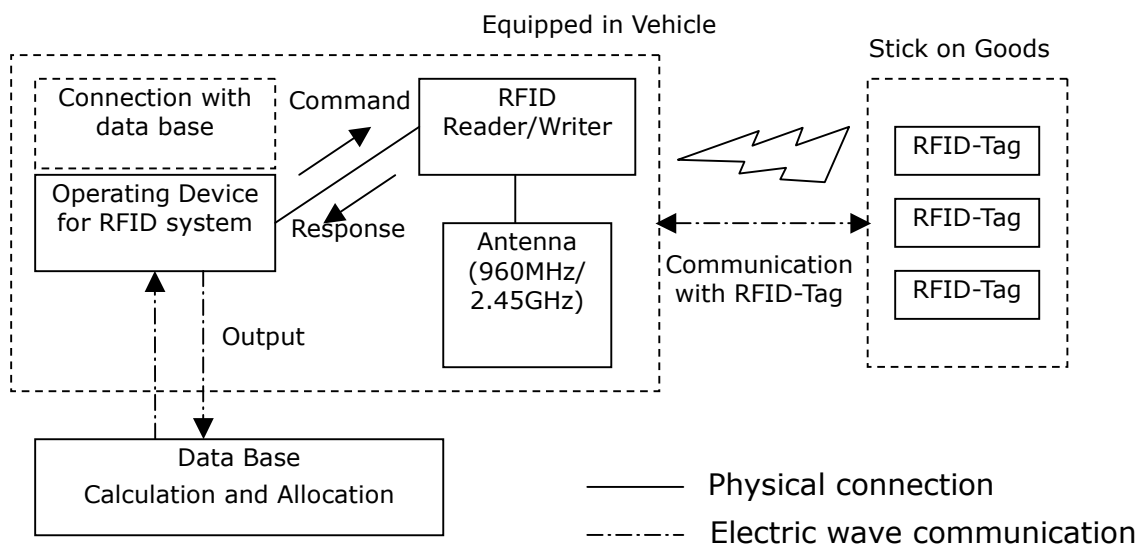


Figure 5: Communication between the data base and RFID-Tag

< Necessary equipment as for one vehicle in this system >

RFID-Tags (These memory size should be increased or decreased according to the volume of information data)

The RFID-Tags are stuck on the commodity or each box, and luggage information is recorded (Figure 6). It is necessary to select an appropriate tag based on the use conditions of a surrounding shield, the noise, etc.

RFID reader and writer: 1 unit

To send and receive the data with the antenna efficiently, we set the output format and frequency of the measurement.

RFID antenna (The number of antennas should be increased or decreased by the situation of operation)

This system is used to communicate with the RFID-Tag. Because there are several frequency bands of Tag-system, it is necessary to select the best one appropriately according to use conditions.

The equipment for operating this system (for vehicle)

In the experimentation phase, we use a laptop PC for operating and maintaining this system. However, another information system instead of the PC might be applied in

the future condition of the fixed antenna setting and large-scale operation.

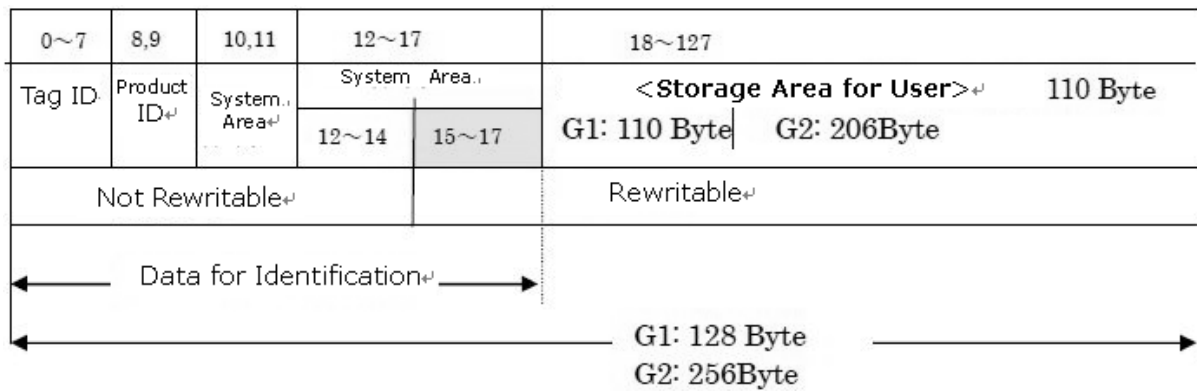


Figure 6: Storage Area in RFID-Tags

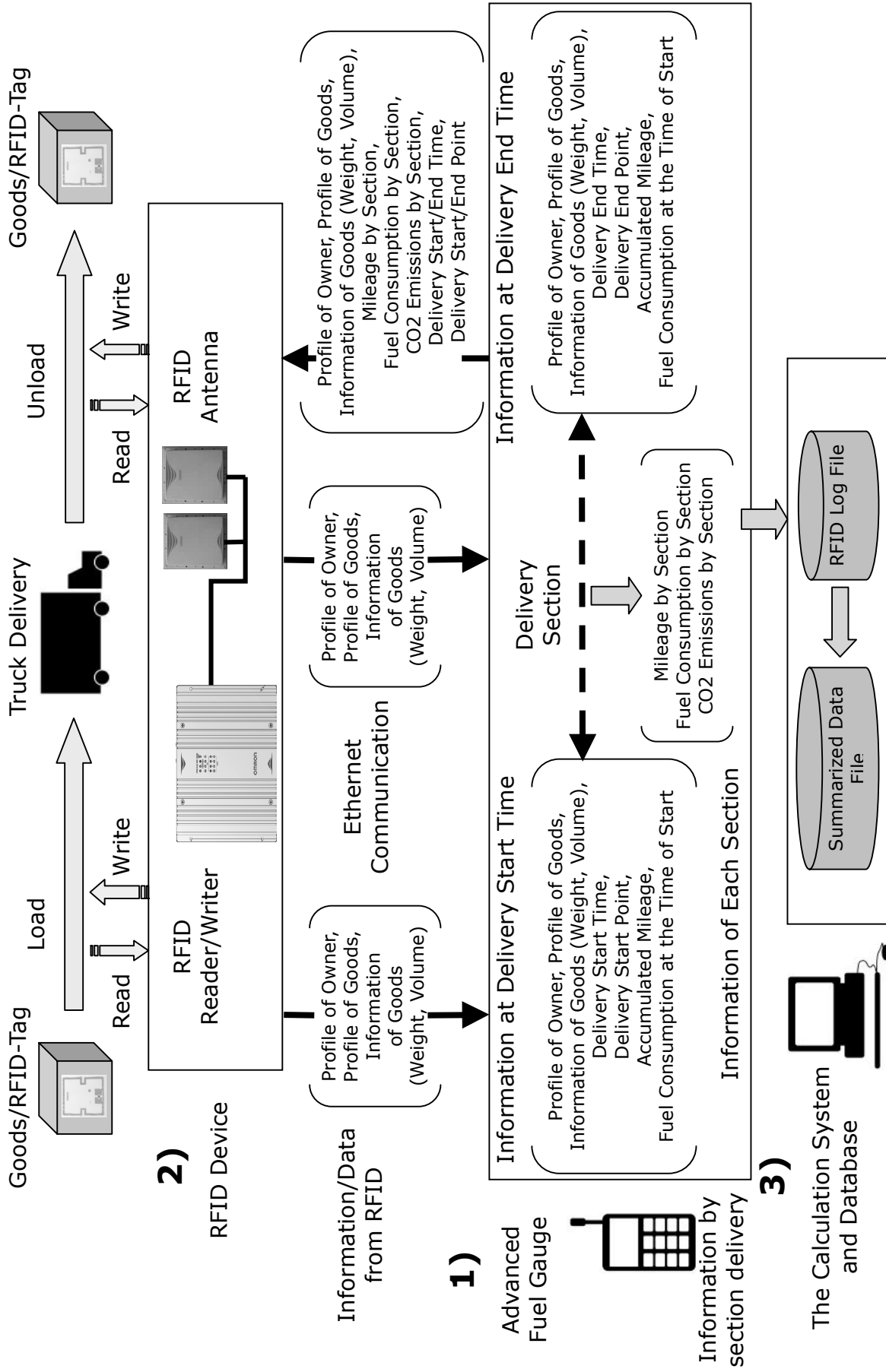


Figure 7: Whole image of this system

3) "The calculation system and database" to unify all information and to allocate CO₂ emissions to owners

Finally, the information from these two systems is integrated. By using the collected information on the database, we allocate the CO₂ emissions to each good by each transportation section in real-time as necessary. Figure 7 shows the whole image of this system. The information system to get the data of fuel consumptions of truck and driving status" and "The RFID-Tag information system to get the data of loads transported by trucks" are connected by the Ethernet communication.

Table 2 shows necessary data at the calculation phase. It means necessity to distinguish the time required for pure running time and other work, and to record in order to share CO₂ emissions to owners.

Table 2: The list of information that we acquire

Label		Explanation
Start Time of delivery		This data is recorded when the delivery starts
Trip ID		ID number allocated each trip of delivery
Start Time of each Section		This data is recorded when deliverer (driver) push the button
End Time of each Section		This data is recorded when deliverer (driver) push the button
Start Time of Loading/ Unloading	Start Time of Loading	This data is recorded when deliverer (driver) push the button
	Start Time of Unloading	
End Time of Loading/ Unloading	End Time of Loading	This data is recorded when deliverer (driver) push the button
	End Time of Unloading	
Start of Exceptional stop time	Start Time of Arrival Time Adjusting	This data is recorded when deliverer (driver) push the button
	Start Time of Rest or Other Action	
End of Exceptional stop time	End Time of Arrival Time Adjusting	This data is recorded when deliverer (driver) push the button
	End Time of Rest or Other Action	
Fuel Consumption Volume In the Section		Fuel consumption data from measuring by using "TRU-SUM"
Section ID		ID number allocated to each section on trip
Mileage in the Section		Mileage data in each section
End Time of Delivery		This data is recorded when the delivery finished

By constructing this system, it enables to grasp information on the amount of the CO₂ emissions and the luggage related to the delivery in real time and understands the amount of CO₂ emissions for each good individually. The ideal system is appropriately switchable to share CO₂ emission according to the difference delivery method such as the route delivery and direct sending.

The volume of CO₂ which is allocated per goods unit is useful information from the viewpoints of both management in transportation activities and marketing strategy by using the information to get the new customers. By using the data of CO₂ emissions for each goods unit, it enables for customers to choose their delivery method from the supplier, i.e., the route delivery and the direct sending by each goods, depending on its environmental loads.

CONCLUSIONS

We developed the information modeling that was able to understand the CO₂ emissions caused by distribution activities and its allocations in detail with using the fuel system and the IC tag system. It is shown that the amount of CO₂ emission that each luggage invented was able to be grasped individually by calculating CO₂ emissions in the delivery activities on real time.

This system makes it possible to get the information of CO₂ emissions and loading/unloading automatically, and to allocate its environmental load while the track is running in real time. Since the detailed CO₂ emission data according to delivery of the goods can be grasped, it becomes to be able to supply necessary information to shippers or owners.

By this concept proposed in this paper, the information of the CO₂ emissions by each transported good is available to purchasing decision when the customers buy the necessary good based on not only its price but the environmental load. This is the new paradigm in the near future society.

To spread this concept and these fundamental systems in practice, the cost factor of the equipment and operation should also be discussed.

It is a future subject to decrease the cost for equipment, to develop the method to gain the data of companies and goods, and to develop the allocation method of CO₂ emissions automatically according to its delivery method in real time.

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MEASURING CARBON FOOTPRINTS ACROSS THE SUPPLY CHAIN

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ABSTRACT

Understanding the importance of green supply chain in modern business environment, this research examines the heat flux and carbon wastages across the supply chain. The study has identified some of the heat and carbon influencing drivers as follows: (i) Mode of Transport, (ii) Inventory Policy, (iii) Network Structure, (iv) Trade Policy, (v) Consumer Density, (vi) Traffic Congestion, and (viii) Technology in Use. The research proposes a mathematical model to measure the carbon footprint across the supply chain by using Lagrangian Transport Method. For ease of visualization, "Heat Links" are developed and these links are normalized by a three-tier color coded temperature state. In short, the heat links are represented in three different forms as green (acceptable carbon emissions), amber (borderline carbon emissions) and red (non-green/ unacceptable carbon emissions) across supply chain network. Through our initial analysis, the research offers some operational and tactical strategies to mitigate the carbon emissions across the supply chain. The research is useful to policy makers as it can offer suggestions to areas pertaining to environmental economic tradeoffs.

Keywords: Carbon Footprint, Heat Link, Lagrangian Transport Model

INTRODUCTION

In modern supply chain networks there is a paradigm shift in the way they operate and look for enhancing the organizations productivity. Historically the global supply chain management concepts were focused on managing the upstream functionalities. Now the programs are moving from compliance to value creation. It's a stage where everybody presence in the supply chain and logistics are conscious about the carbon free supply chain. The concept of green supply chain covers every stage in manufacturing from the first³ to the last stage of life cycle. According to Srivastara (2007) the Green Supply Chain Management (GrSCM) has been defined as an integrated environment thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the product after its useful life. Green supply chain definition has ranged from green purchasing to integrated green closed loop supply chain. Hervani et al. (2005) says that GrSCM is a composition of green purchasing, green manufacturing, green distribution/marketing and reverse

logistics. We adapt this definition by incorporating green forward & reverse logistics, green consumption and green recycling and express this as;

$$\text{Green Supply Chain} = \left\{ \begin{array}{l} \text{Green Supply + Green Forward and Reverse Logistics+} \\ \text{Green Manufacturing + Green Packaging and Distribution +} \\ \text{Green Consumption + Green Recycling} \end{array} \right\} \quad (1)$$

It is generally perceived that GrSCM promotes efficiency and synergy among business partners and their lead corporations, and helps to enhance environmental performance, minimize waste and achieve cost savings. This synergy is expected to enhance the corporate image, competitive advantage, quality of the product and marketing exposure. On the other hand, the use of more environmentally sustainable products, production processes, management practices are often faced challenges within an organization because of the external pressure applied by customers to achieve the requirements of reduced cost, higher quality and faster delivery. There should be a trade off among the cost, quality, carbon emissions, service and international trade.

MOTIVATION FOR RESEARCH

Many progressive companies such as Canon, General Motor, and Sony, are realizing the importance of corporate social responsibility and are now focusing on the environmental burden of their logistics processes. GrSCM, begins with recognizing some of the contemporary environmental dimensions such as carbon emissions, demand on energy and other natural resources. To achieve this objective of GrSCM requires high level and detailed planning and steering of complete logistics chains on an end-to-end basis. Some of the current foci of environmentally acceptable and friendly supply chain objectives involve carbon control of assets and infrastructure, energy efficient usage of transporters, waste reduction through process optimization, and sustainable recycling. This is in addition to the traditional supply chain aims of cost reduction, inventory minimization, and network optimization. Indeed, controlling for carbon and measuring the complete carbon footprint across a supply chain is a challenge for organizations today. For instance, IBM has attempted to provide carbon heat map to illustrate the various degrees of carbon impact on a typical supply chain operations. However, there is a need to quantify and rigorously analyze the impact of the heat (carbon) yielding "devices" within a supply chain.

GrSCM has been given prime importance among researchers, business practitioners, corporate managers, supply chain designers. Literature in green GrSCM are growing in terms of number of publications per year from the past decades. Articles like Lamming and Hampson (1996), Beamen (1999), EPA (2000), Udel (2006), Hoffman, (2007), Parry et al. (2007) discuss the importance of green supply chain and its necessity. Zhang et al. (1997) and Srivastara (2007) reviewed extensively about green manufacturing and green supply chain in their articles respectively. They prove that there are numerous qualitative, interview and case study based papers existing in the literature that report GrSCM and their necessity for an organisation. There are very few articles that discuss quantitative model based green supply and manufacturing (Sheu et al.(2005), Simpson et al. (2007), Zhu and Zarkis (2007), Srivastara (2007) and Zhu et al. (2008)). Whereas carbon foot print measurement across the supply chain in a modern business environment has not been reported until now. This is

vital for modern business environment to understand its footprint, and therefore this research initiates the essence of a model based carbon footprint analysis and paid a roadmap on this. Discrimination

RESEARCH METHODOLOGY

Given this motivation, this paper seeks to map both the non-green and environmentally friendly supply chains and illustrate how the green supply chain framework and practice can affect the architecture of an existing supply chain. We employ the use of both industry survey to better appreciate the evolution of a green supply chain and an empirical approach to triangulate our results.

For the purpose of this paper, we shall seek to determine and examine the various "heat" transfer devices within the context of a supply chain. Specifically, we seek to measure the "heat link" across entities, stages and processes of the supply chain to highlight the intensity and downstream effects (if any) of carbon emissions across the entire supply chain network. In doing so, we can then understand the heat flux and carbon wastage at each node of the supply chain and from be able to calculate the total heat (and hence carbon) transferred from one stage of the supply chain to another. Through this approach, we can then decide what and where the areas of sensible heat flux and acceptable carbon emissions are. For this analysis, we consider a closed loop end to end supply chain having reconfigured entities as shown in Figure 1.

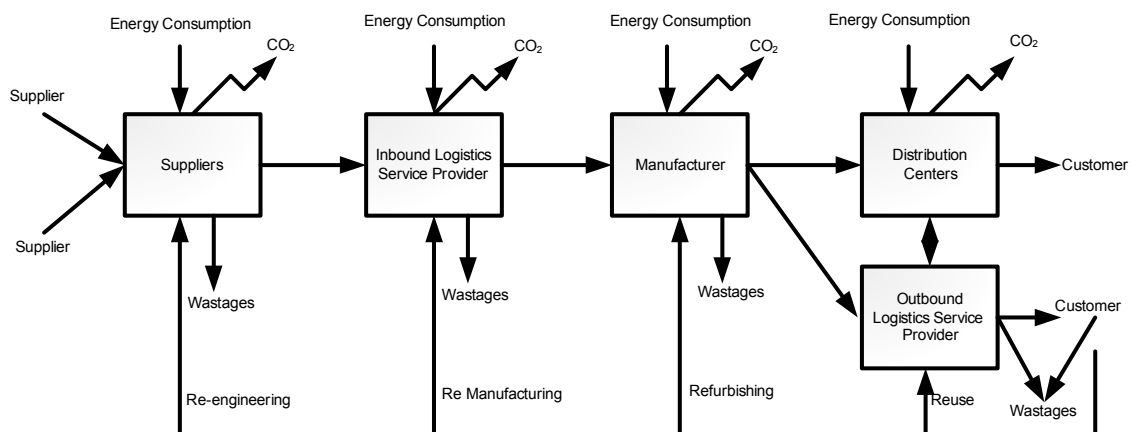


Figure 1. Re-configured closed loop supply chain

In a supply chain, the carbon emission exists from processing raw materials to dispatching finished goods. At supplier side, processing of ore/raw material and preparing the semi-finished parts emits hydrocarbons, oxides of sulfur (SO_x) and wastages in the form of gaseous and acidic compounds. At this stage, proper use of technologies and latest equipments could reduce the carbon foot print considerably. In logistics, the levels and type of carbon emissions depend upon: the mode of transportation and the distance travelled. Diesel engine vehicles such as heavy trucks emit gaseous components of carbon monoxide (CO), oxides of nitrogen (NO_x), Particulate Matter (PM) and volatile organic compounds (VOC) (Hui et al. (2007). At this stage, the total logistics emissions are calculated from emissions by various mode of transportation, total sea/air port link emissions and total warehouse emissions. Total carbon emissions of the manufacturing stage can be measured from direct and indirect emissions of different

manufacturing stages. Finally total carbon emissions at distribution and consumers side depend upon the type of package used, trade policy, consumer density, and the level of reuse. In general, the heat flux influencing drivers of a supply chain controls the emission from upstream to downstream in a supply chain. As the product enters in each node of the supply chain its heat flux gets increased due to various processes. This increase in intensity is depending upon the performance of the product and process drivers of supply chain as shown in Figure 2. Controlling this flux and carbon emission requires to monitor the entire supply chain and redesign this based on the approach.

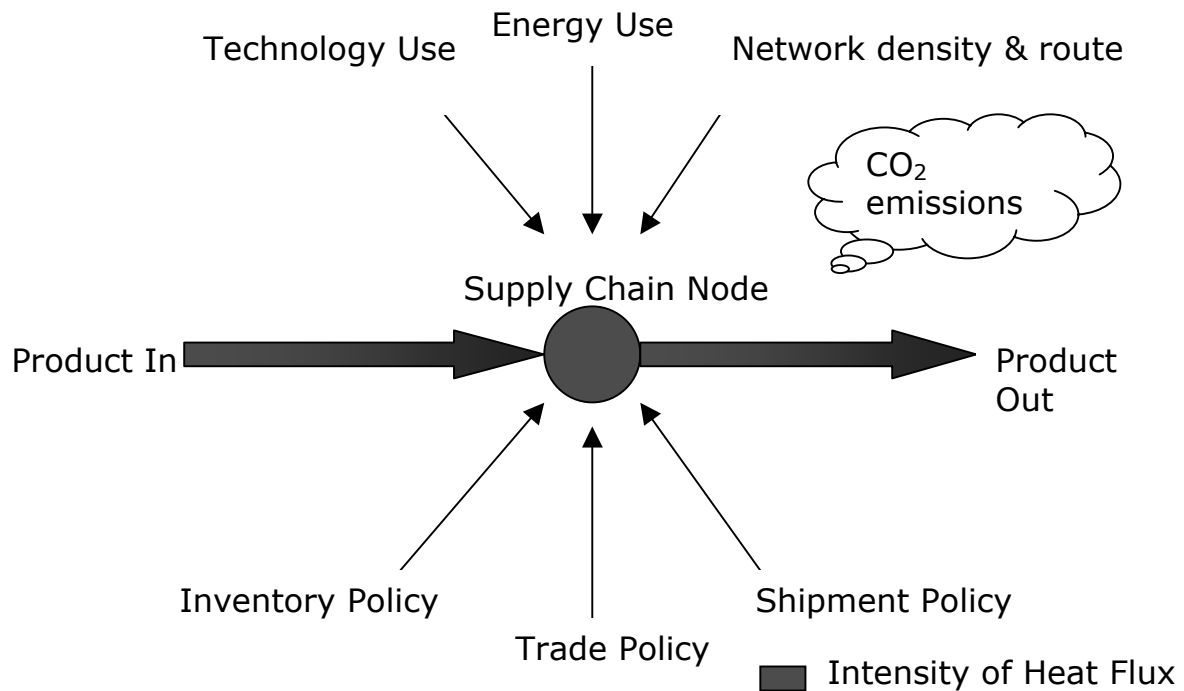


Figure 2 Driving forces of green supply chain

MODEL TO MEASURE THE EMISSIONS

In this research, we develop an analytical model based carbon footprint analysis to monitor the supply chain. By embedding the general footprint mathematical model into lagrangian transport model, hereby we propose a new methodology for carbon foot print measurement. Among the published papers Schuepp et al. (1990) and Hsieh et al. (2000) analytical expressions are popular and extensively been used for flux foot print analysis. Schuepp et al. (1990) expressed mathematical relations to measure the general flux footprint as:

$$f(x, z) = - \int_0^{x_i} \frac{U(z-d)}{u * kx^2} e^{\frac{U(z-d)}{ukx}} dx \quad (2)$$

Where,

- x is distance from the stations in m
- U is mean integrated wind speed in m/s
- z is measurement height in m
- u is friction velocity
- d is zero plan displacement in m
- k is von karman constant

We use lagrangian transport model to calculate the emissions because it has been used wide range of applications in water quality models, submarine outfalls, sediment erosion, oil dispersion and other pollution measures (Taylor (1989) & Lee (2000)). Nevertheless, application of this model in carbon footprint measurement has been reported and we feel it's an appropriate method of measurement because it takes both active and passive tracer in carbon footprint into account.

The lagrangian model expressed by Lee (2000) is of the form:

$$\frac{dc_i}{dt} = E_i + R_i(c_i) - \frac{v_{g_i}(c_j)}{h} - \Lambda_i c_i \quad (3)$$

Where,

- E_i is the emission rate of source in kg/s
- $R(c)$ is the rate of change of source
- v is dry deposition velocity in m/s
- Λ is coefficient of wet deposition displacement in s^{-1}

We have chosen to apply this model to our study as we felt these allows for sufficient explanation of species growth in open space and better match with carbon emission growth variable in open space domain. Therefore, the modified model is of the form:

$$\frac{dc_x}{dt} = E + R(c) - \frac{v^*c}{z} - \Lambda c \quad (4)$$

Where,

- E is the emission rate in kg/s
- $R(c)$ is the rate of change of footprint
- v is dry deposition velocity in m/s
- Λ is coefficient of carbon deposition in s^{-1}

The factor "emission rate" is calculated from the total heat emission of all sources. Total heat emissions consist of heat energy liberated due to carbon dioxide, methane, hydrofluorocarbons, nitrogen dioxide, perfluorocarbons, sulfur hexafluoride. Each node and linkage emits these carbon gases at different intensity (Figure 3). Total heat flux induced in a particular node is expressed as:

$$\text{Total heat flux (q)} = \{CO_2 + CH_4 + HFC_s + N_2O + PFC_s + SF_6\} \quad (5)$$

The total carbon footprints across a supply chain can be measured by using the equations 2, 4 and equation 5. The model can be verified by applying in a supply chain network.

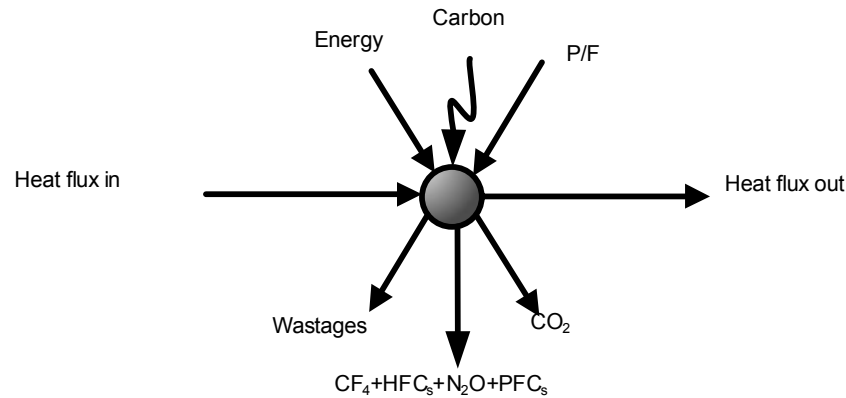


Figure 3. Heat flux through a node

Visualization of Carbon Footprint in a Network

The carbon footprint amount can be visualized from the network diagram with three different color codes (green, amber and red). Color code green depicts acceptable carbon emissions, amber warns for borderline carbon emission and red shows unacceptable carbon emissions. Herewith we show an example of APAC network having three-color codes (Figure 4).

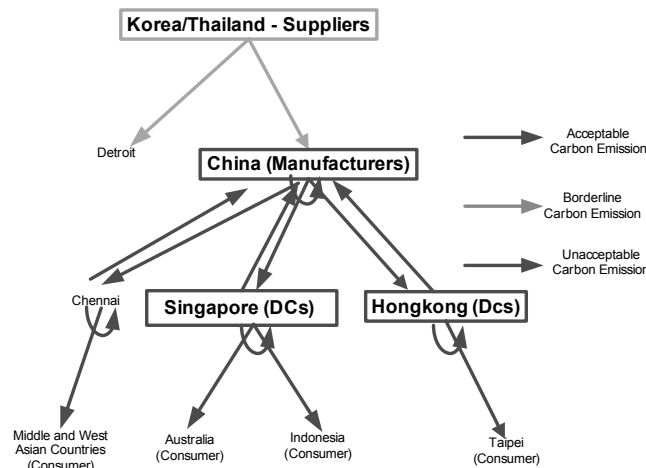


Figure 4. Supply chain network showing carbon emissions

In the upstream part of the supply chain, the environmental impacts are moderate (bound with ore processing and or cleaning). In stage 2, both manufacturing and transportation processes consume energies such as oil, acids, amino-carbons, and electricity, and thus generate significant carbon emissions. At this stage of reverse auto supply chain, the moving returned products back to the distribution centers or manufacturers reduces the waste and is environmental friendly in general though the transportation of used cars back to the manufacturer generates more carbon emissions. At the downstream side of the supply chain, the amount of carbon emissions is less when compared to the whole supply chain network. Moreover they are strictly controlled by environmental regulatory pressures and emission standards.

STRATEGIES TO MITIGATE THE CARBON EMISSIONS

From the initial analysis, the research offers the following operational and tactical strategies to mitigate the carbon emissions across the supply chain:

- Having innovation at design level
- Proper supplier selection drastically reduces the emission
- Having green supply and purchasing policies
- Keeping environmental regulations on transshipment
- Acceptable carbon regulation at manufacturing level
- Leveraging green innovation at logistics services
- Reducing inventory and increasing visibility at distribution level
- Having green packaging and distribution strategies
- Having reduce, reuse, recycle policy at consumption stage and by
- Creating awareness among consumers against carbon

CONCLUSIONS

Corporate social responsibility brought a new structure in the way that company operates and plans their supply chain structure. Modern supply chain objectives have changed from cost reduction, network optimization, profit maximization to carbon emissions reduction, service level improvements, risk mitigation and value creation. This requires a strategic framework for international organizations to work across the supply chain in a more pragmatic way. This paper is an early attempt in mitigating the carbon emissions across the supply chain. The initial framework, model development, analysis and strategies help managers to redesigning the network. This research can be extended in a global scale taking the cost of carbon emissions into account. It can also be extended considering the various organizational pressures in the model at each stage of the supply chain.

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RAIL TRANSPORT FOR ENVIRONMENTALLY SUSTAINABLE AND EFFICIENT QUALITY SUPPLY OF FISH

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ABSTRACT

A discussion is provided regarding seafood export from Norway, transport hubs, and environmental challenges to Norwegian fish export. The purpose is to exhibit a discussion leading to a preliminary research framework and creating research issues.

INTRODUCTION AND PURPOSE

In an increasingly global context logistical goods transforming activities structure and processes are becoming more complex. In Norway, fish raw material is now transported to China to be transformed into packed consumer goods that are re-exported to a global market including Norwegian end users. In this picture transport becomes an increasingly important logistical activity. However, this mode of transport meets constraints from increasing environmental concerns related predominately to global warming. In addition, marketing constraints related to exporting seafood products on this globalising marketplace is becoming ever-more strong. Focus is here directed to a specific logistics resource, a transport hub in Norway with potential for use to export fish products. This involves use of rail transport to export markets. A discussion of a specific transport hub at Narvik in Norway, seafood export, and environmental concerns are discussed. This is followed by a brief discussion of the interrelatedness of these components and thereby proposing research issues linked to an upcoming project.

THE NARVIK TRANSPORT HUB

Focus is directed to a specific transport hub in Narvik, located in Northern Norway. Here a rail-line from extending from the Swedish rail network is extended a few kilometres across the Norwegian border, from Kiruna, in order to reach the seaport of Narvik. This is a transport hub where seafood products carried on truck or by sea potentially may be reloaded onto trains for export. At present most seafood is exported through other means of transport.

Notteboom (2000) defines a seaport as follows: "A seaport is a logistic and industrial centre of an outspokenly maritime nature that plays an active role in the global transport system and that is characterized by a spatial and functional clustering of activities that are directly and indirectly involved in 'seamless' transportation and information processes in production chains." From this definition, one could argue that the sea port and its cluster (port authority, port undertakings, i.e. terminal operators, cargo handlers, logistics forwarders, towage services, ship owners, ship operators, customs, bank services..., etc.) constitute a transport hub or freight village with some main characteristics: intermodal interfaces, ICT infrastructure, good port infrastructure and superstructure (e.g. quay cranes) and good coordination among all the logistics actors. As competition is unfolding between logistics chains and not between individual ports (Meersman et al. 2002), these actors strive to provide for an integrated logistic service (one-stop on-spot service) where the total cost is the main key performance (seamless door-to-door solutions).

Because of its ice free condition, the port of Narvik was chosen by the Swedish iron ore company LKAB as a transshipment port for Kiruna's iron ore. Today, the port of Narvik is the largest dry-bulk transit harbour with approximately 16 million tonnes annually and it has the only container crane in Northern Norway. Narvik is an intersection with roads leading to both north-south and east-west while the railway runs along the quay connecting the harbour with Central Europe, Southern Scandinavia, Russia and Asia. Its intermodal terminal combines rail, sea, and road transports "on-spot". In addition, Evenes Airport, located at ca.75 km far from Narvik can be used for freight movement, for instance, the export of salmon to Japan. There are three certified terminals in the Public Port of Narvik in addition to the private terminal owned by LKAB. When it comes to the container park, it can stack 1,100 TEU¹ currently. All these competitive advantages prompt Narvik Harbour as the most prominent sea port with the biggest development potential in Northern Norway. Therefore, Narvik harbour can be thought of as the transport hub of the region.

Due to freight imbalance and dominance of "North – South" transport up to 1983, *ARE I*², a containerised rail cargo express between Narvik and Oslo, saw the light as a remedy to the situation. Later on, the express cargo *ARE II* came to further strengthen and link Narvik to the European Continent through Padborg (Denmark). Currently, *ARE III*, another containerised rail cargo, is under development in order to connect Narvik to Russia and China. This is a part of the vital project, called the N.E.W.³ corridor, which brought all the supply chain actors and governmental institutions together to make it true and aiming at connecting the East and West through Narvik. In 2008, a first train will connect Narvik to Russia and China.

SEAFOOD EXPORT

Seafood export is Norway's main export industry following the petroleum industry. This importance is founded on natural endowments. Given a population

¹ TEU: Twenty Feet Equivalent Unit considered as a standard unit-load container in the business; e.g., a 40 or 45 feet container is referred to as 2 TEU.

² Arctic Rail Express

³ N.E.W. Corridor: Northern East-West freight corridor that links China, Kazakhstan, Russia, Finland, Sweden and Norway to the East Coast of the United States first by train to Narvik port and then by ship.

of less than 5 million inhabitants, Norwegian produced seafood is mainly an export product. Norway was according to FAO (www.fao.org) statistics in 2004 the second largest fish exporter in the world, following China. In 2006, according to Norwegian government export statistics (www.godfisk.no), Norway exported fish for NOK 35,6 billion (approx. EUR 4,4 billion). Seafood production and distribution is heterogeneous in that many different types of seafood that are distributed, and seafood encompasses different species requiring product classification. Norwegian seafood products based on 2006 export statistics (www.godfisk.no) include trout and salmon (52% export share), groundfish (e.g. cod, halibut with 28% export share), pelagic (e.g. mackerel, herring with 15% export share), and others (5% market share). The largest overall market for Norwegian seafood export is the EU group of countries having 64% export share in 2006 (www.godfisk.no). Also, upcoming markets such as the Asian market, with a 12% export share (www.godfisk.no) in 2006, are rapidly growing. Another feature of Norwegian seafood export is that fish raw-material is sourced from wild ("traditional") catch, about 48%, and aquaculture farming, about 52% (2006 figures, www.godfisk.no). The aquaculture industry supplies mainly trout and salmon. This dichotomy in seafood raw-material supply provides two distinct types of seafood supply chains. Wild catch is regulated in accordance with annual negotiations based on estimates of changes in the wild fish stock, is seasonal, and subject to changes in weather. All this provides a higher degree of uncertainty regarding supply volume. Aquaculture resembles more meat production. As in this industry there are risks in supply volume, e.g. if fish become contaminated due to pollution or disease.

Most seafood export products are, from a Norwegian perspective as raw-material supplier, perceived as commodities. The degree of processing of fish raw material in Norway is usually held at a minimum due to high costs of production. A considerable amount of seafood products are sold fresh; the limitation of materials transformation then representing a product quality feature. Norwegian seafood as raw material is in export markets used in the production of a wide range of processed food products adapted to national tastes. In Norwegian supermarkets it is now common to purchase branded processed frozen fish products made from Norwegian raw material that have undergone processing at Chinese fish factories. The seafood supply network is accordingly a complex distribution system. Seafood export is constrained by quality and safety requirements regarding societal concerns, and sustainable fishing/aquaculture from a natural environment perspective. Seafood products are increasingly subject to traceability requirements. Tracking increases in importance as transport distance increases.

ENVIRONMENTAL CHALLENGES

The environmental challenges accompanied by world economical growth are receiving exponentially increasing attention as the climate change at global base has reached the hill. When Al Gore and IPCC receiving 2007 Nobel Peace Prize which tributes their decades-long fight-off for arousing environmental consciousness and climate improving activities, the message to the world is made clear – the battle against environmental degradation and climate changes has to become first priority in global society.

The level of mobility of people and goods is a crucial indicator of economy growth and social welfare. However, the environmental consequence of transport is considerably critical. Large amount of green house gases (GHG), dust in suspension, waste water and noise stem from water-borne, road or air transportation. Transport at present is already one of the most polluted industries in the world. And its activities are increasing. due to the According to European Environment Agency (2008), intra-EU-25 freight transport has grown by 31% between 1995-2005. As consequence, GHG emission from transport increased by more than 27% in the same period. This macro-trend in rapid growth of total freight transport clearly states the need for increasing portion of environmentally friendly transport in continental and intercontinental business.

As one of the largest fish producers, Norway has exported nearly 1,3 mill tons fish with Norwegian and foreign carriers to over 30 countries in the world in 2007. This represents an increasing of 13.3% from 2006 (Table 1). Denmark, Russia, England, Portugal, and Poland, which are all European countries, serve as five largest import countries of Norwegian fish. The transportation modes applied are dominated by lorries and ships. For those Asian import countries, i.e., Japan and China, a mixture of ship and aircraft is used.

Table 1 Norwegian fish export (ton) according to transport modes (source: Statistics Norway)

Transport quantity	2006	2007
Ships, foreign	212880	267332
Ships, Norwegian	765918	871443
Railway on ships	6	:
Lorry on ships	107779	115598
Trailer on ships	1122	1139
Railway	391	13
Lorry/trailer on railway	:	103
Lorry	512235	601587
Aircraft	45199	57054

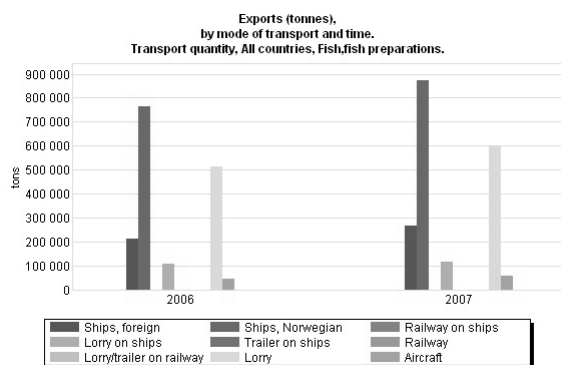


Figure 1 Norwegian fish export 2006-2007

The environmental consequence of this remarkable portion of utilizing lorry and aircraft (over 40%) in long-range fish transportation justifies the necessity of more environmentally sustainable multimodal transport. This includes prioritizing water-rail dominated solution as well as establishing new routes with better environmental performance.

CONCLUDING DISCUSSION

The Narvik transport hub represents the empirical object of investigation. This entity is primarily a complex organisational resource with predominately a logistical function; to manage the movement of goods between different modes of transport. This involves the use of a wide range of different logistics facilities and different logistics activities that must be coordinated to interact efficiently. At

Narvik, viewed as a transport hub, different modes of transport, rail, road, and air interact. Secondly, the Narvik transport hub may also be described as a cluster of logistics actors, some competing, others cooperating. Narvik is a location where specialised logistics actors to varying degrees interact in a supply network. Finally, a transport hub involves the use of a range of inter-coordinated value creating logistics activities in addition to transport; cross-docking, warehousing, terminals, storage, handling, and a range of information-providing services. A transport hub is accordingly a complex organisational and physical resource. This resource is viewed in relation to two factors impacting on the choice of research issues; seafood export from Norway and environmental concerns. In Narvik it is the product flow that is the prime value-creating entity. Integrating a focus on seafood export directs accordingly attention to product-related concerns such as sustaining sales. Seafood exporters need to achieve degrees of agility in order to match volatile market demands through using their business relationships in a more or less competitive market context. Environmental concerns represent both constraints and opportunities; raw material production and logistics activities may be inhibited by these concerns. However, an environmentally-friendly profile may also have positive impact on exporting Norwegian seafood products. An overall research issue is accordingly formulated as follows: "Narvik transport hub as an environmentally friendly mode of exporting Norwegian Seafood". This involves investigating the following sub-issues in interrelationship with each other:

- Transport hubs as complex logistical value creating entities
- Seafood export coordinated with fluctuating market demands
- Natural environment concerns with focus on seafood production and export.

This discussion is part of an emergent process exhibiting some preliminary perceptions and ideas regarding how to structure this research framework. It represents designing a forthcoming research project, moving from a research idea to a more precise research problem formulation. The next step will be to choose a research approach and carry out a literature study to develop and refine this framework.

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SECTION 10

DISTRIBUTION AND THIRD/FOURTH PARTY LOGISTICS

CAPACITY ISSUES IN THE NORTH EUROPEAN CONTAINER PORT SECTOR

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ABSTRACT

Container transport has become an important part of international logistics chains stimulating increasing integration of shipping with inland transport modes. The capacity of the world container fleet has significantly increased and in recent years the emergence of very large containerships has threatened to completely alter established container transport norms. Ports are operating in an environment where the projected demand for container port services continues to outstrip the projected supply, but they are also subject to significant constraints, which hinder their efforts to meet this demand. Thus, bottlenecks in the ports threaten smooth international logistics flows. Here, research is presented which examines the scope for expanding container port capacity by the use of improved handling strategies rather than by additional terminal construction. Significant increases in container yard capacity can be facilitated through a reduction in container dwell time. It is also shown that scope for improvement is also heavily dependent on the level of transshipment being undertaken at a given terminal.

INTRODUCTION

Currently over 70% of all general cargo is transported in containers and on some routes, particularly between developed economies, can be up to 100% (UNCTAD 2006, Muller 1995). Containerisation has both revolutionised quayside cargo handling speeds and enabled ports to better integrate with the main transport modes. Successful ports therefore are those that have maximised the opportunity offered by containerisation. Approximately 21% of all door-to-door container transport costs are attributable to the port (Stopford 2002) and the majority of these costs (approximately 70%) are incurred in the container terminal. Elsewhere, work by Hosley (1995) and Beresford et al (e.g. 2007), has shown the percentages to be very variable depending on overall supply chain length, cargo type and other factors. Whatever the structure of an international supply chain however, container terminal efficiency has a significant impact on the total transport cost and hence on the competitiveness of the chain.

PERFORMANCE METRICS FOR THE CONTAINER PORT SECTOR

A number of different metrics have been developed to measure the efficiency of container port operations. Further, performance measures for each subsystem within a terminal have been developed (World Bank 2001; Dowd and Leschine 1990). These measures are influenced by both hard and soft factors. Elements such as the physical layout of the terminal, the type and characteristics of the handling equipment, operator skill levels and overall management all have an impact on the performance of a container terminal.

Performance ranges for containers terminals in the main global importing and exporting regions show considerable variation (Table 1). In particular, Asian

ports out-perform both European and American ports and several reasons have been put forward for this. European and American ports tend to be city ports established long before the development of containerisation and modern hinterland transport systems. Asian ports, however, tend to be more recent and can take advantage of recent technology and know how in terms of terminal planning and operation (Chen 1998). This does not, however, fully explain regional differences and when performance metrics for deep-sea hub ports are compared (Table 2), Asian ports still out-perform European and American ports.

Measure	Europe	Asia	N. America
Crane moves per gross hour	18 – 25	22 – 30	18-20
Moves per ship working hour	45 – 70	55 – 150	40 – 65
Average cranes per vessel	2.5	4	3.5
Quay productivity Moves/metre	600 -800	750 -2000	500 – 750
Berth working index (%)	80-85	85-90	80-85
Terminal productivity TEUs/Ha	10 – 12,000	20 – 40,000	10 – 12,500
Truck turnaround time (hours)	1 – 3	0.5 – 1	1 – 2

Table 1. Regional Performance Metrics (after De Monie 2004)

	Pusan (1)	Maersk (2)	Maersk (3)	ECT (4)	Altenw'r (5)
Ann. Cap. (m TEU)	3.9	1.3	2.4	~3.2 est.	1.1
TEU/m year	1219	1007	1057	941	1290
TEU/Ha	18,600	10,800	12,200	13,600	20,000

(1). New Container Term'l; (2). Term'l 400 Los Angeles Phase 1; (3). Term'l 400 Los Angeles Phases 1 + 2; (4). Delta Term'l, (5). Term'l Hamburg Phase 1

Table 2. Performance of Selected Regional Deep-sea Container Hub Ports. (De Monie 2004)

These operational measures relate directly to the capacity of a container terminal. A major issue with this type of information, however, relates to the method of measurement (Cullinane 2003). Different terminal operators measure nominally the same performance metric but use different methodologies; as such, direct comparison is fraught with difficulties. Also, these performance measures do not provide an accurate assessment of the efficiency of a terminal. These measures are in effect output measures. They take no account of the input required to generate this level of output. Various techniques have been proposed to evaluate the true efficiency of container terminals. Analysis of a large sample of container terminals using these techniques has shown that the true level of regional differences between ports is smaller (Cullinane et al 2005).

CONTAINER DEMAND AND SUPPLY IN NORTHERN EUROPE

Global container trades have increased significantly in 20 years. Projections for future growth both globally and for Western and Northern Europe vary. In 2000 (Drewry 1999) it was forecast that global container handling volumes would reach 275m TEU by 2003 and 375m - 440m TEU by 2010. In reality, container volumes reached 320m TEU by 2003, 16% more than the most optimistic projection at the time. In 2003, revised estimates suggested that container handling globally would reach between 433m TEU and 470m TEU by 2010 (OSC 2003). More recent estimates put the figure closer to 560m TEU (Drewry 2006).

In Europe, it is estimated that the demand for container handling services will reach 99m TEU by 2010 of which 58m will be in Northern Europe. It is projected that annual demand for container services will grow at the rate of 9.1% globally and 7.8% in Northern Europe (Drewry 2007). The implication for the European container port sector is that there is likely to be substantial sustained growth for the foreseeable future.

As with the projections of the demand for port services, the estimates for the supply of container port services vary considerably. Global port capacity was projected to increase from 378m TEU p.a. in 2002 to 501m TEU p.a. by 2008 (Drewry 2003), representing an annual growth of 4.8%. It was anticipated when these projections were made that the annual growth in demand would be no more than 6.6%. Given this imbalance between supply and demand, it is hardly surprising that capacity utilisation has increased from 72 to 80%. It has been shown previously (Sisson and Ward 2001) that terminal capacity utilisation figures above 70-75% result in significant congestion issues. This rise in capacity utilisation implies that there will be major challenges for the global network of terminal operators in the near future. Recent projections indicate that global port capacity will increase from 550m TEU p.a. in 2006 to 672m TEU p.a. in 2011, an annual average growth of 4.4%. These forecasts suggest that, globally, by 2011, terminals will be operating at around 100% of their design capacity. Although estimates inevitably vary the statistics do imply that many of the major container ports of the world will be faced with serious capacity constraints in the near future; this has prompted operators to look seriously at making on-terminal efficiency gains to increase the capacity of existing facilities.

CONTAINER YARD MODELLING METHODOLOGY

A container terminal can be broken down into three separate subsystems: Quayside operations; Container Yard operations; and Gate operations. When considering the capacity of a container terminal it is the capacity of each of these subsystems, and the complex interactions between them, that will dictate the ultimate capacity of the entire system. Thus to fully evaluate the capacity of an entire terminal it is necessary to evaluate each of these three subsystems separately. As a first stage in this process this analysis is confined to a detailed evaluation of the container yard operations.

Container dwell time is defined as the total time import, export and transshipment containers remain in the container yard. It is proposed here that considerable gains in container yard capacity can be achieved through a reduction in average container dwell time. The specific aims of this research are therefore:

1. To assess the extent to which container dwell time is an issue for container terminals globally
2. To evaluate the impact of reductions in average container dwell time on the capacity of container yards in the Northern European range
3. To suggest strategies to reduce average container dwell time

A static deterministic approach is adopted to evaluate a number of predetermined scenarios based on available data. Static deterministic models of container yard capacity have taken two forms: demand-driven models and supply-driven models. Demand-driven models estimate the required container

yard dimensions and layout given a prescribed capacity requirement. Supply-driven models on the other hand evaluate the capacity of a container yard given prescribed dimensions and layout. For the purposes of this research, supply driven models were judged to be the more appropriate. A number of alternative formulae have been postulated (see, for example, Dharmalingam (1987) and Sisson and Ward (2001)). Each of these authors attribute different weightings to factors such as average container dwell time, the number of ground slots (TEU), container stacking height profile, dwell times, transshipment ratios and the balance of imports/exports. Although their approaches differ slightly, they are in fact almost identical with the numerators and denominators the same. The maximum annual capacity of a given container yard, calculated using their equations and taking mean values for the different factors, varies by approximately 1%. Previous work (e.g. Chen 1998) has shown that a high container yard utilisation has significant impact on the efficiency of all subsystems in a container terminal. It is therefore highly unlikely that 100% utilisation is sustainable.

Work by Sisson and Ward 2001 was felt to best fit the purposes of this research, with a slight modification to the mean container dwell time calculation. The following equation was therefore used to evaluate the impact of container dwell time on yard capacity:

$$C = (C_s * H_e * U * K) / (D * F) \quad 1.$$

Where:-

C is the annual capacity of the container yard (TEUs/Year)

C_s is the number of container ground slots (TEU)

H_e is effective container stacking height

U is equipment utilisation factor expressed as a fraction (0.8-0.9)

K is the total number of days in the period

D is the mean dwell time of the containers in the container yard

F is a peaking factor to allow for peaks in demand, normally 1.2.

D the mean dwell time is calculated using the following equation:-

$$D = (v * D_t) + [(1 - v) * D_{ei}] \quad 2.$$

Where:-

v is the transshipment ratio

D_t and D_{ei} are the mean dwell times for transhipped and the combined export and import boxes respectively.

Clearly these functions operate based on mean data input values. This approach will be valid when used for annual capacity analysis at a top level. As noted above however such an approach will hold true with a shorter the time interval. Ultimately however the objective of the research is to quantify, at a general level, the impact of the factors considered rather than provide absolute values for the individual terminals. Ideally, primary data, especially for critical data, is preferred. However, to obtain the data required for this paper through primary means would have involved prolonged and substantial site surveys. Indeed, with some of the key data, it is unlikely that even these techniques would be sufficient to secure the necessary data. Given these constraints, real data obtained from secondary sources, were seen as the best compromise. The required data for

this programme was supplied by one terminal operator and included details of the following key metrics: Mean Container Dwell time; Mean Crane Productivity; and Berth Utilisation (Table 2). In addition to this specific performance data, general information relating to layout and infrastructure of the individual terminals was obtained.

Terminal	Ground Slots (TEU)	Mean Dwell Time	Capacity. (TEU/Annum)
Terminal A	14000	6	2,313,008
Terminal B	10576	6	428,916
Terminal C	21504	5	3,500,107
Terminal D	9000	6	998,074
Terminal E	6075	8	656,358

Table 2. Input and Output Data for the Container Yard Deterministic Model

To assess the validity of the container yard deterministic model, the outputs were compared to data available in the literature for four of the five terminals under consideration. The measure in question, TEU per acre per annum, is a relatively crude measure as it does not account for container yard space allocated to non-container storage activities. It does however give some indication of the reliability of the model. The variance between the predicted values and actual values is minimal across all four terminals with a maximum variance of less than 1% as shown in Table 3. This, in conjunction with the published literature, provides sufficient confidence in the output of the container yard deterministic model.

Terminal	Terminal Area (Acres)	TEU/Acre/Ann. based on Yard capacity	TEU/Acre/Ann. based on literature	Variance
A	220	10514	9900	-0.74%
B	59	7270	9900	-0.74%
C	583	6004	6000	+0.1%
D	166	6012	6000	+0.2%
E	104	6311	NA	

Table 3. Validation of the Container Yard Deterministic Model Output

CONTAINER DWELL TIME AND YARD CAPACITY

The data in Table 4 shows the dwell time for all of the terminal operator's terminals. The mean container dwell time is just under 6 days with the figures for Asia, Middle East/Africa and Europe all being similar. It is only in the Americas where the mean dwell time is significantly higher. The output of the container yard deterministic model for Terminal A shows that a reduction in mean dwell time of 2 days results in an increase in the capacity of the container yard from 2.6m TEU pa to 3.5mTEU pa. The output for the other terminals under review show similar trends. A reduction in mean dwell time of 2 days in Terminal B increases the container yard capacity from 420k TEU pa to 640k TEU pa. For Terminal C and Terminal D the increases are from 3.5m TEU pa to 5.9m TEU pa and 1 m TEU pa to 1.5m TEU pa respectively. Finally there is a projected increase in container yard capacity from 690k TEU pa to 880k TEU pa for Terminal E.

Given the nature of the deterministic model, the capacity increases achieved through dwell time reduction will be concentric and the only difference between terminals as projected by the model is due to initial mean dwell time in the terminal. A reduction in mean container dwell time for Terminal E down to the current global average increases its yard capacity by approximately 50%. For Terminals A, B and D this increase equates to 15%. When the dwell time is reduced to the reported minimum global dwell time the increase in capacity is very significant. In Terminal E the increase in capacity will be approximately 250%, in Terminals A, B and D the capacity will increase by approximately 150% and in the Terminal C terminal the increase in yard capacity is calculated as approximately 100%.

Region	Container Dwell Time (days)
Global Mean	5.7
Global Maximum	34
Global Minimum	2
Asia Mean	5.1
Middle East and Africa Mean	5.3
Europe Mean	6
Americas Mean	10.2

Table 4. Global and Regional Container Dwell Time

STRATEGIES TO REDUCE MEAN CONTAINER DWELL TIME

The main strategy under consideration is the physical removal of containers from the yard after a given period of time has elapsed. The time periods that were considered are follows: 15 days, 14 days, 12 days, 10 days, 8 days, 6 days, 5 days, 4 days and 3 days. For each period calculations were undertaken assuming that containers with that level of dwell time or greater were removed from the container yard. The new mean dwell time was then calculated. It is then possible to calculate the number of containers removed from the yard and the impact this has on the mean dwell time.

Incorporating transshipment complicates the calculation. To reduce the mean container dwell time from 6 days to 3 days with a transshipment ratio of 20%, 1.3m TEUs pa will require removal from the container yard. If the transshipment ratio increases to 50%, 600k TEU pa need to be removed. This difference is due to the fact that the mean dwell time for transhipped containers is lower than the mean dwell time for all containers. With Terminal D, where it has been assumed that no transshipment takes place, 600k TEU pa need to be removed to reduce the mean dwell time by 2 days. The results demonstrate that with transshipment ratios greater than 40% and 50% the ratio of TEU removed from the container yard to capacity gained is always greater than 1. With a transshipment ratio of 30% the ratio of TEU removed to capacity gained is around one to one: this holds until a capacity increase of approximately 40% is attained. Beyond this, the ratio increases significantly. For transshipment ratios of 20% the capacity increase required is 60% and for no transshipment the capacity increase is 70%.

The data presented regarding mean container dwell time is very significant. Apart from a limited number of terminals in the Americas, the mean dwell time across all of the Terminal Operator's terminals range between 5 and 6 days.

Clearly, this level of container dwell time has become ingrained in the supply chain and is a global issue. Taken in conjunction with the transit time for the Far East/Europe or transpacific trade routes it may seem relatively unimportant, however it does represent significant levels of inventory sitting in container yards throughout the world. From a supply chain perspective, this adds waste and therefore cost to the supply chain. Shippers typically have three days to remove their containers once delivered. Given the global mean is approximately 5 days, a significant number of shippers are paying an average of 2 days demurrage to the terminal operators for these delays.

Alternatively, to facilitate a reduction in container dwell time is for the terminal operators themselves to set up remote facilities to remove containers from the terminal. It has been claimed that the costs of this are relatively small and that significant benefits can accrue from the reduction in marine terminal congestion (Cook 2002). It has been shown that the capacity of the 5 terminals under review here realise significant increases in capacity with reductions in container dwell time, although the level of increase differs between the terminals for a given dwell time. The data shows that a similar percentage reduction in dwell time will yield the same percentage increase in capacity. Significant increases in container yard capacity will be realised where the inland container terminal has a throughput of 1 to 1.5m TEU pa. Such a terminal would place considerable pressure on the transport infrastructure to and from the port.

CONCLUSIONS

This research was undertaken to investigate whether the capacity of the current container port facilities could be increased through alternative handling strategies which could reduce pressure on the gateway container terminals. Current estimates suggest that growth in north European container services will be met almost entirely through the construction of new facilities. It was therefore proposed to look again at existing infrastructure to ascertain whether their full capacity has been realised. The mean container dwell time is very similar throughout the world and clearly this is a global phenomenon. The implications for individual container terminal operators are clear. Current container dwell times are an institutional factor within the industry and as such the chances of an individual operator significantly altering the behaviour of shippers are small. Specifically, analysis here has demonstrated that significant increases in container yard capacity can be realised through the reduction in container dwell time. These increases in capacity frequently equated to several hundred percent. A strategy of removing containers that have remained on the terminal for a given period of time and transporting them inland for storage was proposed. It was found that to realise the capacity increases available in the container yard, the scale of this operation has to be significant. It was also found that this operation was heavily dependent on the level of transshipment being undertaken at the terminal.

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GLOBAL SUPPLY CHAINS OF THE CONTAINERISED FLOW OF GOODS THROUGH THE PORT OF KOPER: TODAY AND TOMORROW

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ABSTRACT

Globalisation is increasing the importance of ports, which are seen as vital intersections of the transport systems of individual countries and also of their wider environment. With ports playing strategically important roles in national economies, creation of new port capacities is being promoted world-wide. In the Mediterranean new ports and terminals are emerging and existing ports are creating new capacities with the purpose of enriching the range of services they have to offer.

The fact that the globalisation is on the way is highlighted by the figures currently achieved in the world-wide international trade, which reflect a significant growth in general and in the particular areas, such as the Mediterranean. The annual increase of container traffic in the Mediterranean is between 12 % and 18 %. The possibilities that already exist, and will be developed in the future within this scheme, can significantly influence the development of transport and logistical activities in Slovenia, and will in particular reflect in the progress and higher valorisation of the Port of Koper.

Slovenia is a European and also a Mediterranean country. Therefore, its developmental strategy is affected by the events and on-going processes in the European Union, Central and Eastern Europe as well as in the Mediterranean area. The adaptation to these developments and the vision (both on the level of the state and of the Port of Koper) will significantly influence the future development. To what extent Slovenia will exploit its good geographic transport position, whether it will be merely a transport corridor or will assume an additional quality, will depend on a cluster of circumstances. Importance will also be laid on how Slovenia will present itself and what it will offer to Europe and the rest of the world. One of its best assets is the Port of Koper in the frame of the whole logistical system. With its favourable location, the organisation and potential of the Port of Koper should form a basis for the formation of competitive advantages and strategies.

The year 2006 has been extremely successful one for the Port of Koper. On 5th December, the Container Terminal achieved a remarkable annual record – 200,000 TEUs for the first time. The relentless expansion of container freight continues and traffic through Koper has risen from 93,000 TEUs in 2001, thus volume has more than doubled in a mere five years. Container throughput prediction (Most Likely Scenario till 2015 - 214,000 TEUs) made by project entitled »Feasibility Study on the Development of a new Port Site, Port of Koper(Slovenia): Dutch – Slovenian Co-operation“(1996)¹ has been achieved already in 2006. The long term strategy anticipates an annual cargo through-flow of 18 million tonnes, increasing to 25 million tonnes by 2025; in effect: a steady

¹ carried out by Dutch companies, Frederic R. Harris BV, and Oranjewoud International and a Slovene company, Vodnogospodarski Inštitut from Ljubljana

and ongoing growth rate of forty percent per decade. Such expansion is predicated on an increase in container traffic, which is itself dependent on the development of a third pier. Until the construction of the third pier the existing first pier (container terminal) will be enlarged in five phases. This paper aims to present: (I) the current state and strategies of the development of the Port of Koper, (II) the enlargement of the existing pier and the construction of the new pier, (III) the market potential, the global supply chains, the scenario of the development of maritime transport, (IV) the conditions for improvement of the whole logistic chain.

INTRODUCTION

The global container transport increase amounts to about 8-10% on a yearly basis. Considering the number of orders for new container ships, the entire number of newly constructed container ships should increase by 27% by the year 2008.

According to BRS-Alphaliner (<http://www.infomare.it>) the number of ships over 7.500 TEU should rise dramatically - by up to 40% between 2005 and 2008. By the end of 2004 there were 49 ships of over 7.500 TEU in use, and within three years this figure should rise to 197. Similarly, there should be a substantial rise in the number of ships of between 5.000 and 7.499 TEU, which means that there should be as many as 378 such ships by the year 2008. Ships of over 7.500 TEU are to have a major influence on specialised container terminals because these terminals will need to adjust their infrastructure and reconstruct their suprastructure. What is noticeable is the obvious increase in orders of ships of over 7.500 TEU, which in turn means a larger margin for ship-owners sending their ships to transport containers on the main East-West, Asia-Europe, and Asia-North America routes.

Interestingly, the trend towards making big ships even bigger is also setting in, thus changing the very development of ports themselves. Ships' capacities are on the increase. Here we talk mostly of ships of 7.000 to 10.000 TEU. Ships planned before the year 2010 should already exceed 10.000 TEU. These are primarily the »Malacca max« type of ships of approximately 15.000 to 18.000 TEU.

Ships of these sizes are intended to transport goods between East and West as close to the Equator as possible. Eventual halts should be brought to a minimum - approximately 5 to 6 halts in the so called »mega hub« ports situated along the route from Los Angeles, Hong Kong, Singapore, and through the Suez canal into the Caribbean sea. It is expected that the present division between hub and feeder ports will be transformed into a division between mega hubs, regional hub, and feeder ports in the not so distant future.

The above-mentioned developments will have a significant effect on the situation in the Adriatic basin which by itself does not have sufficient maritime or market power (its hinterland isn't as vast as it should be) to be able to receive ships of the aforementioned proportions. Nevertheless, the market potential of the northern Adriatic Sea could support the existence of a regional hub port.

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. These effects are most visible in the activities of maritime, road and railway carriers, in freight forwarding, agencies, and in trade, catering, tourist, financial and other services.

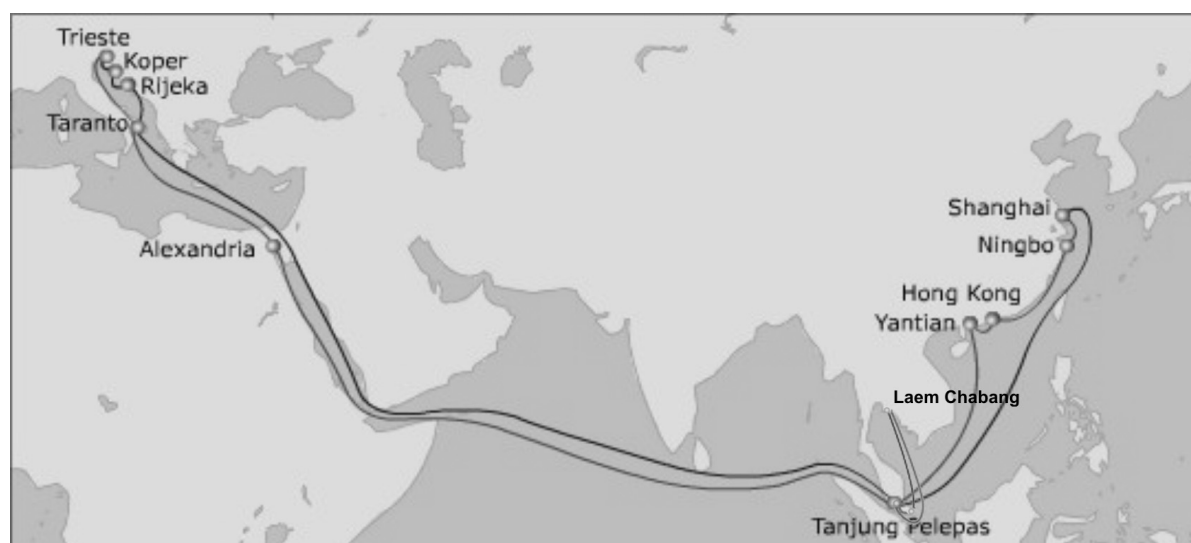
Per one unit of generated value in a direct port activity, eight additional value units are generated in the whole Slovenian economy.

The entire area of the Port of Koper including the development area extends over 1,600 hectares. The Koper port is designed for the handling of various types of goods such as general cargo (coffee, cacao, metals & non-metals, iron, paper, wooden products, fruits and light-perishable goods, etc.) livestock, containers, cars & Ro-Ro, timber, dry bulks, ores & coal, liquid cargo, alumina, cereals. The basic activities are performed by eleven specialised and highly efficient terminals, i.e.: Container and Ro-Ro Terminal, Car Terminal, General Cargo Terminal, Livestock Terminal, Fruit Terminal, Timber Terminal, Silo Terminal, Bulk Terminal, Alumina Terminal, Terminal for Soya, fertilizers and other bulk cargoes, Liquid cargoes Terminal, Multi-purpose Terminal. All terminals are located alongside the berths and are equipped with up-to-date loading, transport and storing technology. At each terminal special warehouse facilities are available: silo, shore-tanks, air-conditioned and deep- freezing storage areas. All of them are directly linked with railway. Exports and imports through the Port of Koper represent a minor share, whereas the traffic in transit has the major share: this proves that the Koper port has predominantly a transit character. Significant shares of traffic of the Koper port are with Austria and Hungary. 70% of land traffic is transported by railway and 30% by road.

Geo-transport position

Today, the countries of Central and Eastern Europe (CEE) have developed into a fast growing and promising part of Europe. The vision of the management of the Port of Koper is to become the most important logistic centre for these countries. In the future the North Adriatic region will have to cope with a further challenge, i.e. an increasing presence of the Asian Pacific economies on the European continent and in the CEE countries in particular. For the traffic flows from this source, the North Adriatic is from the geo-transport aspects the most convenient seaway/ route.

Figure 1: Global supply chains of the containerised flow of goods through the Port of Koper



The strategic goal of the Port of Koper is to become one of the best ports in the southern Europe, to develop from a handling port into a commodity distributional centre (in view of attracting also the economies of the Far East, such as India, Indonesia, Australia, Korea, Japan, China, Africa, America, etc., in addition to European ones).

Figure 2: Maritime connections of the Port of Koper

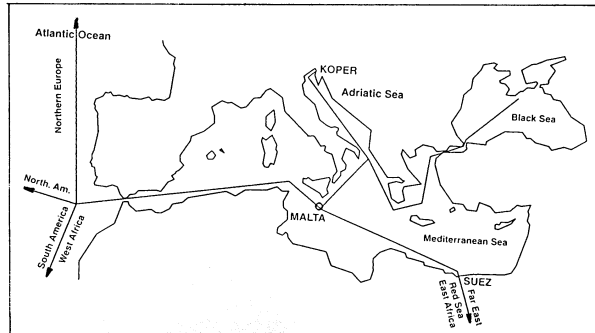
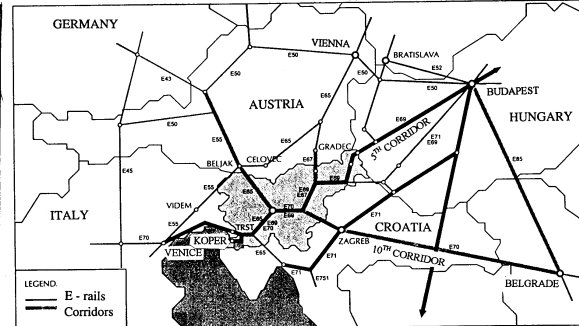


Figure 3: Main Paneuropean transport corridors important for Slovenia

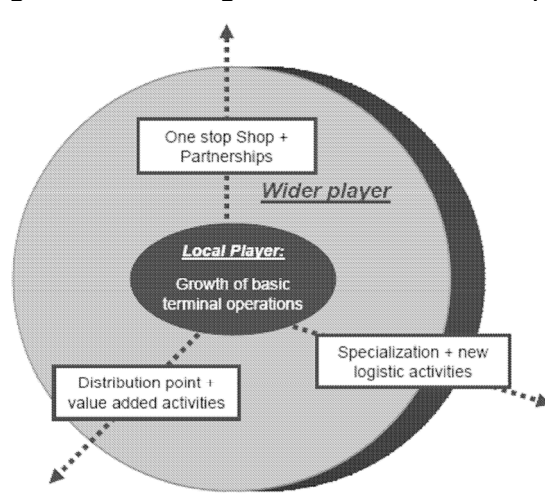


Today the Port of Koper performs most of its services for hinterland countries such as Austria, Hungary, the Czech Republic, Slovakia, Poland, southern Germany, Italy, Switzerland, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and also for Macedonia, Albania, Bulgaria, Ukraine and Russia. From Koper there are regular and reliable shipping container 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 than from North European ports. A larger volume of transport and consequently a better exploitation of the Port of Koper and the railway depend and will in the future depend on increased transit. The geo-transport position requires a more rapid construction of the highway and railway network, chiefly in the main transit connections through Slovenia – the 5th and 10th Paneuropean traffic corridor.

DEVELOPMENTAL POSIBILITIES OF THE CONTAINER TERMINAL

The strategy of the Port of Koper is based on the following basic directions:

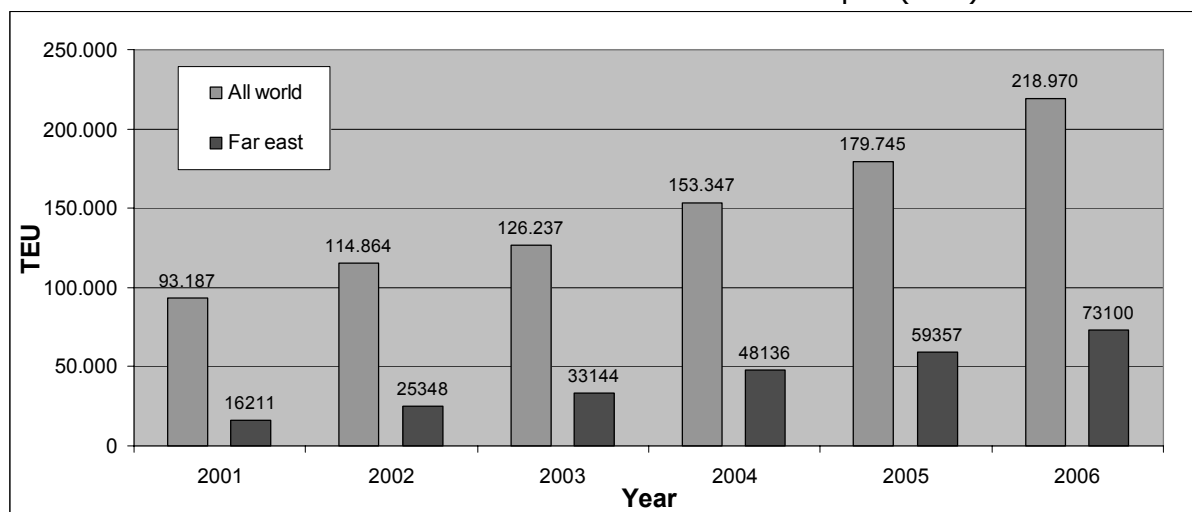
Figure 4: Strategies of the Port of Koper



- the universality of the range of port services offered on the highest quality level;
- the Port of Koper company ('Luka Koper') - a commodity distribution centre;
- an efficient information network and logistical connection with the world;
- stability and profitability of the operation in the long run.

The current container terminal has seen a 17% increase in container transport during the last four years, thus making it one of the more successful terminals globally. The global container transport increase amounts to about 8-10% on a yearly basis, whereas the Koper terminal has seen its traffic double in a mere four years. Recently there has been a dramatic increase in imports especially due to heavy development in China. The year 2006 was a pretentious year for business, especially due to the uncertain international economic situation and the events in the Middle and the Near East. Nevertheless the Port of Koper increased the quantity of handled cargo to the new record -14 million tons. Record was also reached in the container traffic with 218,970 TEUs.

Table 1: Container traffic in the Port of Koper (TEU)



The terminal services of the Port of Koper are currently used by over thirty ship-owners. The activities of the terminal management are increasingly directed into the improvement of feeder connections with so-called HUB ports like Gioia Tauro, Malta, Piraeus, and Haifa. Further goals are an improvement of land connections as well as the optimisation of the operative management of current and potential quantities of containers using information technology. The total potential of the Port of Koper's natural hinterland is estimated at approximately 1.500.000 TEU and even though the so called South transport route has some distinct advantages (the Mediterranean and Asian destinations) we should bear in mind the competitiveness of the Northern European ports. Their estimated influence reaches as far as Milan, Vienna, Graz, and Budapest. Beside the well-organised »block trains« the northern ports offer more intense and faster seaway connections reaching all destinations, especially those across the Atlantic. There is an increasing trend to shift quantities of goods away from the northern ports to the Mediterranean basin, the Middle East and Asian or Central European markets. Another characteristic is that all those ship-owners who have up to now been using

the services of the so called »common feeders« have reached or had the opportunity to reach the critical mass needed to establish their own dedicated feeder service and thus start their own service system. The third characteristic is the attempt by ship-owners to bind their seaway services to those situated on land, thus perfecting the arrivals or departures of trains and ships. This principle is already being used by Maersk (the train from Hungary).

Enlargement of the existing first pier and construction of the new third pier

The growth of container traffic in the Port of Koper as well as the beginning of construction on the new container terminal has made the reconstruction and extension of the current container terminal an absolute priority.

Table 2: Comparisons between port and authors research; real past data from 1996 and prognosis to 2025 in TEU's for pier I. and pier III.

Comparisom between port and authors (real past data from 1996) and prognosis to 2025								
		Year	13,179%	Average yearly growth	Port capacity	8,50%		
		2025	XXXX		XXXX	1.031.691		
		2024	XXXX		XXXX	950.867		
		2023	XXXX		XXXX	876.375		
		2022	XXXX		XXXX	807.719		
		2021	XXXX		XXXX	744.442		
		2020	XXXX		XXXX	686.121		
		2019	1.094.831		XXXX	632.370		
		2018	967.343	13,179	XXXX	582.829		
		2017	854.701	13,179	XXXX	537.170		
		2016	755.176	13,179	1.131.791	495.088		
PIER 3	Faze 2	+ 350 m	2015	667.239	13,179	1.000.000	456.302	= prognosis
			2014	589.543	13,179	905.433	420.555	= real data
			2013	520.894	13,179	800.000	387.608	
	Faze 1	700 m	2012	460.238	13,179	640.476	357.242	
		2011	406.646	13,179	565.896	329.256	= 4 crane (panamax) limit	
PIER 1	Faze 4	+ 140 m	2010	359.294	13,179	500.000	303.461	
	Faze 4	+ 160 m	2009	317.456	13,179	342.000	279.688	= +2 crane (post panamax) limit
	Faze 3	+ 500 m	2008	280.490	13,179	297.450	257.777	
	Faze 2	+ 150 m	2007	247.828	13,179	232.050	237.582	= port capacity limit
	Faze 1	+ 100 m	2006	218.970	13,179	218.970	218.970	
			2005	179.745	21,823	179.745	179.745	
		2004	153.347	17,215	153.347	153.347		
		2003	126.237	21,475	126.237	126.237		
		2002	114.864	9,901	114.864	114.864		
		2001	93.187	23,262	93.187	93.187		
		2000	86.679	7,508	86.679	86.679		
		1999	78.204	10,837	78.204	78.204		
		1998	72.826	7,385	72.826	72.826		
		1997	66.869	8,908	66.869	66.869		
		1996	64.622	3,477	64.622	64.622		
			Average:	13,179				

Source: Authors

The extension is in line with the estimated growth of traffic as well as with the exploitation of present and future terminal capacities. The existing first pier (container terminal) will be enlarged in five phases.

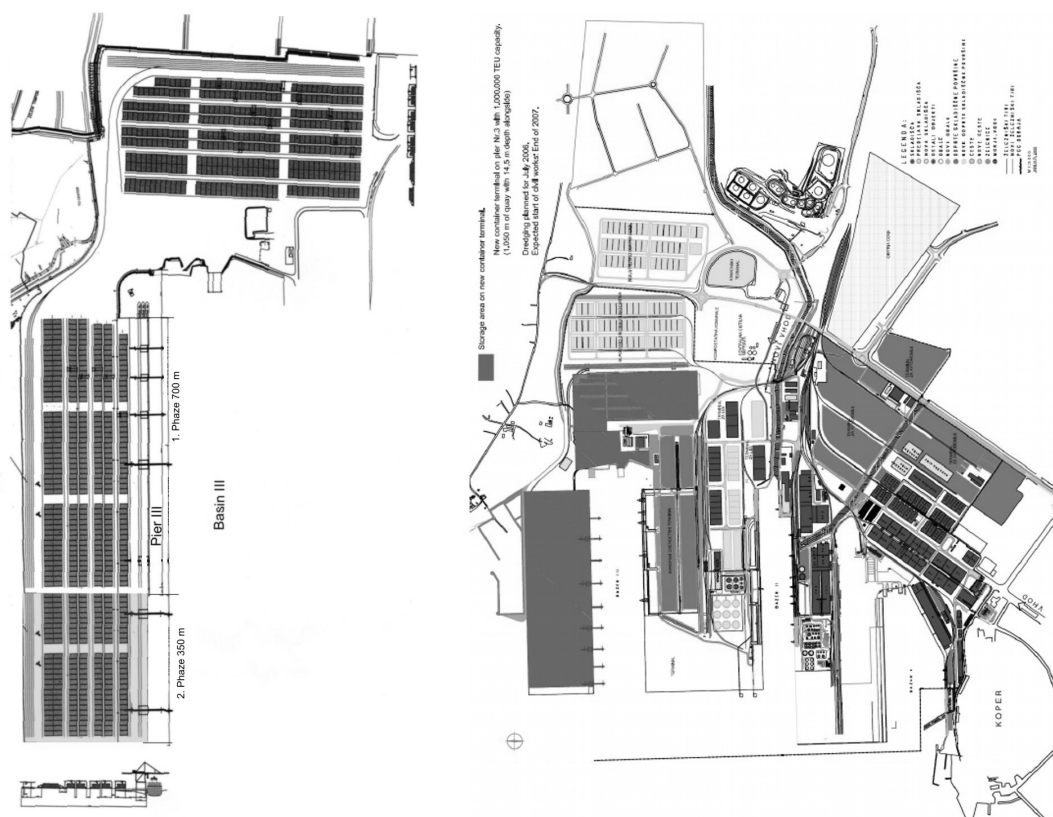
The construction of the third pier is planned to be carried out in two phases:

- By 2012/2013 700 m of the quay area in length enabling transshipment of 800,000 TEU.
- By 2015 additional 350 m in length (total 1050 m) enabling total transshipment of 1,000,000 TEU.

The third pier should be able to receive the latest container ships which are not presently able to dock on the pier one due to its shallowness. The present container terminal in the Port of Koper is capable of receiving ships of maximum 4.500 TEU. Six shore container cranes are to be in operation on shore, at least three of which are post-panamax. Purchasing new, faster and more capable shore

cranes will enable the Port to reach the necessary loading standards and at the same time shorten the time container ships stay in port.

Figure5: Simulation of the future Pier I. and Pier III



Source: Port of Koper and authors

Condition for improvement of the whole logistic chain

Today, the Port of Koper must direct its efforts more to the hinterland and to the foreland to initiate and organise various participants. Operational efficiency of the transport-logistics cycle is affecting, by all actors involved: linear companies port authorities, stevedores, forwarders, agents, as well as hinterland transportation modes. Moreover, there are some important developmental reserves as far as the effectiveness of railway transport is concerned. These should be brought about by the privatisation and by the restructuralisation of the sector itself, which can mostly be seen in the Central and Eastern European countries. For one thing, organising the so called »block trains« in the Adriatic basin is a strategy that hasn't been exploited to the fullest. In this respect the northern ports have the upper hand. In order for the Port of Koper to be able to load 400.000 TEU on a yearly basis the number of »blocks trains« should increase to approximately 45 per week and approximately 8 per day respectively. In the near future modernisation of the Koper-Divača railway connection will increase cargo flow by 30%. The construction of the second railway track has a net worth of 700 Million Euro and forms a part of the Fifth Corridor from Lyon to Kiev, which puts it on the priority list of projects co-funded by the European Union. The construction of the two track railway should be completed by 2015.

CONCLUSION

The feature of modern economic activity is a tougher competition, and transportation to all major geographic areas which presents a challenge to the whole transportation and logistics line of business. Therefore, ports will retain a relevant /special position within the transport chain. The service providing industries and Slovenia's role as an intermediary in linking the East to the West appear as a practicable opportunity. With the European Union growing eastwards and by the establishment of important production facilities in the countries of Central and Eastern Europe, the hinterland potential is bound to grow even more. It is therefore expected that once the two key conditions concerning the infrastructure are met (new pier and railway infrastructure), direct lines from the Far East could be drawn to the Port of Koper using ship mothers for the job. Thus the yearly growth of traffic in the Port of Koper could easily exceed 15%.

The container terminal which is located in the Port of Koper has only poor chances of development, and the best option is the construction of a new container terminal on pier III. The sea depth, the length of the shore as well as the loading machines would enable the pier to receive large container ships. Thus, all the necessary conditions would be met to make the Port of Koper the regional HUB port.

It is clear that good opportunities as: 1) political and market development in Europe (chiefly East European Countries), 2) development of infrastructure and connections to the important markets in the hinterland and foreland, 3) scenario of maritime transport as well as 4) supporting factors, stand for the predominant developmental impulse to the development of the Container terminal of the Port of Koper as the south-european gateway primarily for the countries of Eastern and Central Europe.

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SHOULD THE MAXIMUM LENGTH AND WEIGHT OF TRUCKS BE INCREASED? A REVIEW OF EUROPEAN RESEARCH

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ABSTRACT

This paper reviews recent research undertaken in Europe to assess the benefits and costs of a wider introduction of longer and heavier trucks. It presents an analytical framework for this assessment and examines the difficulties of quantifying three key variables: degree of load consolidation, freight modal shift and induced freight traffic growth.

INTRODUCTION

Over the past two years, several European governments and the European Commission have begun to review the case for increasing the maximum length and weight of trucks. This is proving to be one of the most controversial issues to arise in the freight transport field for many years. Various studies have been undertaken which arrive at differing conclusions on the relative economic and environmental costs and benefits of relaxing legal limits on truck capacity, while various interest groups have begun to campaign actively for or against longer and heavier vehicles (LHVs). The contradictory positions are well illustrated by the European Shippers Council (2007) and German Environment Ministry (Umwelt Bundes Amt, 2007). The former argues that LHVs will *'reduce fuel consumption and pollution, lower transport costs, contribute towards an increase in the available capacity utilisation of the primary road network, reduce the number of lorry trips per annum, and increase the competitiveness and sustainability of EU industry'*. The latter asserts that *'megatrucks do not contribute towards sustainable development of freight transport. Their use relieves neither the environment nor road infrastructure'*.

This paper does not attempt to resolve this current debate. Instead it reviews the problems that researchers have experienced in trying to assess the net benefits / costs of allowing LHVs to operate on European roads and explains why some of the conflicting results have emerged.

A BRIEF HISTORY OF LHVS IN EUROPE

For the purposes of this paper, LHVs are defined as trucks longer than those currently permitted for cross-border haulage in the EU, i.e. 16.5 metres for semi-trailer articulated vehicles and 18.75 metres for draw-bar trailer combinations. The weight threshold can either be 40 tonnes for cross-border operations or 44 tonnes in some EU countries such as the UK and Belgium.

LHVs have been operating in Sweden and Finland for over 20 years¹. At the time of these countries' accession to the EU in 1996, special provision had to be made to allow them to continue to operate these vehicles which were much bigger and heavier than those permitted elsewhere in Europe. An EU Directive (96/53) was approved which granted all EU member states the right to operate longer

¹ Sweden permitted 24 metre trucks in 1968 and allowed them to run at weights up to 51.4 tonnes from 1974

vehicles so long as they conformed to the standard modular dimensions in existence at that time. This has since become known as the European Modular System (EMS). The main objectives of the directive were to avoid a proliferation of vehicle dimensions and promote the harmonisation of modules than could be transferred between modes. Although the 96/53 Directive allowed member states other than Sweden and Finland to legalise LHVs for use within their national borders, no country did so until recently.

Outside Scandinavia, the demand from hauliers and shippers for LHVs has arguably been greatest in the Netherlands. The Dutch government has responded by permitting two trials of LHVs, between 1999 and 2003 and 2004 and 2006. The results of the more recent trial were considered sufficiently positive to justify the general legalisation of LHVs in the Netherlands up to 25.25 metres long with maximum gross weights of 50 tonnes from 2008. Following a more limited trial in several Germany lander between 2006 and 2007, the federal government rejected the case for allowing LHVs to operate on German roads, ostensibly on safety grounds, though it is reckoned that this decision was also strongly influenced by plans to privatise half the country's rail system. A limited trial of LHVs began recently in Denmark. In the UK, a desk-based study has been commissioned by the government to assess the economic, environmental, safety and infrastructural effects of allowing various types of LHVs to operate on British roads². This British research has reviewed a much broader range of LHV options than considered in previous studies, extending from a slightly longer semi-trailer with gross weight of 44 tonnes to a road-train configuration 34 metres long with maximum gross weight of 82 tonnes. In response to the growth of interest in LHVs at the national level, the European Commission is also funding a study of LHVs. This is examining four scenarios relating to possible modifications to the 96/53 Directive.

ANALYTICAL FRAMEWORK

Figure 1 shows the inter-relationship between the various costs and benefits associated with an increase in vehicle capacity. At its centre is the consolidation of loads in fewer vehicles, the source of all LHV benefits. This yields two streams of benefits: (i) a reduction in vehicle operating costs which is internalised by the carrier and / or shipper and (ii) a reduction in lorry traffic levels which helps to alleviate environmental impacts and congestion, cutting the external costs of road transport. Against these benefits must be set a series of four potentially offsetting factors:

1. Possible shift of freight from less-environmentally-damaging modes to LHVs to take advantage of the lower road freight costs they offer. As LHVs have higher external costs per tonne-km than these alternative modes, the environmental benefits from load consolidation must be scaled-down accordingly.
2. Possible generation of new freight traffic if companies respond to the reduction in freight costs by making their logistics operations more transport-intensive, e.g. by sourcing products more widely and/or centralising inventory / production. This can offset some of the vehicle-km, fuel and emission savings accruing from load consolidation

² This study has been done by TRL and Heriot-Watt University. The author has been a member of the study team.

3. Possible increase in the severity of accidents as a result of the greater weight and size of LHV. Accident costs per vehicle-km may therefore rise, though there will be an offsetting reduction in total vehicle-kms.
4. Possible increase in expenditure on road infrastructure to accommodate LHV. As it is normally assumed that maximum axle weights will remain unchanged and that any additional payload weight will be spread across more axles, road wear and tear is unlikely to increase. On the contrary, the reduction in truck-kms will be likely to reduce maintenance costs. The extra infrastructural cost is likely to be capital expenditure on modifications to road layouts and bridge strengthening.

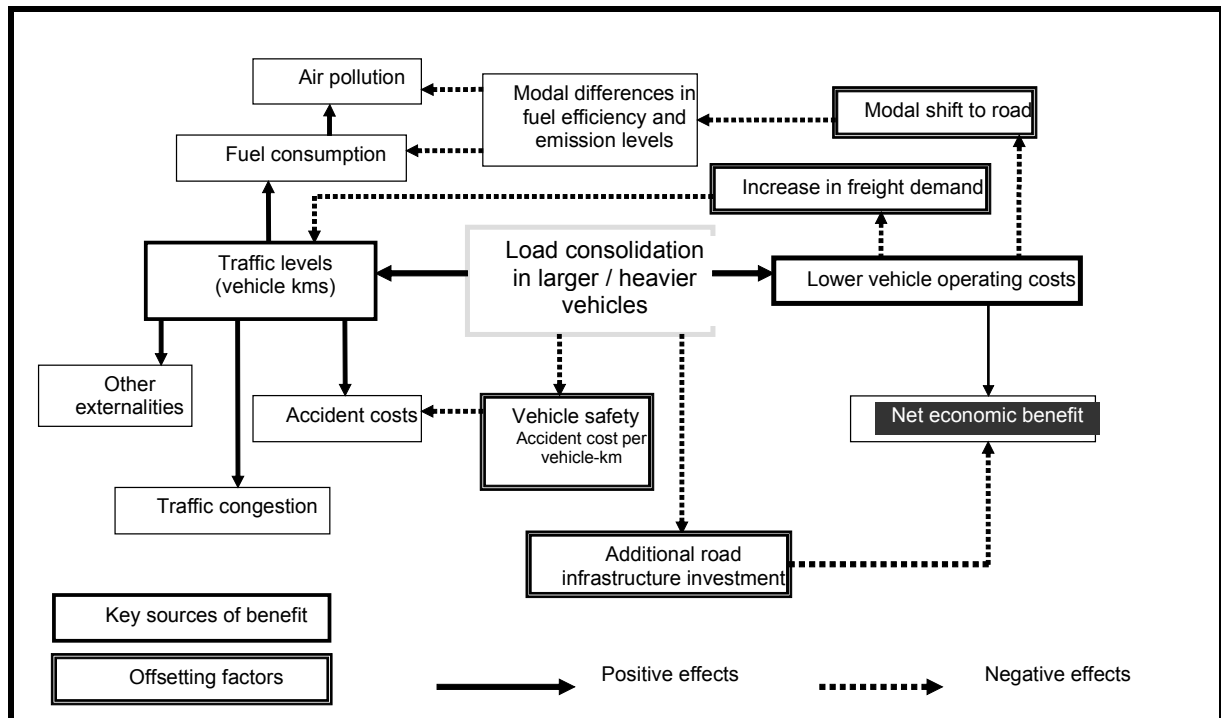


Figure 1: Inter-relationships in the cost-benefit analysis of LHVs

The solid black lines in the diagram represent the positive / beneficial effects of LHVs while the broken lines show the offsetting negative effects. In assessing the case for permitting LHVs, researchers are therefore presented with a classic cost-benefit analysis problem whose solution depends critically on the weighting factors attached to the various positive and adverse effects and their monetary valuation.

In later sections of the paper we will examine the analytical problems that one encounters in trying to quantify three of the key variables in the cost-benefit analysis: degree of load consolidation, freight modal shift and induced traffic growth. These problems are compounded by differences in the maximum length and weight of LHVs and in their design. These differences are considered in the next section.

DIFFERENT TYPES OF LHV

In Scandinavia the dominant type of LHV is rigid vehicle hauling a 13.6 metre trailer with a maximum length of 25.25 metres and gross weight of 60 tonnes. Other European countries that have recently examined the case for LHVs have

explored other configurations but focused mainly on the 25.25 metre maximum length. In the Netherlands 162 LHVs were trialled which conformed to five LHV configurations, 59 of which operated at a maximum weight of 50 tonnes and 103 at a 60 tonne limit. The sample of LHVs trialled in Germany (Lower Saxony) were 25.25 metres long but subject to the same weight limit as existing articulated trucks (40 tonnes). In the desk-based study conducted in the UK, seven LHV scenarios have been tested. These are essentially regulatory scenarios relating to maximum lengths and weights. Each scenario can accommodate differing vehicle designs. The scenarios range from the *status quo* to a 34 metre road train with gross weight of 82 tonnes. Three of the scenarios, for the longer semi-trailer and the 25.25 metre vehicle, introduce the concept of '*payload neutrality*'. This would involve increasing the maximum gross weight of the vehicle in line with its tare (i.e. empty) weight and not permitting any increase in payload weight. It would allow companies moving low density products which currently '*cube out*' to take advantage of the additional space in LHVs, without suffering a loss of weight-carrying capacity.

Reference is often made to the LHV as a single distinct type of vehicle. In practice it represents a heterogeneous category of vehicles varying both in their maximum weights and dimensions and in their design. As the carrying capacity, operating costs, energy efficiency and emissions all vary with regulatory specification and design, it is impossible to generalise about the net economic and environmental effects of LHVs.

DEGREE OF LOAD CONSOLIDATION

It is possible to predict the likely degree of load consolidation in LHVs by:

1. assessing the proportion of loads that are capacity-constrained in trucks operating at the current maximum size and weight limits, and
2. estimating the proportion of these loads that will migrate to LHVs

Since 1998 EU member states have been required to collect data on the proportions of road freight subject to weight and/or volume constraints. This has revealed that in some countries with relatively high gross weight limits, such as the UK, a much larger proportion of tonne-kms are constrained by volume than by weight (Department for Transport, 2007). In such countries, expanding the deck area / cubic capacity will offer greater load consolidation opportunities than increasing the weight limit. It is generally acknowledged too that the average density of freight is declining, partly as a result of the substitution of lighter materials for heavier ones, but also because of increased packaging. Unfortunately, however, no official data are available on the density of capacity-constrained loads. It is not possible, therefore, to model the migration of loads of varying density to LHVs of differing dimensions and maximum weight limits.

In an earlier UK study of the consolidation of loads in heavier vehicles (Commission for Integrated Transport, 2000), various % migration rates were applied to test the sensitivity of economic and environmental benefits to this variable. In the case of LHVs, this sensitivity analysis is much more complicated as vehicle dimensions can also be varied independently of the maximum weight. The most complex of the desk-based LHV studies conducted to date has been that in the UK, where three maximum length and three maximum weight options

have been assessed. The three length options met the requirements of the EMS in conforming to existing modular lengths. The maximum weight options were (i) retaining the *status quo*, (ii) allowing a payload-neutral increase in gross weight and (iii) permitting an increase in gross weight commensurate with the increased number of axles³. In theory, however, the optimum gross weight, offering the greatest load consolidation opportunities, may lie at an intermediate position between these three benchmark weights. Insufficient data exists, however, to model this empirically.

The load consolidation issue is further complicated by the likelihood that at least some categories of LHV would have their movements confined to particular classes of road. In Sweden and Finland, for example, where LHVs have operated for many years, they are denied access to some urban roads. The imposition of route restrictions on LHVs can be justified on several grounds, particularly their inability to negotiate local road layouts, the over-taking problems they would create for other categories of traffic on single carriageways and public opposition in sensitive neighbourhoods. The tighter the network restrictions on LHVs, the less flexible will be their use and the lower the rate of load migration from existing trucks. In the course of the UK LHV study an attempt was made to model the effects of differing degrees of network restriction on the likely uptake of LHVs using trip-specific data from the main annual survey of road freight movements. This analysis was underpinned by numerous assumptions relating to vehicle loading, the compatibility of loads for consolidation and the coupling / decoupling of trailers at strategic locations on the road network. The possible impact of route restrictions on the use of LHVs was also explored in a series of focus group discussions with 72 carriers, shippers and trade bodies. Companies were asked to indicate the extent to which their demand for different sizes of LHVs would be reduced if they could only be operated on (a) motorways (b) trunk roads or (c) all roads outside urban areas. In the context of the focus groups, few companies were able to give a meaningful response to this question. This would require more detailed analysis of individual companies' patterns of road freight flow and more precise information about the likelihood of LHVs gaining local access to industrial / commercial premises⁴.

Not all journeys made by LHVs would move loads that are too large or too heavy to be transported in trucks meeting current regulations. Some will be run empty, while others will be only partially laden. In assessing the degree of consolidation, therefore, allowance must be made for the likely utilisation of LHV capacity. This too is very difficult to quantify in a desk-based study. It can simply be assumed that the average levels of empty running and lading will be the same as those achieved by trucks operating at the current maximum size and weight limits. This may under-estimate the level of LHV utilisation, however, because, as these vehicles require additional capital investment, companies are likely to deploy them mainly on journeys which take advantage of their greater carrying capacity. This was a view strongly expressed by delegates attending LHV focus group discussions in the UK. Few participants, however, would

³ Most of the European studies have assumed that maximum axle weight will remain unchanged and that heavier weights will be distributed across more axles.

⁴ If LHVs were restricted to motorways or trunk roads, they would have to be given some dispensation to travel short distances on local roads, probably on pre-defined routes, to access these premises.

speculate on the extent to which the average utilisation of LHVs would exceed that of existing vehicles. An alternative approach is to determine how high the vehicle utilisation factor would have to be for LHVs to yield a net economic and / or environmental benefit. A study conducted by the German Ministry of the Environment, for example, estimated that the average load factor⁵ on LHV 25.25 metres in length would have to be at least 77% for them to yield a net environmental benefit, well above the average achieved by trucks within current regulations (64%).

The actual experience of LHV operation in those countries where they have been permitted may provide a better guide to the actual degree of load consolidation. On the basis of Swedish and Finnish data, TFK (2002) estimated that the use of LHVs cut vehicle trip numbers by 32% and road transport costs by 23%. More recent research has reversed this analysis by assessing the likely impact of the removal of LHVs from Swedish roads and imposition of current EU regulations on truck size and weight (i.e. 18.75 metre and 40 tonne maxima). This indicates that vehicle numbers would have to increase by 37% and road freight costs by 24%. The recent Dutch trial indicated that *'depending on the level of the preconditions'* permitting LHVs could cut truck numbers by between 2000 and 5000, reduce road congestion by 0.7-1.4% and save 1.8-3.4% in road transport costs (Arcadis, 2006).

FREIGHT MODAL SPLIT

Railway trade bodies and their railfreight member companies have been strongly campaigning against wider introduction of LHVs in EU countries. They see LHVs as a major threat not only to the future growth of railfreight traffic but also to the existing railfreight market. UIC et al (2006), for example, argue that the *'advent of mega-trucks'* would result in the transfer of 7 bn tonne-kms per annum from road to rail in Germany (i.e around 16% of railfreight tonne-kms carried by rail in 2005). In the UK, the main railfreight operator, EWS (2007) has claimed that *'taking both the vulnerable bulk market sectors and the high-value intermodal sector, roundly half of all the freight moved by train in the UK is at risk from moving to road if LHVs were introduced'*. On the other hand, it is worth noting that in Sweden where LHVs have been operating for many years, rail's share of total road and rail tonne-kms in 2005 was roughly twice the EU25 average (29% as opposed to 14%) (Eurostat, 2007).

As discussed earlier, the displacement of freight from rail (and to a lesser extent waterborne modes) to road is recognized to be one of the major disbenefits of LHVs. Some modal shift may be acceptable, however, so long as this disbenefit is more than offset by economic and environmental benefits accruing from load consolidation on the road network. As the UK's Commission for Integrated Transport (2000) stated, *'encouraging freight consignors to use rail, canal or sea transport should be regarded as a means towards the end of environmental benefit, not as an end in itself'*.

Predicting the impact of LHVs on freight modal split is fraught with difficulty. This is partly because of a lack accurate, reliable and up-to-date modal cross-elasticity values. The analysis undertaken for the UK railfreight operator EWS,

⁵ Measured in terms of loaded pallets per trip.

for example, employed price elasticity values for freight transport quoted in a 1990 paper and largely based on North American experience (Oum et al, 1990). Dings (2007) quotes cross-elasticity values for rail of +1.8 to 3.0 which were derived by the Netherlands Economic Institute and CE Delft. On the assumption that the use of LHVs would reduce road freight rates by 20% he calculates that between 36% and 60% of railfreight would divert to LHVs. This would only apply, however, to the sector of the freight market within which rail and LHVs would be in direct competition. This in turn would depend largely on the maximum gross of the LHVs. As the railways tend to carry heavier, higher-density freight, competition from LHVs would be particularly sensitive to their gross weight limits. If vehicle length were increased and maximum weight left unchanged, there would be limited traffic erosion from rail. The main exception to this general statement would be containerised traffic. This is because many commodities moved by rail in containers are relatively light, but LHVs still pose a major threat to the rail container market. 25.25 or 34 metre long LHVs, after all, permit the carriage of multiples of 40 ft and 20 ft containers and thus effect a step-change in the cost of moving containers by road. Research in the UK has suggested a price elasticity value of 2.5 for deep-sea container traffic moving by rail⁶ (MDS Transmodal, 2006). If, as has been suggested by a UK railfreight operator, the use of a 25.25 metre LHV reduced the average cost of transporting containers by road by 15%, one might expect 37.5% of rail deep-sea container traffic to transfer to LHVs in the UK.

The Dutch trial suggested that the impact of LHVs on modal split was very limited with only 1.4-2.7% of railfreight diverting and 0.2-0.3% of inland waterway traffic switching (Arcadis, 2006). Given the wide differences in national freight markets, however, it would be very unwise to extrapolate these modal shift estimates to other countries or, as Debauche and Decock (2007) point out, to international transport in Europe.

INDUCED ROAD FREIGHT TRAFFIC GROWTH

An argument regularly used against increases in vehicle capacity limits is that it will induce a '*rebound effect*' with the resulting transport cost reductions stimulating an increase in the demand for freight movement. It has been claimed that, in the case of LHVs in Europe, '*increased demand for road transport would cancel out any environmental gains from the increased efficiency*' (European Federation of Transport and Environment, 2007). Attempts to quantify this traffic generation effect are again frustrated by a lack of accurate and reliable price elasticity values for road freight transport. This has not deterred some consultants from attempting to estimate the additional external costs likely to arise from the '*market generating*' effect of LHVs. For example, Oxera in its study for EWS (2007) calculated that these external costs would have a monetary value of £907 million per annum. This estimate dwarfs Oxera's valuation of the reduction in external costs accruing from load consolidation (£44 million) and additional environmental costs resulting from modal shift from rail to road (£71 million). Oxera, however, give no indication of the likely source of this large amount of additional freight traffic. Its econometric analysis is detached

⁶ This elasticity value is expressed with respect to rail freight rates, though as road is the only competing mode and container volumes are relatively insensitive to inland transport rates, it can be applied to a relative reduction in road freight costs.

from the real world of production and logistics management. There is strong counter evidence too to suggest that it grossly exaggerates any traffic generation effect. A retrospective analysis of the impact of the increase in maximum truck weight in the UK from 41 tonnes to 44 tonnes in 2001 could find little statistical evidence of this measure reinforcing the rate of freight traffic growth (McKinnon, 2005). Focus group discussions with logistics managers in the UK have also challenged the premise that road transport savings arising from the introduction of LHVs would be unlikely to unleash a new wave of centralisation and / or wider product sourcing.

CONCLUSIONS

This paper has focused on three issues at the heart of the current debate in Europe over the merits of LHVs: load consolidation, modal split and traffic generation. Space limitations have precluded discussion of other important issues such as safety, energy efficiency, emissions, road investment and enforcement. The review of recent research has highlighted the difficulty of making a desk-based assessment of the net benefits / costs of LHVs using currently available data. The long experience of LHV operation in Scandinavia and recent trials in the Netherlands have provided both macro and micro-level data on the impacts of the dominant LHV configuration. One must exercise caution, however, in extrapolating this data to other countries, to the EU as a whole and to a broader range of LHV size and weight scenarios.

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TRAIN PATH ALLOCATION, OPERATIONS, INVESTMENT AND MAINTENANCE ISSUES: THE CASE OF THE ROTTERDAM–CONSTANZA CORRIDOR

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ABSTRACT

The main objective of European Commission funded RETRACK project is to develop, demonstrate and implement a commercially viable privately operated rail freight service along the West - East corridor from Rotterdam to Constanza traversing the five national railway networks of The Netherlands, Germany, Austria, Hungary and Romania. To achieve this, the project was required to conduct research including in-depth literature review and field surveys followed by demonstrations. The current paper describes the infrastructure issues for the rail freight operation along the corridor. The study finds that all of national network vary in their response to the European Commission's Railway packages, rail path specification, allocation processes, operations, investment and maintenance issues. However, the generic features of the entire corridor are: standard 1435mm rail gauge is used throughout; the loading gauge varies on the route; the route operates under differing power supply systems for electric locomotive operation; electric traction operations are feasible over the main routes over the principal lines; there are varying speed, axle weight and total trailing train weight limits in force; train control and signalling systems are based on individual national methods and patterns; and all the railways along the RETRACK corridor are UIC (International Union of Railways) members and work within its rulings and objectives.

Keywords: railway, infrastructure, freight, train path

INTRODUCTION

An efficient and competitive transport system is a key for modern economic growth in a global competitive market. It is also a source of negative effects including congestion, noise, and air pollution (Maibach, et al, 2007). The European Commission aims to achieve sustainable transport system by minimising negative effects without compromising the much needed economic growth of EU (EC, 2001, 2006, 2007). Roads in Europe are highly congested and although the rail infrastructure suffers from congestion, there are underused paths from which key links can be made. Over the years the rail mode has lost freight market share, even though rail transport is generally accepted as an environment friendly option. Supporting measures for the modal shift of freight traffic from road to rail, sea and canal have been at the heart of European transport policy (Kukacka, 2007) until the revised mid term review of 2005 when co-modality weakened the drive to modal shift. This drive to modal shift has been accompanied by the wider thrust of EU policy to deregulate and liberalise. In railways the three 'railway packages' were the key elements of reform. These

packages require rail infrastructure management and train operations to be managed by *separate structures*, but not necessarily in *separate institutions*.

The objective of the RETRACK project is to develop, demonstrate and implement an innovative and market-tested rail freight service along the East-West trans-European corridor of Constanza in Romania to Rotterdam in the Netherlands through Hungary, Austria and Germany (RETRACK, 2008). The service will be operated by private rail companies and not the previously state owned incumbents.

	The Netherlands	Germany	Austria	Hungary	Romania
Rail operator	3	3	1	1	1
Terminal operator	2	9	5	1	2
Port authority	1	2	1	-	1
Infrastructure manager	1	1	1	1	1
Rail regulator/ Ministry	2	2	2	2	2
Total	9	17	10	5	7

Table 1: Breakdown of interviewed stakeholders along the RETRACK corridor

This paper identifies issues on rail infrastructure on this corridor through an in-depth literature review and 48 field survey interviews amongst the stakeholders including rail operators, infrastructure managers, port and rail terminal operators, and national rail regulators (details in table 1). The literature review included best practices, technology use along the corridor, private research, and prior expert knowledge. The country-specific findings are discussed in the following sections.

THE NETHERLANDS RAILWAY INFRASTRUCTURE

The railway reform packages for liberal market application in Europe are positively reinforced in the Dutch rail freight sector. The liberalization process and open access to the system has induced new operators into the market all of whom are compliant with the requirements of the Network Management Statement (NMS). The NMS underpins the method of working on the railway infrastructure manager, ProRail in detail and at the strategic level. The NMS lists the rights and obligations of both ProRail and titleholders/users. They contractually establish the position in relation to access agreements and procedures determined for capacity requests. ProRail is a private company under national law where the Dutch government is the sole stakeholder under a management concession granted by the Dutch Ministry of Transport. The concession governs the quality, reliability and availability of the infrastructure, a fair, transparent and non-discriminatory distribution of capacity on the network and executive control of the traffic on the network in accordance with provisions established in granting the concession. Also ProRail ensures safe infrastructure without excessive attrition, traffic control, and risk analysis and risk management.

The rail infrastructure in The Netherlands extends over 2600 km of which 2000km is electrified. It is one of the most densely operated rail systems in Europe with a mix of international, inter-city, regional and commuter trains all operating on the network. Much of the network has multiple lines with bi-directional signalling multi-aspect colour light signalling. Line capacity has been enhanced to accommodate the high levels of train activity particularly peak travel. The maximum train speed on the main network is 160kph for passenger and 100-120kph for freight trains. Maximum train length for freight is 750m. New freight only capacity has been commissioned in June 2007 between Rotterdam and Emmerich on the German border to facilitate the high levels of growth of intermodal traffic. This will be the primary rail freight corridor between The Netherlands and Germany and beyond. The line is double tracked with an axle load of 25 tonnes per axle without any level crossings. The line is operated by Keyrail with participation from ProRail and the port authorities of Amsterdam & Rotterdam.

Keyrail is responsible for traffic control, capacity & operational management and maintenance. The main railway system is electrified at 1500v d.c. although some specialised sections are now being adapted to 25kv a.c. as part of a move towards a European standardised power technology. These are the High Speed lines and the Betuwe line and the linkages to Amsterdam (via 's-Hertogensboch-Utrecht) and Ijmuiden. The Rotterdam area is a very busy rail traffic zone and there are issues relating to the maintenance of the railway infrastructure (track, signals and power supply) that constrain the ability to run trains on a 24/7 basis. The planned maintenance intentions of the infrastructure operator are advised to train operators in advance or embedded in the NMS. In the short to medium term the operation of RETRACK rail freight services, at least one train per day, is feasible but more trains per day may become a problem. Congestion statements have been issued covering rail yards in Maasvlakte, Europoort, Botlek and Waalhaven for 2007.

New control protocols built around ERTMS Levels 2 & 3 are being developed to address issues such as train detection, interlocking and speed control without external signalling. Traffic monitoring is undertaken by the normal train signalling system with train operations governed by pre-planned routing, schedules, stopping points, recovery times etc. Any "out-of-course" schedule delays are resolved by individual signalling centres and the national infrastructure manager. Train schedules are developed in the form of representations to the infrastructure manager for train paths by a prescribed date (normally in April) to secure a scheduled path. Requests made after this period are dealt with on an ad-hoc basis by the infrastructure manager. The option to apply for an international train path through RailNetEurope or to individual national infrastructure managers is available to train operators to determine the best way of securing their requirements.

GERMAN RAILWAY INFRASTRUCTURE

Germany claims to be one of the most liberalised freight markets for rail in Europe. Since the market began to de-regulate nearly 300 companies have secured licenses to operate within the freight market. Of these over a third are

active in the provision of traction for train haulage or shunting. Some operations are highly localised serving a specific location or enterprise. Many are tiny and exist as tertiary industrial activities. The market in terms of volume and production (tonne km) is still dominated by DB's rail arm, Railion, which has control over the infrastructure and a huge market presence.

The German national rail infrastructure comprises 34000 km controlled by DB Netz which is wholly owned by Deutsche Bahn. DB Netz was established in the second stage of railway reform in Germany. It acts as the infrastructure manager covering track, power supply and signalling and communications. It is one of the three major subsidiaries of DB (Networks). It is a part of the German model of liberalization and discrimination free access to the national infrastructure for domestic and international services. It is not, however, required to separate finances between passenger, freight and infrastructure. Access charges are not openly published and therefore discrimination has to be claimed by a complainant and is not immediately obvious from published material.

DB Netz publishes a NMS describing its objectives, responsibility and methods of working. It has developed a programme (ProNetz) aimed at increasing capacity and reducing operational bottlenecks. The rail network in Germany is intensively used by a mix of (day and night), international, national, regional and local/commuter services. The development of the high speed network as a separate entity has removed some traffic onto a completely separate infrastructure. For RETRACK operations there have been expressions of concern over the capacity of the route along the Rhine and the risk of being allocated less than adequate quality train paths in terms of schedule and routing.

Trains are monitored in transit on the rail network through the active signalling and train control mechanism based on scheduled access to train paths, routing and schedules granted through the formal bid process or ad-hoc arrangements which cannot always fulfil the path requests made by specific operators. Cargo trains operate within UIC agreed loading gauge limits for vehicle height and width. The maximum axle load on the German portion of the RETRACK corridor is 22.5 tonnes. Maximum freight train speed is 120kph. The RETRACK corridor in German part is electrified at 15kv a.c. The signalling system is distinctly different from those of other countries on the corridor. ERTMS is being developed on the RETRACK route. In the event of service disruption cross border traffic is most highly rated followed by passenger services and then national freight services.

Train path allocation is conducted in a transparent process establishing schedules, routings, stopping points and related technical issues. Key personnel within the train operators are assigned for dispute resolution, related commercial negotiations and settlements. Slots not allocated by the process are available under short term rules. The option to re-bid or pay a higher fee for a preferred path is available. The short term slots are available outside the main timetable/train path position and can include declared unused or redundant slots. The RETRACK routes (proposed) are all double track. There is an option with flexibility to loop around any obstruction. It is possible that a locomotive could be requisitioned to move a failed train out of the way under rules set by the NMS. Maintenance is a significant issue and significant construction work is planned

into the annual timetable. Smaller projects are notified to train operators in advance (3 months) with a resolution process driven by the rail regulator.

AUSTRIAN RAILWAY INFRASTRUCTURE

The infrastructure activities are split into operation and maintenance of the network and a separate section is devoted to the development and enhancement of the network. Access to the national rail network (Betreib AG, a part of OBB) is governed by stipulations set out in the NMS including an operating licence, safety certificate, insurance and an allocation of infrastructure capacity. The NMS details line characteristics, operations methods, signalling and axle box counter/hot box detector location. Various categories of train operators are allowed to apply for access including internationally based groups intending to serve the Austrian market or requiring transit. Betreib AG ensures the network availability for traffic, maintenance requirements, safety and efficient train operation. Infrastructure maintenance is governed by scheduled activity for up to three years forward.

All primary routes are built to 1435mm track gauge and over 70% of the system is electrified at 15kv a.c. which permits through traction operations into Germany and Hungary. Train paths are allocated to operators on the basis of requested routes, operator details, train weight, length, speed and braking characteristics, any hazardous cargo, traction unit capabilities, border processes for hand over and checks, crew changes, gauges for inter-modal traffic /combined transport and connections. Deadlines for the application of train paths in the annual timetable planning process are required by April for the following year. An ad hoc train path can be requested on a diminishing time basis but with the risk of not being able to satisfy the request on a shorter time span. In the event of an operating incident procedures have been developed to ensure contact is established with named personnel within train operator's organizations to advise intentions to restore stability.

Train path priorities have been identified in descending order from passenger to long haul, long terms contracted operations over short distance, short term operations. There are train monitoring processes in place and response measures in the event of disruption of disturbance of a planned train sequence. A total of 24 railway undertakings have licences to operate. The capacity enhancement is ongoing in the West of Vienna between Linz and St Paulten which is classified as a high priority route. OBB Betreib has issued a forecast map of major engineering works including capacity enhancements as part of the NMS. The RETRACK route will be affected by some of these works.

HUNGARIAN RAILWAY INFRASTRUCTURE

The management of the infrastructure has been nominally separated from train operations. The railway network is composed of 7700km of which 40% is electrified at 25kv a.c. which complicates cross border traction operations into Austria. Only 20% of the network is double track which may create concerns over capacity in the medium term. MAV, State Railway Company, is the infrastructure manager. There is a small jointly owned (Hungarian and Austrian) cross border route. Parts of the RETRACK corridor routing in Hungary will allow freight train operations to a maximum line speed of 100-120kph. Maximum axle loads are 22.5 tonnes and maximum train length is 750m.

The network has a spare capacity to accommodate new traffic. However, the deterioration of the network due to maintenance backlogs will need to be addressed. The network has a high level of participation in intermodal traffic including international container services operating to Budapest from Western Europe. At least 20% of the annual line capacity has been allocated to railway undertakings other than the incumbent and enjoy comparable journey times to the incumbent operator. Huge investments (Euro 450 million) made since 1990 have upgraded the infrastructure. ECTS is already in operation on the route between Vienna and Budapest and was one of the first applications of this technology.

Access to the rail network is granted under licence and in compliance with safety, competence and insurance credentials. Capacity is allocated by a capacity allocation office nominally separated from the infrastructure manager (MAV) although this separation is opaque. A fully independent Rail Regulator is in place. The market share of the new train operators is very low and competition is still developing. There are only a few (4) players identified capable of operating competitive train services. MAV Cargo has recently been sold to Rail Cargo Austria but the process is now under investigation by the Hungarian and Austrian authorities. Traffic control and monitoring is through a mix of signalling and train control mechanisms which reflect national systems that also incorporate train speed commands to train crew. In terms of train inter-operability rail vehicles have to be compliant with UIC loading gauge stipulations on dimensions, braking loading and speed characteristics.

ROMANIAN RAILWAY INFRASTRUCTURE

Separate regulatory and safety inspectorates are to be fully developed as per EC railway reform packages. The total national network comprises 11,300km of which 40% is electrified at 25 kv which will allow through operation on the same power supply as the neighbouring Hungarian system. The railway is to standard European gauge (1435 mm). The dense network of lines offers multiple routing options for RETRACK corridor trains in the event of disruption or lengthy track possession for engineering work. Maximum train length is set at 620m and a gross trailing weight of 1500 tonnes. This can be raised to 2600 tonnes with additional traction resources added. Rolling stock and traction are governed by UIC stipulations on dimensions, weight and operating capabilities.

CFR is the railway infrastructure manager responsible for modernization and capacity allocation. The railways in the North and West are in mountainous territory which constrains train performance. The network is being developed to allow an increase in train speed between Bucharest and Constanza. In addition significant infrastructure enhancements are being made in and around the port to allow additional trains operation. These investments will enhance rail's competitive position. A NMS has been prepared to describe the responsibility of CFR and operators. However, it is for the guidance and advice only and not a contractual document. The NMS includes general rules, deadlines, processes and criteria regarding the system of levying charges and allocating railway infrastructure capacity. It facilitates non-discriminatory access to information for existing and new market entrants. The railway infrastructure is made available to railway undertakings in a non-discriminatory way based on licensing, safety

certification and an access contract with CFR. This will set up the scope of rail services to be offered, access to infrastructure services and any supplied services, additional and auxiliary services. There is no option to swap or trade capacity allocations by the train operators without recourse to CFR. Paths are allocated for one timetable period (normally one year) but may be extended by mutual consent.

Traffic management on the network is undertaken by traffic regulators coordinated by regional regulators and centrally by the Central Office for Railway traffic control. An integrated rail information system is used for monitoring and control purposes. Disruption response is undertaken by increasing degrees of involvement of the hierarchy. Trains operate on allocated paths based on the annual timetable, average traffic programme (10-30 days forward) or on a spot basis with a lead time of 24 hours. There are 24 railway undertakings in Romania with sanctioned access to the network for freight traffic operations.

SUMMARY AND CONCLUSION

The table 2 summarises the findings of the RETRACK corridor. The degree of adoption and implementation of the EC railway reform packages varies along the corridor. The railway network on RETRACK corridor is in general capable of accommodating additional international freight services to achieve this. None of the corridor countries has a dedicated freight-only network, although efforts are in place, for example in the Netherlands. The existing network is shared by both passenger and freight services. The allocation of path is an important issue, in particular in the intensively used networks in the Netherlands and Germany. The strategic allocation is made annually. Preparing and submitting an application on time to national infrastructure manager is vital in this regard. The option to apply for an international train path through RailNetEurope apart from individual national infrastructure managers is available to train operators to determine the best way of securing their requirements. This process is still evolving with operators electing to pursue either option or both to safeguard their interests.

The NMS details the rights and obligations of the infrastructure managers and operators. It also describes the scheduled maintenance and investment programmes. The status of NMS varies, for example, it is a contractual document in the Netherlands whereas it is only a guide in the Romania. Generally the access to path is non-discriminatory i.e. open to all operators. There are national rail regulators in place to oversee the activities. There is a significant difference in the approaches to the regulatory task which needs harmonisation to facilitate service development. Some parts of the network are under planned development activities, in particular in the East. Maintenance works are done through advice and notice of a reasonable period (generally three months). Dedicated personnel in the infrastructure managers and operators solve the disruption related issues.

There are limitations on the maximum length (620m) and maximum load per axle (22.5 tonnes) of freight train. There are also different electrified systems (15kv a.c. and 25kv a.c.) in place. The train operation will require multi-system locomotives as they are all a.c. powered. The development and operation of services along the corridor as part of an EC sponsored initiative appears to be feasible and the measures set out in the various "railway packages" have given a firm basis for service development and commercial positions to be developed.

The aim is to deploy and operate a demonstration service in early 2009 moving to full scale commercial application.

	The Netherlands	Germany	Austria	Hungary	Romania
Railway route	2600km	34000km	5650km	7700km	11300km
Electric system	1500v d.c. & 25kv a.c.	15kv a.c.	15kv a.c.	25kv a.c.	25kv a.c.
Infrastructure manager	ProRail	DB (Network)	OBB Betreib	MAV	CFR
Number of Rail freight operator	8	300	24	4	24
Independent Rail regulator	In place	In place (?)	In place (?)	In place	To be developed
Passenger/ freight priority	Passenger	Passenger	Passenger	Passenger	Passenger
Network Statement	Published/ updated	Published/ updated	Published/ updated	Published/ updated	Published/ updated
Maximum speed (freight)	120 kph	120 kph	120khp	120khp	120kph
Maximum train length for freight	750m	750m	750m	750m	620
Per axle load	25 tonnes	22.5 tonnes	22.5	22.5 tonnes	22.5
Path allocation	Annual Timetable Spot option available	Annual and interim with higher pay	Annual timetable spot or short term options available	Annual Timetable	Annual timetable, average traffic program or spot basis
ERTMS	ERTMS		ECTS	ECTS	ERTMS

Table 2: Summary of the infrastructure issues along the RETRACK corridor

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CRITERIA OF GETTING BACKHAUL LOADS FOR TRUCKLOAD CARRIERS

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ABSTRACT

In Japan, there are a lot of load finding services through the Internet. However, truckload carriers do not have clear criteria of decision making about getting backhaul loads. The purpose of this paper is to clarify the criteria. We present a simple model of freight trucking with the backhaul load first. After that, we study the criterion of load efficiency along the model. This criterion brings the improvement of load efficiency compared with the case of no backhaul loads. We also study the criterion of contribution margin along the model. This criterion brings the improvement of carrier's contribution margin compared with the case of no backhaul loads. Moreover, we execute a numerical experiment according to each criterion. As a result of the experiment, we can find that the criterion of load efficiency contributes to the reduction of CO2 emission.

Introduction

Many truckload carriers pay attention to backhaul loads as means to improve load efficiency, because the backhaul loads can decrease negative environmental impacts and increase carrier's profit. In Japan, decrease of the load efficiency is a serious problem as the number of a small amount of truckload is increasing. As one of the solutions, there are a lot of load finding services through the Internet. However, truckload carriers do not have clear criteria of decision making about getting backhaul loads.

This paper clarifies two criteria of the decision making. We present a simple model of freight trucking with a backhaul load first. After that, we study the criterion of load efficiency along the model. This criterion increases the load efficiency compared with the case of no backhaul load. We also study the criterion of contribution margin along the model. This criterion increases carrier's contribution margin compared with the case of no backhaul load. Moreover, we execute a numerical experiment and confirm the effectiveness of criteria.

Criteria of Decision Making

[1] Simple Model with Backhaul Load

To clarify the criteria of decision making about getting a backhaul load, we present a simple model of freight trucking with a backhaul load as illustrated in Figure 1(Fujita et al., 2006).

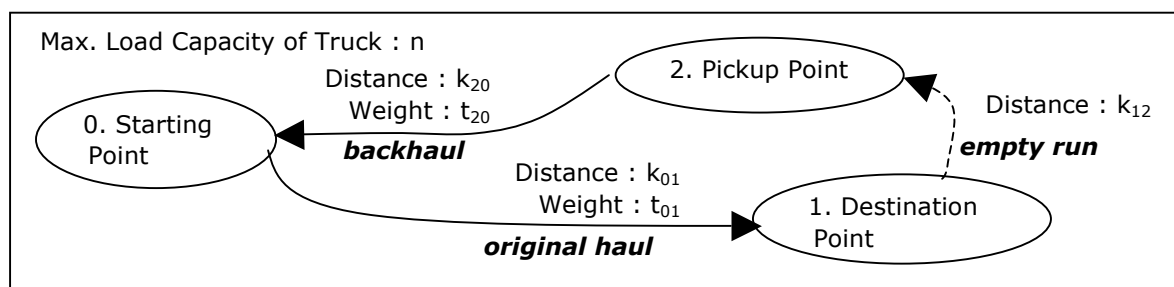


Figure 1 Model of freight trucking with a backhaul load

Hereafter, the conditions from the expression (1) to the expression (6) are assumed in the model.

$$\begin{array}{ll} n > 0 & (1) \\ 0 < t_{20} \leq n & (3) \\ k_{20} > 0 & (5) \end{array} \qquad \begin{array}{ll} 0 < t_{01} \leq n & (2) \\ k_{01} > 0 & (4) \\ k_{12} \geq 0 & (6) \end{array}$$

[2] Criterion of Load Efficiency

In the Annual Statistical Report on Motor Vehicle Transport, freight ton kilometers and ability ton kilometers are announced (Ministry of Land, Infrastructure and Transport, 2007). The ability ton kilometer is a freight ton kilometer that assumes the case where the truck always runs by the maximum capacity loading. It is general that the load efficiency is calculated by the following computational expression (7).

$$\text{load efficiency} = \frac{\text{freight ton kilometer}}{\text{ability ton kilometer}} \quad (7)$$

When the truck is shuttling in the starting point and the destination point without any backhaul loads, the load efficiency is expressible like the following expression (8) from Figure 1.

$$\frac{t_{01}k_{01}}{2nk_{01}} \quad (8)$$

On the other hand, the load efficiency with a backhaul load is expressible like the following expression (9) from Figure 1.

$$\frac{t_{01}k_{01} + t_{20}k_{20}}{n(k_{01} + k_{12} + k_{20})} \quad (9)$$

When the backhaul load is secured, a condition that improves the load efficiency is expressible like the following expression (10) from the expressions (8) and (9).

$$\frac{t_{01}k_{01}}{2nk_{01}} < \frac{t_{01}k_{01} + t_{20}k_{20}}{n(k_{01} + k_{12} + k_{20})} \quad (10)$$

Moreover, the expression (10) can be transformed into the following expression (11).

$$k_{12} < \left(\frac{2t_{20}}{t_{01}} - 1 \right) k_{20} + k_{01} \quad (11)$$

In addition, we try to show the backhaul distance and the empty distance based on the original haul distance. The backhaul distance ratio BDR and empty distance ratio EDR are expressed by the expressions (12) and (13).

$$BDR = \frac{k_{20}}{k_{01}} \quad (12) \qquad EDR = \frac{k_{12}}{k_{01}} \quad (13)$$

In addition, we try to show the backhaul weight based on the original haul weight. The backhaul weight ratio BWR is expressed by the expression (14).

$$BWR = \frac{t_{20}}{t_{01}} \quad (14)$$

The expression (11) can be transformed into the following expression (15) from the expressions (12), (13) and (14).

$$EDR < (2BWR - 1) BDR + 1 \quad (15)$$

In a criterion of load efficiency, the decision making about getting a backhaul load is done based on the expression (15).

[3] Criterion of Contribution Margin

In managerial accounting, a contribution margin is recognized as the difference between sales and variable costs. A net profit is the difference between the contribution margin and fixed costs (Ghosh et al., 1988). Therefore, almost all managers always do the effort to increase the contribution margin.

To calculate truckload carrier's contribution margin, we assumed that the sales vary linear with the actual haul distance and the variable costs vary linear with the travel distance. If a sale per unit of actual haul distance is S and a variable cost per unit of travel distance is C , the contribution margin without any backhaul loads is expressible like the following expression (16) from Figure 1.

$$k_{01}S - 2k_{01}C \quad (16)$$

On the other hand, the contribution margin with a backhaul load is expressible like the following expression (17) from Figure 1.

$$(k_{01} + k_{20})S - (k_{01} + k_{12} + k_{20})C \quad (17)$$

When the backhaul load is secured, a condition that improves the contribution margin is expressible like the following expression (18) from the expressions (16) and (17).

$$k_{01}S - 2k_{01}C < (k_{01} + k_{20})S - (k_{01} + k_{12} + k_{20})C \quad (18)$$

Moreover, the expression (18) can be transformed into the following expression (19).

$$k_{12} < \left(\frac{S}{C} - 1 \right) k_{20} + k_{01} \quad (19)$$

The expression (19) can be transformed into the following expression (20) from the expressions (12) and (13).

$$EDR < \left(\frac{S}{C} - 1 \right) BDR + 1 \quad (20)$$

In a criterion of contribution margin, the decision making about getting a backhaul load is done based on the expression (20).

Numerical Experiment

To confirm the effectiveness of criteria, we execute a numerical experiment according to each criterion. The numerical experiment follows the Monte Carlo method based on uniform distributions. Fundamental data of it are decided depending on actual data of Japanese truckload carriers.

[1] Fundamental Data

The Automobile Business Association of Japan issues the Management Index Report on Motor Vehicle Transport every year. In this report, 333 Japanese typical truckload carriers' activities in year 2004 were announced (Automobile Business Association of Japan, 2006). From there, we can obtain data as shown the following Table 1.

Table 1 Truckload carrier activity data (333 carriers)

Total Travel Distance (1000 km)	3,460,071
Total Haul Distance (1000 km)	2,840,575
Average Daily Travel Distance Per Truck (km)	154
Total Sales (1000 yen)	1,675,280,537
Total Variable Costs (1000 yen)	396,057,701

Total variable costs in Table 1 include fuel expense, maintenance and repairs, road tolls, ferry tolls and variable driver cost. We calculated the variable driver cost as 49.5% of whole driver cost according to a material provided by the Japan Trucking Association(Japan Trucking Association, 2006). The sale per unit of actual haul distance S obtained from Table 1 is 589.77 yen/km. The variable cost per unit of travel distance C obtained from Table 1 is 279.55 yen/km. These values are used in the numerical experiment.

[2] Experimental Procedure

The following steps explain the experimental procedure.

(Step-1) With the aid of Microsoft Excel 2003, we generate 5 data based on uniform distributions as shown the following Table 2. A group of these data shows one transportation. Each distance range is based on the value of average daily travel distance per truck from Table 1.

Table 2 Experimental data

Item	Range
Original Haul Distance (km)	1 to 102
Empty Distance (km)	0 to 102
Backhaul Distance (km)	1 to 102
Original Haul Weight (kg)	1 to 10000
Backhaul Weight (kg)	1 to 10000

(Step-2) We generate 200 groups of data and compose 200 transportations as a sample. We obtain 3 samples according to this procedure.

(Step-3) The 3 samples are made to correspond to each case as shown the following Table 3. For each case, we calculate 200 CO₂ emissions per unit of freight ton kilometer and contribution margins.

Table 3 3 cases of transportations

Case 1	The truck always runs without any backhaul loads. The truck is shuttling in the starting point and the destination point.
Case 2	The truck runs with a backhaul load or without any backhaul loads depending on the criterion of contribution margin.
Case 3	The truck runs with a backhaul load or without any backhaul loads depending on the criterion of load efficiency.

When calculating, we assumed that the truckload carrier can select the most effective truck from a group of 3 trucks that the maximum load capacity is 2 ton, 4 ton or 10 ton. We assumed their mileages as shown the following Table 4 and the CO₂ emission coefficient is 2.62 kg-CO₂/l according to a material provided by the Japan Institute of Logistics Systems(Japan Institute of Logistics Systems, 2006).

Table 4 Mileages of trucks(diesel oil)

Maximum load capacity	Mileage
2ton	8.0 km/l
4ton	5.5 km/l
10ton	3.5 km/l

Experimental Result and Discussion

[1] CO₂ Emission

The sample mean values and standard deviations of the CO₂ emissions per unit of freight ton kilometer are shown in Table 5 and 95% confidence intervals of the mean values are shown in Figure 2. To confirm the statistical significance of the

mean value difference, we considered multiple comparison procedures. The Games-Howell pairwise comparison test was executed with the aid of SPSS 11.5, because the means had unequal variances (Games et al., 1976). This result is shown in Table 6.

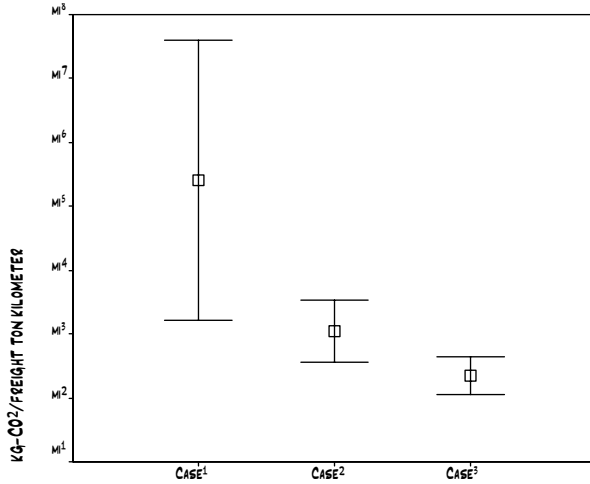


Figure 2 95% confidence interval of mean value(kg-CO2)

Table 5 kg-CO2 per unit of freight ton kilometer

Case	Mean	Std. Deviation
1	0.5402	1.57025
2	0.3049	0.34578
3	0.2356	0.20880

Table 6 Multiple comparison(kg-Co2)

Pair		Difference	Significance Probability
(I)	(J)	(I - J)	
Case 1	Case 2	0.235301	0.099
Case 1	Case 3	0.304614*	0.019
Case 2	Case 3	0.069312*	0.042

From Figure 2, we find that the variance of Case 1 is extremely large compared with other cases. It is likely that the truckload carriers get stable CO2 emissions when the truck runs with a backhaul load or without any backhaul loads depending on the criteria.

From Figure 2 and Table 6, we find that the criterion of load efficiency (Case 3) decreases the CO2 emission per unit of freight ton kilometer compared with the case of no backhaul load (Case 1). In addition, we find that the criterion of load efficiency decreases it compared with the case that the truck runs depending on the criterion of contribution margin (Case 2). It is likely that the criterion of load efficiency contributes to the reduction of CO2 emission.

[2] Contribution Margin

The sample mean values and standard deviations of the contribution margins are shown in Table 7 and 95% confidence intervals of the mean values are shown in Figure 3. To confirm the statistical significance of the mean value difference, the Games-Howell pairwise comparison test was executed with the aid of SPSS 11.5. This result is shown in Table 8.

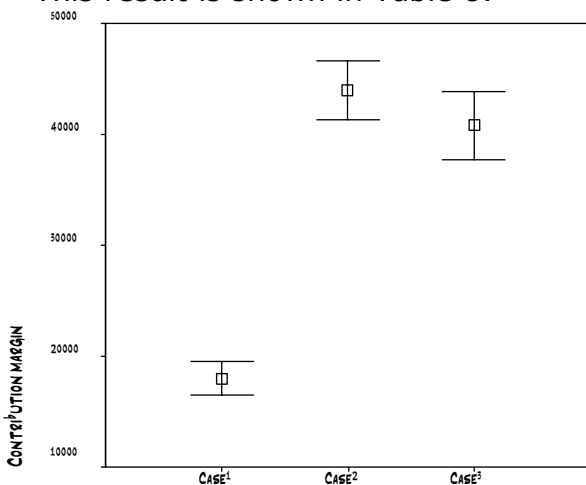


Figure 3 95% confidence interval of mean value (contribution margin)

Table 7 Contribution margin

Case	Mean	Std. Deviation
1	17994.09	10821.80
2	44011.41	19096.00
3	40792.49	21997.31

Table 8 Multiple comparison (contribution margin)

Pair		Difference	Significance Probability
(I)	(J)	(I - J)	
Case 1	Case 2	-26017.32**	0.000
Case 1	Case 3	-22798.40**	0.000
Case 2	Case 3	3218.92	0.263

From Figure 3 and Table 8, we find that both Case 2 and Case 3 increases the contribution margin compared with Case 1. In any case, getting a backhaul load probably improves the contribution margin.

We cannot confirm the statistical significant difference between Case 2 and Case 3. If these cases have the same effect to improve the contribution margin, the criterion of load efficiency is the useful criterion when the truckload carriers make decision about getting a backhaul load.

Conclusions

In this paper, we presented the simple model of freight trucking with a backhaul load to clarify the criteria of decision making about getting backhaul loads. After that, we discussed the criterion of load efficiency and the criterion of contribution margin along the model.

To confirm the effectiveness of criteria, we executed the numerical experiment that follows the Monte Carlo method based on uniform distributions. Fundamental data of it were decided depending on actual data of Japanese truckload carriers. As a result, we found the following points.

- 1) The truckload carriers can get stable CO₂ emissions when the truck runs depending on the criterion of load efficiency or the criterion of contribution margin.
- 2) The criterion of load efficiency is effective to decreases the CO₂ emission.
- 3) In any case, getting a backhaul load improves the contribution margin.
- 4) We cannot confirm the statistical significant difference of contribution margins between the case where the truck runs depending on the criterion of contribution margin and the case where the truck runs depending on the criterion of load efficiency.

Therefore, we think the criterion of load efficiency is the useful criterion when the truckload carriers make decision about getting a backhaul load.

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INDIA'S TRANSPORT INFRASTRUCTURE: BOTTLENECKS IN THE PORT INTERFACE AND POSSIBLE REMEDIES

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ABSTRACT

The present-day manufacturing boom in India has been a major factor for the demand surge on transportation facilities and a cause for the congestion that is prevailing. Presently, the Indian economy is showing an over 8% annual GDP (gross domestic product) growth. The projections show somewhat similar growth rates for India for a considerable period of time and the level of production is expected to escalate rapidly. But, India's transport and intermodal infrastructure is not ready/developed to keep pace with the requirements of the international trade, although the country is conceived to be an emerging world economy.

The inward and outward cargo projections for its container port sector alone show a four-fold increase to 20 million twenty equivalent units (TEU) by 2014. The Indian authorities with the involvement of the local and international private sector are planning and implementing projects for new container terminals and intermodal facilities/infrastructure to be in place in time for the increase. The aim of this paper is to explore the issues in the Indian port interface and suggest possible areas of focus for improvement. The research was exploratory in nature and used qualitative techniques. The methodology comprised of secondary data analysis from literature sources and semi-structured interviews conducted with managers from business entities involved in the Port interface in India. The data collection was done in line with methods suggested by Miles and Huberman (1994). The data was analysed using grounded theory methods to explore the issues further. This paper presents an initial research model derived from the data analysis. This will be explored further in the next stage of the research.

INTRODUCTION

India has been experiencing a manufacturing boom on account of low labour rates in recent years and is recognised as one of the strong sourcing centres for the developed world. As an emerging economy with a population of over one billion people, India is faced with many challenges in facilitating the logistical needs of its international trade. Hence, it is very important that India develops a modern infrastructure and the associated processes that go with it, in order to meet the requirements of growing international trading opportunities.

But, India's infrastructure, especially the port facilities, is still not completely in a position to provide the required level of service. There are a number of reasons and the following quotations highlight some of the acute difficulties the country's container ports are faced with.

'A cargo that takes six days to travel from Singapore to Mumbai could sit in the port for 30 days before it is unloaded. The reason is that there is insufficient

capacity to service today's large cargo ships at Indian ports.' (**Kundu – Asia Times, Feb 2005**)

'Congestion at ports, inland and roads have rapidly increased- thus directly augmenting logistics costs. ...average train speed is 23.3kmph in India. This is 100kmph in Europe.' (**Vaidyanathan, 2007**)

'Indian Ports are congested and inefficient. Port traffic has more than doubled during the 1990s, touching 521 million tons in 2004-05. This is expected to grow further to about 900 million tons by 2011-12. India's ports need to significantly ramp up their capacity and efficiency to meet this surging demand.' (**World Bank website, accessed on 24 November 2007**)

'India's port sector has reached a stage where the available capacity is facing saturation on account of growing traffic. This has resulted in congestion and delays. Owing to inefficiency and growing congestion, the average pre-berthing detention and the average turnaround time are high by international standards. The building of additional capacity is, therefore, critical for rapid improvement in the sector.' (**Planning Commission, Government of India, July 2007 p6**)

This highlights to some extent, the issues faced by India's ports and the necessity to carry out appropriate action to reduce the impact.

ISSUES AFFECTING CONTAINER PORTS

Container ports/terminals are one of the main interfaces in the maritime logistics chain. Notteboom and Winkelmanns (2001, p.87) suggest that, *'...a successful port, like a successful actor, must constantly be prepared to adopt new roles in order to cope with the changing market environment'*. Ports are an integral third party in the supply chain between producers and consumers that add an interface in the value-driven chain with an increasing complexity (Robinson 2002). Carbone and De Martino (2003) recognise the fact that good supply chains contribute towards increasing the efficiency of ports. At present, however, most ports suffer congestion and this situation is on the rise, the container terminal utilisation level which is 79.3% (on average) in 2006 will go up to 94.8% in 2011 (Verschelden, 2007).

Notteboom and Rodrigue (2005) have suggested a 'Port regionalisation' model as a new port logistical concept to tackle issues related to challenges faced by ports. Various researchers have studied issues relating to port performance and efficiency. De Monie (1987) has discussed the importance of developing ways and means of measuring, and evaluating port performance, Briano, et al. (2005) discuss different simulation and mathematical modelling methods available to the maritime logistics operations as a proven technique to increase the efficiency, whereas, Cullinane (2002) cites the Data Envelopment Analysis (DEA) model as a non-parametric method that can be used in measuring the efficiency of ports and terminals. Bassan (2007) identifies the importance of both analytical methods and simulation to reach optimal levels of port/terminal efficiency with minimal investments in port operations, whereas Choi et al. (2003) suggest the use of Enterprise Resource Planning (ERP) in container terminals. Dragovic, et al. (2006) have analysed and modelled the "ship-berth" link in a terminal's overall efficiency and productivity. Bichou and Gray (2004) further discuss the lack of developed performance measuring mechanisms in ports as logistics centres. Tongzon (1995) suggests that finding suitable benchmarks to assess port efficiency is a difficult task. It is also suggested that port comparisons are only

valid if compared like with like. Bichou and Gray (2004) have also discussed the lower level of knowledge and awareness of port managers about logistics and supply chain management concepts as an important issue.

INDIA CENTRIC ISSUES

India's container port/terminal transformation began in the mid-1990s. Venkiteswaran (1995) discusses the limitations that were in force in India's legal framework in respect of privatisation. The obstacles faced by India in restructuring its port industry and moving towards a landlord port system based on the Government's liberalisation policy adopted in 1992 are discussed in De Monie (1995). The paper deals with the decision made to privatise the Nhava Sheva container terminal at Jawaharlal Nehru Port which began the transformation process from an antiquated system to a modern customer-oriented format. This was an imperative step to facilitate India's manufacturing boom and growth in international trading opportunities. Bennett (1995) discusses the small scale private sector involvement in India's port sector activities and the importance of large amounts of funds to develop port facilities in the future. This paper which appears as one of the first academic piece of work further deliberates the need to progress on privatisation of the ports on an urgent basis irrespective of national consensus on labour issues. Baird (2002) argues that especially, for developing countries, such as India, the way forward is only with a higher level of private sector participation. Haralambides and Behrens (2000) discuss the transformation of the Indian port sector. The privatisation process that commenced in India at JNP in the mid 1990s with the trade liberalisation has now been embraced by almost all the container ports.

Cumbersome import/export procedures and their adverse effects have been examined by Taneja (2004). Kumar (2001) discusses the trading opportunities and the competition India is facing with China since its accession to WTO and the infrastructure bottlenecks. Compared with China, India's progress is slow, Kumar states. The study carried out by De and Ghosh (2003) to ascertain the co-integration and causality between performance and traffic found that performances precede traffic in most Indian ports.

Kumar (2001) discuss the infrastructure bottlenecks. The opportunities available for the development of transport and port infrastructure through Public Private Partnerships (PPP) and, successful implementation of such projects are discussed by Sharma (2008). India's maritime sector prospects and challenges have been discussed in Vaidyanathan (2007) and Deloitte (2006). India's democratic political structure is cited as one of the main reasons for slow decision making compared with China. The diagnostic work carried out by Raghuram (2006) and Ray (2004) on JNPT, the largest container port in India, are comprehensive studies on the limitations of the port, Intermodal connections (rail and road) and other logistics infrastructure that cause port congestion. The potential and the lucrative opportunities prevailing in the port sector, the inherent bottleneck and issues that get in the way have been discussed in Lloyd's List (2005).

A detailed impartial analysis about the infrastructural requirements of India to absorb its economic growth is made in RREEF (2007). The report discusses the weak transport networks and port infrastructure. The authors suggest that the present situation 'scares off' foreign investors. Raghuram and Gangwar (2007)

discuss India's challenges in the context of its robust growth in trading volumes. The authors stress the need to develop deeper and state-of-the-art container terminals in order to avoid transshipment over ports in another country.

RESEARCH APPROACH

The literature review on port issues in India highlighted the factors that affect the productivity and efficiency of India's port interface. These factors are: port capacity limitations, insufficient investment, limited intermodal facilities and government bureaucracy. To obtain a better insight into the factors affecting port interface, the research approach used was that of qualitative research. In order to explore the issues further, interviews were conducted with 10 senior executives of ports/ container terminals, the recipient organisations of port services and other parties who have commercial interests in the industry. This included; shipping lines, logistics service providers and the other auxiliary services providers to the industry, consultants and academics. As the interviews could not be recorded and transcribed, for analysis purposes, the information was taken from the notes written on the 'contact summary sheets' and 'document summary sheets'. The analysis was based on the suggested methods by Miles and Huberman (1994) using the early analysis technique following the date sequence of interviews. Relevant chunks of information were extracted from interviews. They were in the form of quotes and phrases. Subsequently, these were clustered into themes, which were initially referenced from the literature review. The clusters which didn't have identified themes were given new titles. Some of the major concepts from the contact summary sheets, were as follows: capacity limitations as the capacity growth doesn't follow the demand growth, the depth/length overall (LOA) restrictions in ports, high costs, obsolete equipment, heavy dependency on private sector funding/ investment.

The data which was derived from the literature was analysed using the same method. This information was transferred to the document summary forms. The document summary forms were analysed and new themes emerged. These themes were then compared with interview data and the focus was narrowed down for this research. Two new factors have emerged were;

- (a) Human perspective in interpretation of policy
- (b) The degree of human contribution to port inefficiencies

RESEARCH MODEL

Figure 1 shows the research model depicting the themes that were identified through the exploratory research. At the centre of the model is human involvement as this features very strongly throughout the research. This is shown to be affecting the four other themes: Bureaucracy, Infrastructure Investment, Capacity limitations, Port efficiency. Human involvement is an essential theme as:

1. it affects policy and decision making through bureaucratic processes
2. it affects investment decisions
3. it affects capacity utilisation
4. it affects port efficiency

The outer layer of the figure depicts a process map which is cyclical in nature starting with the bureaucratic process which affects infrastructure investment. The shortage of adequate infrastructure leads to capacity limitations which may lead to inefficient port operations. Inefficient port operations are looked on by bureaucracy as being a poor return on investments leading to a decision for reducing investment.

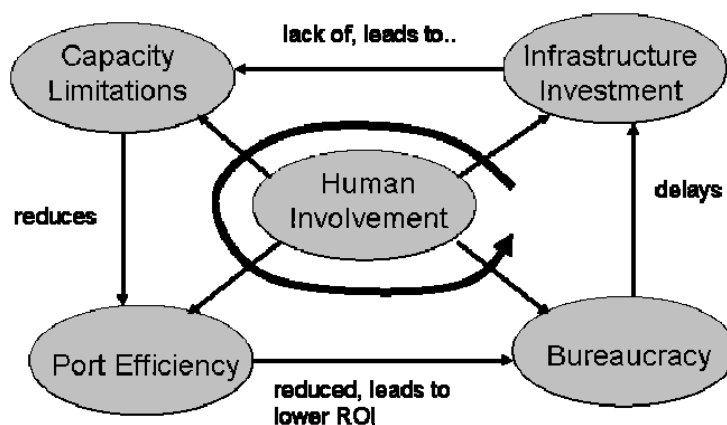


Fig.1 Issues affecting Indian Port interface

DISCUSSION

This research focuses on the bottlenecks and other pertaining issues that hinder the performance of Indian ports. The port interface is a vital component of the supply chain for a country such as India, which is experiencing an exponential growth rate in international trade. The port privatisation process that commenced in the 1990s required some control methods in place to maintain the true spirit of competition as the traditional government-controlled port trusts shifted to a 'landlord' role. This paved the way to set up government regulatory bodies such as Tariff Authority for Major Ports (TAMP) to look into the complaints of unfair practices and price increases in port services. The interviews revealed that some of the recent decisions made by TAMP are unfair to the private sector port management companies that have invested large sums to improve the facilities. It was further revealed that the private operators cannot apply a commercial 'cost plus' approach to pricing and the basis for the same is not driven by market forces. The attitude of the authorities who are interpreting the country's policies appears to be a distraction to the present and prospective private sector port management companies for investing in the port sector. This can create a substantial impact on the port capacity of the country. Also a cap on the rate of return on investment has been introduced and does not allow covering all recurring costs which may discourage the port operators to achieve optimal utilisation levels of the capacity/facilities or higher efficiency levels. This could create a detrimental situation for a developing-country such as India, which is expecting two thirds of its port funding requirement from the private sector. Further, this may even shrink the existing capacity due to management complacencies based on the 'why bother' attitude.

In contrast to long delays owing to environmental restrictions/procedures in Europe, India is suffering from delays due to cumbersome bureaucratic procedures in approving and implementing projects. Also, it is vital that India

sends the right message to the world to prove its consistency and reliability in the process of attracting new investors/terminal operators. The research, however, revealed that it is imperative that India expedite the processes in order to create the container port capacity ahead of demand. At present, the throughput growth is higher than that of capacity. The capacity utilisation of the Jawaharlal Nehru Port, which is the main container port of India, is about 112%, compared with its designed annualised capacity of 3.6 million TEUs. These situations usually bring the service standards down and may pose an adverse impact on productivity as a result.

Occasional port strikes and 'work to rule' situations are adding to the labour inefficiencies of Indian ports. Also, the stringent inflexible regulations such as export cargo cut-off times seem to be creating undue delays and adding to the congestion in some ways. The bureaucracy and procedural delays in export/import document processing are another factor that could adversely affect the efficiency of the ports. The literature search and the interviews highlighted the antiquated and complicated approval procedures that are still in place. Also, it has been noted that the security procedures should bring in a compromise situation with efficiency. Even though some modern terminals are equipped with modern access systems with a large number of gates, the bottlenecks in the access roads curtail the gate efficiency. Although this area is out of the scope of this paper, it is a contributory factor to port inefficiencies. The crane productivity level, however, have improved immensely with the private sector involvement in port management and at least, in a comparable situation with the main ports in Colombo, Hong Kong or Colombo. But, the efficiency levels of the areas where manual labour is involved has a lot of room for improvement.

The required periodical capital dredging, which is a responsibility of the government-controlled port trusts to maintain the right depth in entrance channels seems to be another area posing challenges to Indian ports. It was revealed that tenders are not being awarded in an organised way to carry out the dredging operations in time. As a result, some ports are unable to bring in larger vessels, and, therefore, facing difficulties in utilising the capacity. Most of the main ports do not possess higher depths required for larger vessels that are in service.

CONCLUSION

This paper has presented the results of a qualitative study conducted to explore the issues pertaining to the Indian port interface. The data was analysed to form themes and "human involvement" has been identified as one of the most important themes for this research. This is relevant in terms of recommending actions and suggestions with respect to more training of people involved in port operations, less bureaucracy, better resource utilisation. The research is still in the initial phases. In the future, more in-depth data will be collected to understand the processes as depicted in figure 1.

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INTERNATIONAL PORT COMPETITIVENESS: EMERGING MARKETS

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ABSTRACT

The purpose of this study is to perform an international comparison on port operations with a main focus on emerging countries. Using data from port industry during 2000-2005, this study conducts Data Envelopment Analysis (DEA) to analyze the efficiency performance of container port operations for emerging countries. In parts of CCR model and BCC model, the research findings suggest that China's largest container port (Shanghai) and Bangladesh's one (Chittagong) are very more efficient than ports of industrialized group. Based on self-assessment from CCR and relative assessment from CCR cross efficiency, we find that Bangladesh, China, Brail and Egypt are much more efficient and possess more competitive advantages than others. DEA analysis shows that this study focused only on land and equipment as input variables primarily because of the lack of data on worker efficiency. This paper makes a contribution to having a better understanding about competitiveness for the emerging economies (BRICs & Next 11) which are viewed as rising stars and yet have not been fully investigated in existing literature.

Keywords: Competitiveness, Emerging countries, Ports, DEA, RCA

INTRODUCTION

The BRIC's (Brazil, Russia, India and China) have three common characteristics plentiful natural resources, relatively young populations and large land areas that have prompted economic analysts to group them together as countries that will have a profound effect on the global economy in the future. O'Neill et al. (2005) at Goldman Sachs looked at the economic development potential of another set of developing countries, called "The Next Eleven (N-11)," that could rival or even surpass the BRICs.

Some emphasized that port efficiency is an important factor for a nation to achieve internationally competitive advantage (Tongzon, 1989, Chin and Tongzon, 1998).

As most import and export freights for a nation are mainly through container ports, to improve the nation's port efficiency of port becomes a challenging yet critical task. Ports are an important link in the logistics chain so the level of port efficiency affects – to a large extent – the country's competitiveness, since port efficiency results lower tariffs for exports which, in turn, favor the competitiveness of country products in international markets (González and Trujillo, 2007). Little international comparison research has been conducted on transportation industry and shipping industry.

Based on the above discussion, exploring the consequences of the problems spawned by economic growth of emerging countries on its transportation and shipping industries is of considerable importance, but an area that few scholars to date have pursued. This study will first review and discuss the country's logistics industry and the efficiency of its container ports and then describe respectively the use of revealed comparative advantage (RCA), DEA models and the derivation of input and output for the efficiency of container ports in the DEA sector. The paper will then analyze the actual results and present conclusions and suggestions for logistics sector in the emerging countries.

LITERATURE REVIEW

Previous scholars have used Stochastic Frontier Analysis(SFA), Data Envelopment Analysis (DEA), Multiple Linear Regression, Total Factor Productivity(TFP) and Free Disposal Hull (FDH) as their methodology to estimate the efficiency of container ports. This section will compare the methodologies used in the above-mentioned studies on container port efficiency.

Free disposal hull (FDH) and DEA were used by Wang et al. (2003) to analyze 28 of the world's most important international ports and the efficiency of their container terminals. The study found that the two models yielded different results, and the scholars suggested that DEA was the more effective model in evaluating efficiency in terms of decision making units' operational performance. Cullinane et al. (2005a) obtained the same results, and noted that the FDH model was not a sensitive tool in that it belongs to nature of its underlying logic and step function solution algorithm. The FDH model in fact concluded that the performance of decision making units was efficient when it actually was not. Cullinane et al. (2006) used SFA and DEA to evaluate 28 of the world's most important international ports and the efficiency of their container terminals. The study concluded that the SFA model was preferable when analyzing port operations because the hypothesis of constant returns to scale in the production frontier could not be rejected.

As we can see from the above-mentioned literature on comparison among SFA, FDH and DEA, the DEA approach seems to be appropriated to fulfill our research need not only because it is non-parametric but also because it does not require an explicit a priori determination of relationships between inputs and outputs, or the setting of rigid importance weight for the various factors, and it's an efficiency evaluation model based on mathematical.

METHODOLOGY - DATA ENVELOPMENT ANALYSIS

Looking back at previous studies, scholars who have addressed the subject of port efficiency relied primarily on the DEA-CCR and DEA-BCC models, so this study also used them as its base models. Wang et al. (2005b) mentioned that in terms of model orientation, input-oriented model is closely related to operational and managerial issues, whilst the output-oriented model is more associated with planning and strategies. With rapid expansion of globalization and international trade, many container ports must frequently review their capacity in order to ensure that they can provide satisfactory services to port user and maintain their competitive edge. From the perspective, this study used output-oriented model-CCR and output-oriented model-BCC to evaluate the efficiency of container port operations.

The CCR model proposed in Charnes et al. (1978) assumes that the production process yields constant returns to scale. When returns to scale increase or decrease, production combinations will be scaled up or down proportionally. Then, inefficiencies can be attributed to operations with different returns to scale. Banker et al (1984) expanded on the constant return to scale model by proposing variable returns to scale. When the CCR and BCC models assign a value of one to the efficiency of decision making units (DMU), it is impossible to rank the efficiency of container ports in India, the G7, the BRICS and the N-11 or differentiate their relative strengths and weaknesses. To address the issue, Anderson and Petersen (1993) proposed an A&P model that could differentiate the relative efficiency levels of decision-making units with efficiency ratings of one.

Input and Output Variables

Many different variables have been proposed so far by many scholars as indicators of port efficiency. As can be found that terminal area, the total quay length, the number of quayside gentry, the number of yard gantry and the number of straddle are often mentioned as input, and the number of container is often used by many as output. In addition, these variables can also be identified in Containerization

International Yearbook (2000-2007). As a result, these six variables serve as the input and output variable for our DEA model. As for inputs, the study adopted Cullinane and Wang's approach (2006) combined three variables (the number of quayside gantry, the number of yard gantry, and the number of straddle) into a single composite variable for later analysis.

The decision making units (DMU) for our DEA model are the largest container ports over the period of 2000-2005 in each country. Twenty-two countries were included in our DEA analysis. They are classified into three groups: the advanced economy (G7 –USA, France, Italy, Canada, Germany, Japan, UK), the BRICs groups, Brazil, Russian, India, China) and the Next Eleven group (Bangladesh, Egypt, Indonesia, Iran, Korea, Mexico, Nigeria, Pakistan, Philippines Turkey, Vietna).

RESULTS

This section analyzes twenty-two countries' operational performance of their container ports. Table 1 shows the CCR model, BCC model, A&P model, CCR cross efficiency model and BCC cross efficiency model rankings for ports in 22 countries between 2000 and 2005.

In the factor of CCR model, Shanghai, China and Chittagong, Bangladesh proved to have particularly efficient container port operations. Then, China's port is more competitive than India-port of Jawaharlal Nehru (0.6524), Brazil-port of Santos (0.7217) and Russian-port of Saint petersburg (0.2703)for the BRICs group and more efficient than the Next 11 group except for Bangladesh- port of Chittagong (1).In the BCC model rankings for the same 22 ports between 2000 and 2005, which yielded similar conclusions. After comparing the results seen between CCR model and BCC model in Table 1, the values obtained under the DEA-BCC model were higher than those yielded by the DEA-CCR model. The main reason is that the DEA-CCR model is limited by its assumption of constant returns to scale while the DEA-BCC model is not. Nonetheless, the CCR and BCC models had a correlation value of 0.877863, indicating that the two models are closely correlated.

Using A&P model to differentiate ranking of the decision-making units that have CCR-model efficiency values of one, such as China and Bangladesh, to separate them in the efficiency rankings. The result is that operations at Bangladesh's maritime freight port are more efficient than those at China's ports. Among DMUs, it is the country with the highest container operations efficiency.

Model Country	CCR	Rank	BCC	Rank	A&P	Rank	CCR cross efficiency	Rank	BCC cross efficiency	Rank
USA	0.8247	4	0.9177	5	0.8252	4	0.5317	5	0.5537	6
France	0.2733	20	0.3273	20	0.2733	20	0.233	20	0.2341	20
Italy	0.5133	9	0.5911	13	0.5133	9	0.4537	8	0.5206	8
Canada	0.4014	16	0.4264	19	0.4014	16	0.2896	17	0.2862	16
Germany	0.3166	19	0.6321	11	0.3166	19	0.2746	18	0.3291	15
Japan	0.5856	7	0.6972	9	0.5856	7	0.4744	7	0.5259	7
UK	0.3476	17	0.4511	17	0.3476	17	0.2935	16	0.2843	17
China	1	1	1	1	1.8474	2	0.935	1	0.9252	3
Russian	0.2703	21	0.2934	21	0.2703	21	0.2092	21	0.2254	21
Brazil	0.7217	5	0.7760	8	0.8158	5	0.6011	4	0.6637	4
India	0.6524	6	0.6877	10	0.6524	6	0.5048	6	0.5904	5
Bangladesh	1	1	1	1	7.4615	1	0.6376	3	2.3615	1
Egypt	0.4582	13	0.5625	14	0.4582	13	0.4020	11	0.3912	13
Indonesia	0.5659	8	0.6141	12	0.5659	8	0.4517	9	0.4440	10
Iran	0.5105	11	0.8042	7	0.5105	11	0.3123	15	0.2468	18
Korea	0.8819	3	0.9633	4	0.9521	3	0.7991	2	1.0503	2
Mexico	0.5047	12	0.8171	6	0.5047	12	0.3849	12	0.4149	11
Nigeria	0.0623	22	0.0626	22	0.0623	22	0.0574	22	0.0528	22
Pakistan	0.5111	10	0.9760	3	0.5112	10	0.4307	10	0.4609	9
Philippines	0.419	14	0.4757	15	0.419	14	0.3142	14	0.3525	14
Turkey	0.3379	18	0.4566	16	0.3379	18	0.2352	19	0.2352	19
Vietnam	0.4120	15	0.4348	18	0.4120	15	0.3603	13	0.4029	12
Number of Efficient ports		2		2		2		0		2

Note: N/A= data not available

Table 1 National Port Efficiency Comparison – Mean and Rank of CCR, BCC, A&P Model, CCR cross efficiency model and BCC cross efficiency model (2000-2005)

On the basis of self-assessment (absolute efficiency value) from CCR and relative assessment (relative efficiency value in comparison with other DMUs) from CCR cross efficiency, the two sets of efficiency values are positively associated with the correlation level of 0.936192. The self-assessment dimension from CCR is classified into three groups on the y axis. These groups are named 'less favorable self-assessment group', 'favorable self-assessment group' and 'more favorable self-assessment group', respectively. Similarly, the relative-assessment dimension from CCR cross efficiency

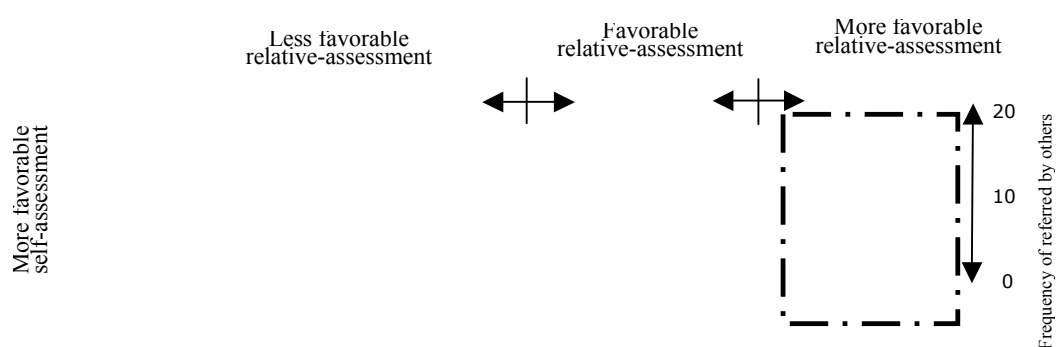
is classified into three groups on the x-axis into 'less favorable relative-assessment group', 'favorable relative-assessment group' and 'more favorable relative-assessment' group, respectively. The overall results on the operational efficiency of CCR and CCR cross efficiency are shown in Figure 1, with 21 countries divided into three groups (note: no cargo ports for Nigeria in 2005).

Group - (Self-assessment from CCR efficiency scores = 1, relative assessment from CCR cross-efficiency scores > 0.8)

The Group is composed of ports that are considered as benchmarking units. These ports are much more efficient and possess more advantages than others, including Bangladesh, China, Brail and Egypt. Then, the frequency of reference for Bangladesh, China and Brail by others are 14, 12 and 17 times, respectively. These ports should keep on maintaining their benchmarking status.

Group - (Self-assessment from CCR efficiency scores < 1, relative-assessment from CCR cross-efficiency scores between 0.6 and 0.8)

The Group constitutes of ports that need to improve their weakness of operational efficiency areas constantly. The group includes India, Korea and Japan.



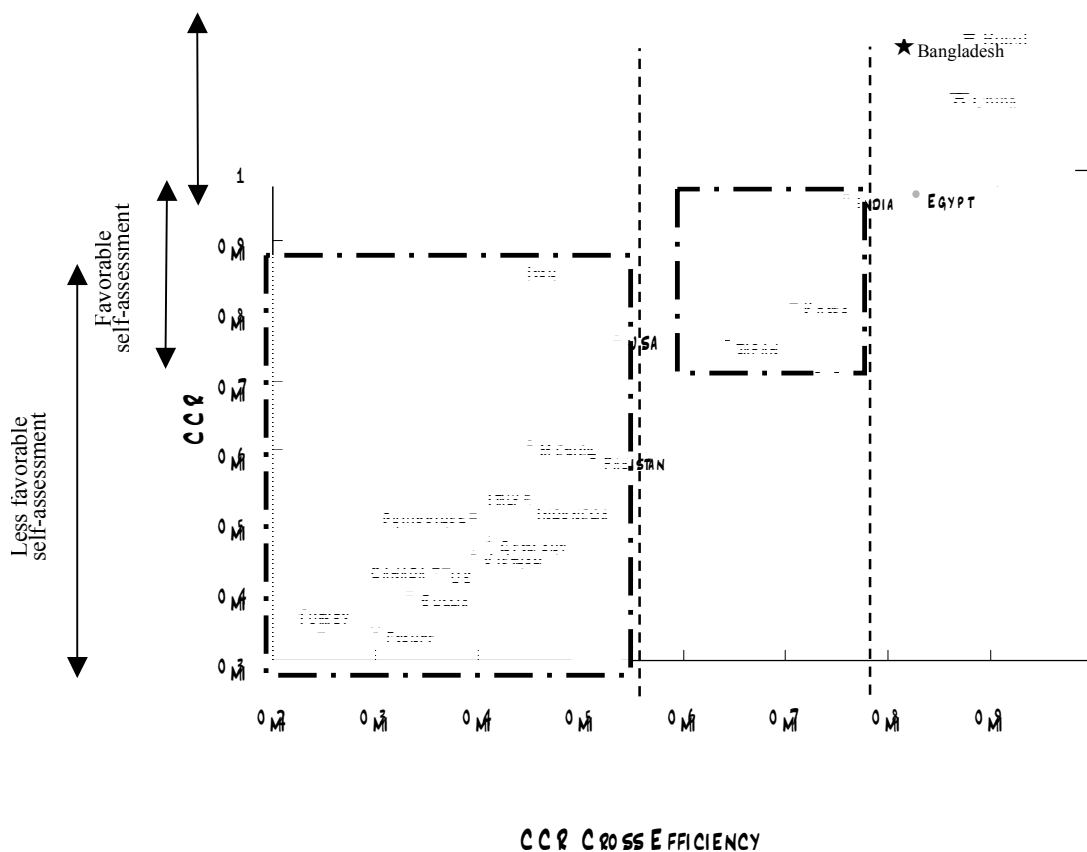


Figure 1 Chart of efficiency group for National Ports (2005)

Note: no maritime cargo ports for Nigeria in 2005

Group - (Self-assessment from CCR efficiency scores < 1, relative assessment from CCR cross-efficiency scores < 0.6)

The Group □ mainly includes ports that have no obvious competitive advantages over its counterparts in terms of port performance efficiency. These ports should urge to investigate their weakness of port performance and make more improvement efforts. It is surprising to note that this group includes USA, Iran, Pakistan, Mexico, Italy, Indonesia, Germany, Vietnam, Philippines, Canada, UK, Russia, France and Turkey some of which are located in industrialized countries.

CONCLUSIONS

This paper examined the efficiency of maritime port operations in emerging countries. Past studies in the field have focused primarily on the operational efficiency of container ports in developed countries, or of the top 30 container ports in the world, or on regional comparisons of ports. Very few have explored port operations in emerging economies.

Using the DEA-CCR and DEA-BCC models to measure the efficiency of ports in developing countries, this study found that the ports of Shanghai in China and Chittagong in Bangladesh had efficiency levels between 2000 and 2005 that even surpassed those found in advanced countries. There is no question that every port (except for China and Bangladesh) needs to upgrade its facilities and capacity urgently or else it will suffer from severe bottlenecks as trade volume expands. For example, India's biggest infrastructural deficiency is its lack of electricity, especially because high economic growth often leads to increases in electricity demand that far outpace the speed at which new power plants can be built.

Based on self-assessment from CCR and relative assessment from CCR cross efficiency, we find that Group (Bangladesh, China, Brazil and Egypt) are much more efficient and possess more competitive advantages than others. Furthermore, it is surprising that there are no ports of G7 falling into Group. Only Japan from G7 is included in Group, other ports from G7 are all in Group. If their main ports of every country can rapidly improve their links to external transportation networks and build up in-port railroad transportation services, they will be able to upgrade their operational efficiency (Kaisar et al., 2006).

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USAGE SEGMENTATION OF AIR CARGO MARKET OF HIGH-TECH INDUSTRY —FORWARDER OR EXPRESS?

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ABSTRACT

This study aims to develop a quantitative model to analyze usage segmentation of air cargo market of high-tech industry in Taiwan. A Generalized Linear Interactive Model (GLIM) was constructed to model the usage rate or market share of forwarder and express based on five categorical macro-segmenting variables. 540 recent cargo shipments commissioned by 150 Taiwanese high-tech manufacturers were collected and analyzed. They are used to stepwise examine the log-linear model accounting for the usage rate of forwarder and express. In addition to the individual variable effect, an interaction effect between variables was found. In using effective variables, 24 segments were established to divide the air cargo market. For each segment, market shares can be measured by using the parameters calibrated from the best-fit models. The empirical evidences provide valuable insights to support air carriers' decision-making on market targeting and service positioning.

Keywords - Air cargo, Generalized Linear Interactive Model, Usage segmentation, High-tech industry

INTRODUCTION

High-tech industry plays an important role in the developing countries such as Taiwan, South Korea, and China. When the industries attain the level to produce high value products (e.g. high-tech products like cellular phones), so as to upgrade the service quality, and match the life cycle of high-tech products which have become shorter (Lobo et. al, 1999), air freight will be used frequently to deliver these high-value goods (Baum, 1999) to reduce delivery time for satisfying international customers' needs of high speed and in time delivery. In 2003, the high-tech industry generated sales of US\$149 billion, accounting for 50.4% of GNP of Taiwan. In 2007, for certain high-tech products such as dedicated semiconductor foundry, TFT-LCD, and motherboards, Taiwan was at the leading stage in the world (MOEA, 2007). To enforce competitive advantages, business corporations will outsource non-core activities (e.g. transportation) to seek professional division for improving performance. In Asia, the transportation outsourcing activities attains to highest percentage of 96% (Langley, 2005).

Supporting industries have been important elements of high-tech industrial clusters in the development of high-tech industry (Chen & Huang, 2004). Air cargo transportation is one of the key supporting sectors for high-tech industry. World air cargo traffic will grow at 6.1% per year for the next two decades, tripling current traffic levels (Boeing World Air Cargo Forecast 2006-2007, 2006). Asia's air cargo markets will expect to lead the world. Average annual growth rates of domestic China and intra-Asia markets are expanding 10.8% and 8.6%, respectively. Meanwhile, the mature North America and Europe markets reflect slower and thus lower-than-average traffic growth rates, as in the past. At the same time, international express has grown at more than twice the rate of total worldwide air cargo traffic, averaging 12.9% annually over the past decade (BWACF, 2006). Vertically integrated companies such as Fedex, and UPS dominate the high-end express delivery sector of the air cargo industry, and

these integrated express carriers are also viewed as integrators (Forster & Regan, 2001). The express sector has creamed off high yield traffic and start to encroach on even heavier cargo. The traditional air freight companies and forwarders were threatened, since the market segments of air freight and express are less clearly defined (Lobo et. al, 1999). However, the empirical evidence was also not seen.

Market segmentation is defined as the act of dividing a market into distinct and meaningful groups of consumers by definable (identifiable) consumer characteristics (May, 1985). It can reduce operational costs via elimination of redundant efforts, as well as effectively allocate the firm's resources to target markets (Berrigan & Finkbeiner, 1992). Segments showing higher or lower usage rates may indicate immediate information for market targets and positioning (Sarel & Marmorstein, 1996; Wang et al., 1996; Weinstein, 2002). Segmenting markets by usage or consumption patterns is known as usage segmentation (Hu & Rau, 1995). To measure the market segments, we utilize usage rates to compare their competitions and market share. But to date, study of usage segmentation in the air cargo market is lacking. In the absence of segmented consumption information, specific air cargo competitions are often difficult to justify. Usage segmentation classes customers by demographic or other characteristics to differentiate among their usage pattern. However, in previous studies, the quantitative relationship between demographic characteristics and usage segments has not been clearly established (Hu & Rau, 1995; Wang et al., 1996; Weinstein, 2002). ANOVA (Analysis of variance) has often been used in segmenting analysis, but it is capable only of exploring the differences in the demographic referents of the usage segments. Furthermore, effects of the interaction between variables have not been satisfactorily quantified, and the usage rates of segments cannot be count directly through the estimates of model calibration.

Taking these concerns into account, this study aims to develop a quantitative model for application to usage segmentation and the interaction between segmenting variables in the air cargo market of high-tech industry. We utilized the concept of Generalized Linear Interactive Model (GLIM) to analyze the market share of air cargo carriers (forwarder and express) in each different segment. Within the model, we also assess the competition between forwarder and express.

To be identifiable for future implementation, segmentation variables include five categorically macro-segmenting variables: shipment destination, shipment size, delivery frequency, delivery time, and product status. The usage rate has been designated as the usage variable, in a non-negative quantitative form for precise expression. GLIM, a categorical data analysis tool, is capable of formulating the relationship categorically. Categorical segmentation variables can be well expressed within the GLIM. The model can as well as handling the non-negativity characteristic of usage rates, through a maximization of a Poisson log likelihood function. More importantly, the technique can clarify the associations and interaction structure of the variables (Tsai and Su, 2004).

We conducted face-to-face interviews with high-tech manufacturers from three main Science Park in Taiwan on their air cargo consumptions. Our big scale survey collected 540 recent air cargo shipments of consumptions commissioned by 150 Taiwanese high-tech manufacturers were collected between 2007 and 2008. SAS 9.1 software was used for the computations involved in model calibration. The results were distributed into 24 segments and delimit five competitive areas: forwarder-dominated market, forwarder-prone market, fierce competition, express-prone market, and

express-dominated market. The empirical evidences provide valuable insights on behavioural understanding of high-tech firms and serve as a basis to support air carriers' decision-making on future market targeting and service positioning. In the long run, the ability to analyze the segments of high-tech manufacturers is critical for air cargo forwarder and express in developing effective operational and marketing strategies.

ANALYTICAL MODEL

Segmenting variables

The principles that define a market segment are whether the identified population is sufficient in size, identifiable, stable, and accessible in terms of marketing costs (Schiffman & Kanuk, 1994). Industrial market segmentation based on broad two-step classifications of macro-segmentation and micro-segmentation (Wind & Cardono, 1974). The advantages of macro-segmentation variables are: (1) obvious and clear, (2) easy to identify, (3) easy to get, (4) easy to discriminate differences, and (5) easy to understand the characteristics and components (Wind & Cardozo, 1974; Hassan et al., 2003). Moreover, Usage rate can also be used to estimate international market size and potential demand in the marketplace (Nakip, 1999). To be identifiable for future implementation in our survey market, segmentation variables have largely referred to literatures (international and local), demographics, and interviewed by specialists of air cargo forwarder and express. Furthermore, in consideration of the limited sample size of the industrial case, we identified five categorically macro-segmenting variables that have been determined to be stable and identifiable for segmentation in previous studies, and each of the variables contains categorical levels among two to four, as indicated in Table 1. By the same token, the usage rate has been designated as the usage variable (Sarel & Marmorstein, 1996; Wang et al., 1996; Weinstein, 2002), in a non-negative quantitative form for precise expression.

Table 1 Segmenting variables and levels

Variable	Parameter symbol	Level	Description
Shipment destinations (Wind & Cardozo, 1974; Hlavacek & Ames, 1986; Tsai et al., 2007)	D	1	North America
		2	Europe
		3	China
		4	Asia (excluding China)
Shipment size (Shapiro & Bonoma, 1984; Bond & Morris, 2003; Tsai et al., 2007)	S	1	Small (45kg)
		2	Medium (45kg, and 100kg)
		3	Heavy (100kg)
Delivery frequency (Wind & Cardozo, 1974; Perreault & Russ, 1976)	F	1	Low-frequency (5 times, per month)
		2	High-frequency (5 times, per month)
Transit time required by customer (Maier et al., 2002; Danielis et al., 2005)	T	1	High-speed (4 days)
		2	Low-speed (4 days)
Product status (Wind & Cardozo, 1974; Webster, 1979; Tsai et al., 2007)	P	1	Work in process
		2	Final goods

Taken together, these five variables produced 96 (or $4 \times 3 \times 2 \times 2 \times 2$) market segments for analysis.

Generalized linear interactive model (GLIM)

The analytical usage segmentation model is expressed as a log-linear form of Generalized Linear Interactive Model for Poisson distributed data. GLIM is a well-developed categorical data analysis tool. The nature of this specification relates to the association and interaction structure among the variables. The parameters are calibrated by that use and maximum likelihood estimation (MLE) technique. So the parameter values estimated are those that maximize the likelihood of the models through a process of iteration. In the study, we justify our GLIM design for the following four reasons: (1) segmenting variables can be expressed categorically within GLIM.

(2) the model allows the statistical significance of partial and marginal association to be tested for a given combination of categorical factors; (3) the non-negativity characteristic of usage rates and consequences can be handled through a maximization of a Poisson log likelihood expression (see Saccomanno & Buyco, 1988); and (4) the parameters calibrated by GLIM is proved to be the best linear unbiased estimator (BLUE) (Agresti, 1990). In the development of the GLIM, the dependent variable of usage rate is measured by dividing the number of shipments which high-tech firms use air cargo transport service in a segment by the total amount of shipments in that segment, as indicated in Equation (1):

$$r = \frac{c}{n} \quad (1)$$

Where r is the usage rate in last 1 year,

c is the number of air cargo shipments signed by high-tech firms, and

n is the total amount of shipments in the segment.

The GLIM model specifies how the size of a cell count depends on the levels of the categorical variables for that cell. It is expressed in a log-linear form, to avoid negative numbers, and behaves as a Poisson-like function, with values ranging from 0 to infinity, reflecting a discrete outcome. The algorithm for calibrating log-linear models of the usage rate (r) permits the inclusion of the total amount of shipments in the segment (n) as an offset in the expression, as indicated in Equation (2). The strength of the association between the variables is expressed by the calibrated parameters of θ_r , in which five segmentation variables may be a multiplying factor specified as the interactions between the segmenting variables:

$$\begin{aligned} \log(r) &= \log(c) - \log(n) \\ &= \theta_r(D, S, F, T, P, DS, DF, DT, DP, \dots, TP, \dots, DSF, DST, \dots, DSFT, \dots, DSFTP) \end{aligned} \quad (2)$$

Where θ_r is a matrix of the calibrated parameters for usage rates.

In exponential form, the Equation (2) can be rewritten as Equation (3)

$$r = e^{\theta_r(D, S, F, T, P, DS, DF, \dots)} \quad (3)$$

DATA COLLECTION

To encourage the growth of high-tech industry, the Taiwanese government has established a number of science parks. Science parks also provide an important resource network for high-tech industry (Tsai et al., 2007). There are 588 high-tech firms approved in the three main Science Parks (Hsinchu, Southern Taiwan, and Central Taiwan) which generated total sales of US\$64.68 billion (National Science Council, 2007) in Taiwan, but only 495 high-tech manufactures produce in scale and export abroad. Firms which produce in amount tend to use air transport for exporting goods normally and regularly. To increase the credibility and validity of the results of our analysis, we mainly used face-to-face interviews with high-tech manufacturers' managers on their air cargo consumptions. If they were too busy to accept our direct interview, we adopted few questionnaires from them by mailing or faxing. For each of the manufacturers, a high-ranking manager in charge of the company air cargo transport decisions was invited for interview. According to our pre-study and pre-test, each respondent's recall was almost in two weeks, and the shipments they wrote were average within four in each questionnaire.

Our big scale survey collected 540 recent air cargo shipments (including 30 ineffective ones) of consumptions commissioned by 150 Taiwanese high-tech manufacturers

(average each firm provides 3.6 shipments) from three main Science Park in Taiwan between 2007 and 2008. Out of the total survey population of 495, the number of collected firms associated with air cargo usage was 150 (contributing to a response rate of 30.3%). Table 2 illustrates the general statistics of air cargo shipments of high-tech firms used in this study. The sample counts and the distribution between these categorical levels for each variable are expressed. Based on the statistical law of large numbers, the figures may give a picture of Taiwanese high-tech firms' demographics across these five variables.

Table 2 Statistics of the 540 samples used

		Variables	Levels	Sample counts	ratios	
Independent variables (categorical)	D (Shipment destinations)		1	128	25.1%	
			2	97	19.0%	
			3	131	25.7%	
			4	154	30.2%	
	S (Shipment size)		1	195	38.2%	
			2	71	13.9%	
			3	244	47.8%	
	F (Delivery frequency)		1	231	45.3%	
			2	279	54.7%	
	T (Transit time)		1	354	69.4%	
			2	156	30.6%	
	P (Product status)		1	131	25.7%	
			2	379	74.3%	
	Dependent variables	Number of using air cargo transport by forwarder (1) or express (2)		1	233	45.7%
				2	277	54.3%

MODEL TESTING AND PARAMETER CALIBRATION

The 510 effective samples were analyzed for model test and parameter calibration using the SAS 9.1 statistical software. The measure of goodness of fit for each model is scaled deviance, and measure of improvement in fit from one model to another is the reduction in the scaled deviance. Changes in the scaled deviances should have an approximately χ^2 distribution with the given degrees of freedom if the relevant factors introduced in moving from one model to the next do affect usage rates (Tsai & Su, 2004). Fitting and testing of the stepwise models is illustrated in Table 3, which summarizes the hierarchical steps used in a log-linear expression to the contingency table of segmentation variables that affect usage rate. In the process, terms can be added in a stepwise analysis of individual interactions. As indicated in Table 3, the 'best-fit' expression is obtained for Model (13), where the second-order term of ST (shipment size to transit time) is added to the sum of the first order of three individual variables, including shipment destinations (D), shipment size (S), transit time (T). Delivery frequency (F) and product status (P) were found to be ineffective in explaining usage rate. In GLIM form, the 'best-fit' model can be written as Equation (4).

$$\text{Log}(r) = 1 + D + S + T + ST \quad (4)$$

Table 3 Stepwise model fitting

Model number	Model fitting	Model testing	Scale deviance	Difference in S.D.	DOF	Difference in DOF	Conclusion (χ^2 5%)
1	Mean		140.5199		80		
2	D	1-2	129.9113	10.6086	77	3	S
3	S	1-3	79.7819	60.738	78	2	S
4	F	1-4	136.9149	3.605	79	1	N
5	T	1-5	120.2522	20.2677	79	1	S
6	P	1-6	139.934	0.5859	79	1	N
7	D+S	2-7	67.0661	62.8452	75	2	S
8	D+T	2-8	104.7396	25.1717	76	1	S
9	S+T	3-9	71.7761	8.0058	77	1	S
10	D+S+T	7-10	55.9193	11.1468	74	1	S
11	D+S+T+DS	10-11	49.779	6.1403	68	6	N
12	D+S+T+DT	10-12	53.375	2.5443	71	3	N
13	D+S+T+ST*	10-13	49.5992	6.3201	72	2	S

Note: DOF, degrees of freedom. *Model 13 is the 'best-fit' model.

The parameters of the 'best-fit' model were calibrated and the values are indicated in Table 4. Based on the analysis in SAS, the values of the final categorical level associated with the main and higher-order interaction effects in the model are intrinsically set

to zero. Thus, the estimates of all other levels for a given level of interaction are relative to the levels that are set to zero. Usage rates for various combinations of segmentation variables may be measured by directly using these calibrated parameters in the log-linear expression that includes these segmenting variables. For example, the usage rate of the segment of high-tech firms' export products transported to North America ($D=1$), packaged in small shipment size ($S=1$), and required high-speed transit time ($T=1$), can be labeled "111" and measured as:

$$\text{Log } r(111) = -0.0696 - 0.5048 - 0.4418 - 0.2842 - 0.8725 = -2.1729$$

$$r(111) = \exp(-2.1729) = 0.1138$$

Table 4 The values of parameters and effect of levels

Parameter symbol	Level	Parameter estimate	Effect of each variable
Mean		-0.0696	—
D	1	-0.5048	0.604
	2	-0.2222	0.801
	3	0.0396	1.040
	4	0	1
S	1	-0.4418	0.643
	2	-0.1744	0.840
	3	0	1
T	1	-0.2842	0.753
	2	0	1
ST	11	-0.8725	0.418
	12	0	1
	21	-0.0859	0.918
	22	0	1
	31	0	1
	32	0	1

RESULT ANALYSIS AND FINDINGS

The analytical model shows that three segmentation variables, including shipment destinations, shipment size, and transit time requirement by customers (similar results in Murphy & Daley, 1994; Tsai et al., 2007) are associated with air cargo usage in Taiwan, especially the interaction of shipment size and transit time. Further strategies of forwarder or express should be extensively reviewed to include the considerations of the shipment destinations, shipment size, and transit time required by customers. According to these three significant variables, we can minimize the original 96 segments in our study into 24 ones. In addition to give a clear and effective model for forwarder and express, high-tech manufacturers can also review their needs, and depend on their conditions of shipments to choose the better and more competitive air cargo service providers.

The parameters can also be used to analyze the effects of the categorical levels of a segmentation variable, when the other variables are held constant. The results are displayed in the last column of Table 4. It is found that the usage rate of shipment destination deliver to North America by forwarder (parameter estimator = -0.5048, and measured as $e^{(-0.5048-0)} = e^{(-0.5048)}$) is approximately 60% that of shipment destination deliver to Asia. Not only use the same manner above, but also want to recognize the relation of these four levels more easily, we set the effect of level 3 (China) into 1, then the ratios of North America, Europe, Asia to China are approximately as 0.58:0.77:0.96:1. It indicates that forwarders can penetrate the air cargo market more effectively in China, followed by Asia (excluding China), Europe, and North America. In addition, shipment with small levels had lower levels of air cargo usage by forwarder than medium and heavy shipment size (0.64:0.84:1, and measured as $e^{(-0.4418-0)} : e^{(-0.1744-0)} : e^{(0)}$). It means that forwarder has powerful capability to deliver heavier cargo than smaller ones, and it also shows that express gains the advantage in shipment with small size more than heavier ones. Similar results were

found in previous study of demand choices of high-tech industry (Tsai et al., 2007). Moreover, the usage rate of shipments with high-speed transit time which delivered by forwarder is approximately three-fourth that of low-speed transit time (0.753). Finally, the interaction effect of two variables, including shipment size and transit time, indicates that small shipment size with high-speed transit time delivered by forwarder is almost one-third (i.e. $e^{(-0.4418-0.2842-0.8725)-(-0.4418+0+0)} = e^{(-1.1567)} = 0.31$) the rate of small shipment with low-speed transit time delivered by forwarder, while the usage rate among medium shipment size with high-speed transit time transported by forwarder was 70% that of medium shipment size with low-speed transit time transported by forwarder.

By interaction, 24 segments of three effective demographic variables (4*3*2) that were statistically different in usage rate were located (Figure 1 and Table 5). Heavy shipment size with low-speed transit time delivered to China were identified as the segment with the highest usage rate (0.97, termed Segment 24). In order to compare the competition of forwarder and express based on their market share, we separate the usage rate into five zones and list the rates on each zone. The five competitive zones of forwarder and express are forwarder-dominated market, forwarder-prone market, fierce competition market, express-prone market, and express-dominated market (see Table 6). It indicates that forwarder and express compete with each other indeed. In accordance with each segment of each market zone, we can also find that forwarder have advantages over China and Asia market. Except small shipment size with high-speed transit time market prone to delivered by express, even the medium and heavy shipment size with high-speed transit time are dominated by forwarder (among Z1, Z2 and Z3).

The empirical evidences provide valuable insights on behavioural understanding of high-tech firms and serve as a basis to support air carriers' decision-making on future market targeting and service positioning. For express, in recent years, they try to enter the heavy air cargo market worldwide by cooperation or mergence with native service provider. In our study, it shows that express certainly extends their market share into medium and heavy cargo market. Moreover, they take advantage of their flexible flights to strike the low-speed transit time market. For example, in 2008, Fedex in Taiwan advertises for providing lower-speed delivery and cheaper charges for customers. For air freight forwarder, if they want to withstand the offensive competition, our study displays actually market share which can provide them to find the niche market. If they can coordinate with carriers to shorten the delivery time and do customer relation management effectively with high-tech manufactures, they may continue reaping profits. For users, they can also get better service in the competitive air cargo market.

Table 5 The usage rate of forwarder by segments

Segments	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
usage rate (y1)	0.114	0.327	0.424	0.362	0.473	0.563	0.151	0.433	0.562	0.480	0.627	0.747	0.189	0.541	0.702	0.600	0.783	0.933	0.196	0.563	0.730	0.624	0.815	0.970
D	1	1	1	1	1	1	2	2	2	2	2	2	4	4	4	4	4	4	3	3	3	3	3	3
S	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
T	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2

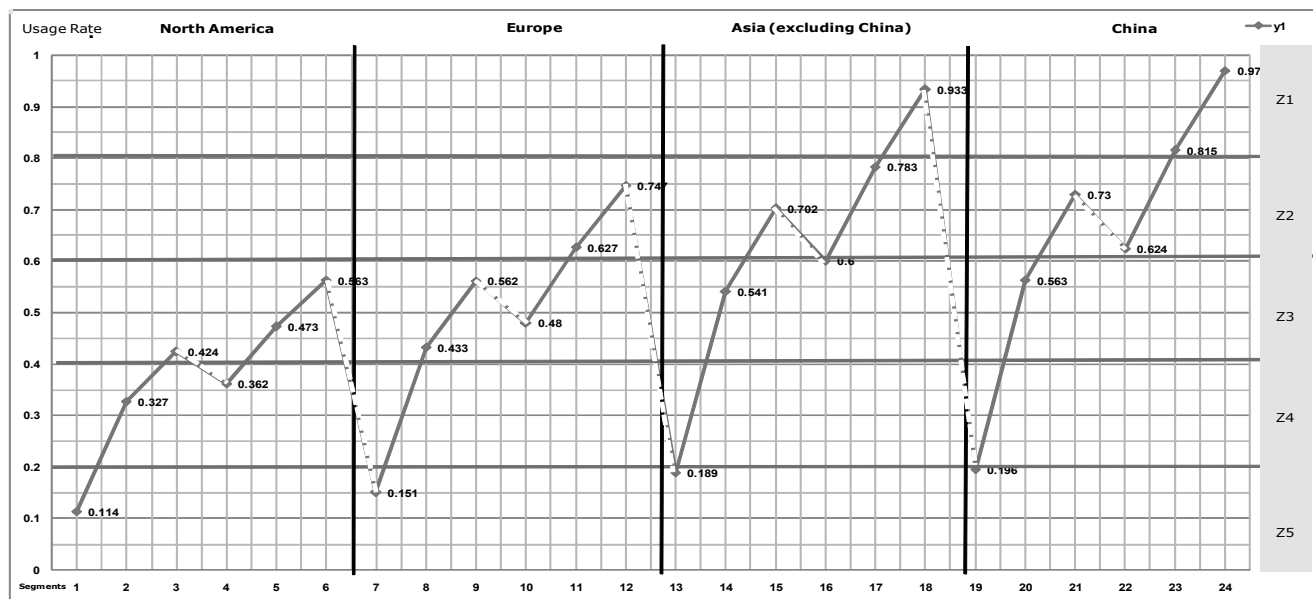


Figure 1 The usage rates by segments

Table 6 The market competitive zone of usage rates

The market zone	Description	Segment contained	Usage rate
Z1 (forwarder-dominated market)	usage rate 0.8	Segment 18 Segment 23 Segment 24	0.933 0.815 0.97
Z2 (forwarder-prone market)	0.6 usage rate □ 0.8	Segment 11 Segment 12 Segment 15 Segment 17 Segment 21 Segment 22	0.627 0.747 0.702 0.783 0.73 0.624
Z3 (fierce competition market)	0.4 usage rate □ 0.6	Segment 3 Segment 5 Segment 6 Segment 8 Segment 9 Segment 10 Segment 14 Segment 16 Segment 20	0.424 0.473 0.563 0.433 0.562 0.48 0.541 0.6 0.563
Z4 (express-prone market)	0.2 usage rate □ 0.4	Segment 2 Segment 4	0.327 0.362
Z5 (express-dominated market)	usage rate □ 0.2	Segment 1 Segment 7 Segment 13 Segment 19	0.114 0.151 0.189 0.196

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AN ALTERNATIVE DISTRIBUTION CHANNEL FOR FRESH AGRICULTURAL PRODUCTS AND PROPOSAL OF ITS BUSINESS MODEL

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ABSTRACT

In this paper, we present our research project to support small farmer's collaborative enterprise with Information and Communication Technology. The project has mainly intended on farmer's store called *Sanchoku*. In the store, farmers, most of them are small and aged, directly sell their crops such as green vegetables and fruits to consumers living suburbs. Hanzawa et al (2007) proposed the management supporting information system for the store. In the work, a prototype information system for the store is proposed. The system is characterized with its inventory control of products and web application for promotion of the store. We have extended the system and build a business model for the store with extension of concept of Vender Management Inventory. We proposed and implemented an information system for information sharing among farmers, the store and consumers to reduce stock shortage and opportunity loss. We have applied the systems to a certain *Sanchoku* store and have carried out an empirical test of the proposed system. With our system, the annual sales of the market achieved 10% incense from previous year.

Key words: SCM, VMI, Mobile Application

INTRODUCTION

A new distribution channel has lately attracted considerable attention for this decade where green vegetables and fruits are directly traded between consumers and farmers, especially in the suburbs in Japan. The channel is generally called *Sanchoku* from Japanese literal meaning of direct trading. The channel has several variants in management style. In this paper, we focused on the store style. The store has advantage in quality and security of products. Here we refer vegetables and fruits for sell in the store as product in this paper. However, most of managers are farmers, who are representative of farmer's union, and do not have strategy for retail trading. Therefore, the advantage of the store is usually spoiled.

In this study, we propose a new business model for the *Sanchoku* store to enhance its efficiency as a distribution system and product's value supported by information system. Hanzawa et al (2007) proposed the management supporting information system for the store. This paper extends the outcome of Hanzawa et al (2007) and presents a business model for the system. We have applied the information system on certain *Sanchoku* store for over a year. We present some comparisons of sales data to evaluate the proposed information system. With the empirical data, we discuss availability and effect of our proposed business model.

SANCHOKU DISTRIBUTION SYSTEM

Generally speaking, fresh agricultural products, which are vegetables and fruits in this case, are distributed from farmers to consumers via Agricultural Cooperation, Consumer Wholesale Market and Retailer in Japan. It has been a few decades since Farmer's store distribution channel as an alternative, called

Sanchoku, becomes highlighted. The store has originally started from petty trading for surplus vegetables on daily use only among the farmers. Nowadays, it has greatly become one of the major distribution channels of fresh agricultural products in the suburb areas in Japan. Meguro (2008) reports that the number of stores reaches 13538 in 2005. The annual sales of the store we investigated now reached over 200 million Yen, about 1.2 million Euros.

Members and Business

The *Sanchoku* store consists of consumers, farmers, a manager who is a representative of farmers and a store. The store is located in production area. Inside the store, there are shelves and each shelf is assigned to a farmer. The farmer prepares and manages his products on the shelf for sale. Consumers walk around inside of the store and take some favourite products from these shelves. They make payment at cashier like supermarket while the farmer is able to work and spend his time in his farming field. Occasionally, he visits the store to confirm the inventory. If stock level gets below then he replenishes the products. After closing the shop, the manager calculates total sales of the day and informs each farmer of the total income.

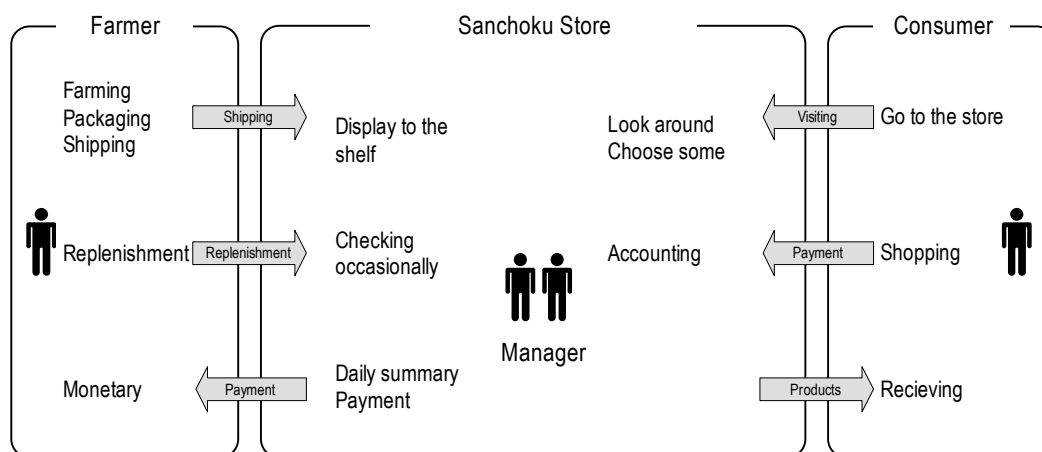


Figure 1. *Sanchoku* store and components

Characteristics and Role

The *Sanchoku* store has the following characteristics. First, quality of the product is relatively better than that of ordinary distribution channel such as General Merchandizing Stores. They are fresher because lead time from harvest to consumption is absolutely short. Furthermore, consumer can identify the farmer who grows the products. That means consumer can buy both products and food security. Price of the products is also relatively lower because distribution cost is significantly low. Note that consumer takes transportation function between production area to consumption area. Second, the store became an important source of income for small-scale and aged farmers. In fact, farmers obtain higher unit profit than other distribution channels. Like other developed countries, Japan is also facing the problem of aging society. Agricultural industries have been affected the problem and require a solution how to earn income by themselves. The system is expected to be one of solutions to the problem. Finally, the market does not have significant business model and its best practice. Core competence of farmers is agricultural farming. Therefore, they do not have enough strategies to compete with other distribution channels. For example, most *Sanchoku* stores have installed

POS terminals for consumer's payment. However, the sales data has not been reflected on the shop's strategies. Main competitor of the store is supermarkets including General Merchandizing Stores. Some comparisons between them are summarized in Table 1.

Table 1. Comparison of *Sanchoku* and Conventional stores.

		<i>Sanchoku Store</i>	<i>Conventional Store</i>
Location of store		Production area: takes time to go	Consumption area: easy to access
Founder		Farmers union, etc.	Corporation
Advantage for customer		<ul style="list-style-type: none"> ● Freshness (short lead-time) ● Low price with low cost ● High food security 	<ul style="list-style-type: none"> ● Wide variety ● Reliability on stock level ● Convenient store layout
Disadvantage for customer		<ul style="list-style-type: none"> ● Limited variety ● Stock shortage ● Inconvenient in store layout 	<ul style="list-style-type: none"> ● Less freshness ● Unclear distribution process
Advantage for farmer		<ul style="list-style-type: none"> ● High unit profit ● Meet customer's demand 	<ul style="list-style-type: none"> ● Stable demand ● High volume
Disadvantage for farmer		<ul style="list-style-type: none"> ● Unstable demand and Inventory risk ● Management works 	<ul style="list-style-type: none"> ● Low unit profit ● Strict criteria for shipping

SANCHOKU BUSINESS MODEL

We have proposed a new business model for *Sanchoku* store. The model aims two objectives. One is efficiency in operation management especially on inventory control. We have focused on information sharing among farmers, *sanchoku* store and consumers. The model is developed under concept of Vendor Management Inventory, VMI, see e.g. Lee(2006) for VMI. We introduce an information system for sales management and inventory control to prevent from stock shortage and opportunity loss. A farmer periodically receives e-mail through his cellar phone for replenishment. The inventory information is also provided to the consumers through the Internet. A consumer can check the number of current stock in the store by name of products. The consumer can reduce his risk for stock shortage while at his home. The web page can be powerful marketing tool for the store because people who have attention to the store surf the web pages frequently. At each step of the whole supply chain from farmer to consumer, stocks are maintained in proper level and, therefore, stock shortage and opportunity loss are greatly reduced.

The other aim is improvement of the product value especially on food security. Product of the store has advantages in food security as producer can be identified. Furthermore, each farmer has own technique for cultivating and is proud of them. However, farmer does not have enough access to media to

promote his product and himself. We have implemented Content Management System for this web promotion combined with Store-Consumer information sharing.

Inventory Information Sharing Model

The model is comprised three actors: farmer, consumer and store manager. See Figure 2.

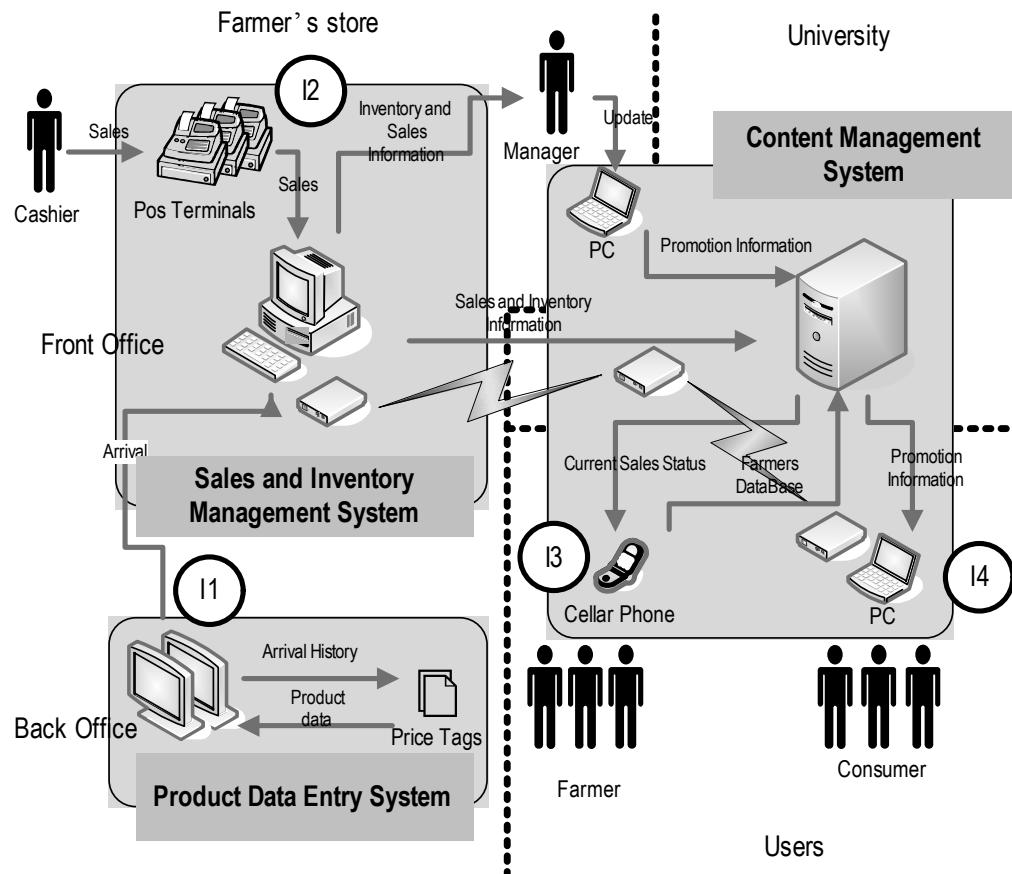


Figure 2. Sanchoku Business Model and Function of Information System

Farmers

- F1) A farmer harvests his crops, packs them into plastic bags, delivers to the store.
- F2) At the store, he enters data of the crops into PC and prints out price tags on which names of the product and the farmer are described.
- F3) He set the crops on his shelf and returns his farming field.
- F4) He receives e-mail about current sales status. He goes to the store to replenish his crops if necessary.
- F5) After closing of the store, he receives summary of today's sales.

Consumer

- C1) A consumer checks the current stock level through the web pages.
- C2) If there is enough stock for products he wants, he drives his car to the store. If there isn't, he can save his time to go.
- C3) When he arrives at the store, he buys some products in supermarket style. He can check the producer's name on the tag.

C4) Payment is done to the store manager at the cashier.

Store Manager

M1) When a customer comes to the cashier, manager responds to it.

M2) At the end of the day, he calculates daily summary of sales by information system and gives to each farmer by the form of small receipt.

Function of Information System

I1) When a farmer enters crops data at (F2), the server updates inventory information of the crops. Price tags are printed out simultaneously. History information is utilized to enter the data to reduce bothersome operation.

I2) Sales information of POS register at cashier (C4, M1) is sent to update inventory information immediately.

I3) At predetermined time, the server sends e-mail of current sales status for each farmer to urge replenishment (F4).

I4) The server updates inventory information periodically on web pages (C1).

CASE STUDY

We have carried out an experiment with Akasawa Sanchoku to evaluate our proposed business model. The experiment is organized by a consortium of Akasawa farmers union and Iwate Prefectural University. The role of university is business modelling and implementation of information systems.

Akasawa Sanchoku Store

The store is located in the suburb of Morioka city and it takes 30 minutes drive from the city centre. It is opened in 1985 and moved to current location in 1997. The annual sales of the market are about 200 million Yen, 1.2 million Euros, in 2006. The number of registered farmers is 124. Some farmers, 21% in recent investigation, ship their products not only the store but also ship to conventional distribution channels. The rest earns their income from the market and annuity. More than 50% of the sales are obtained from fruits, i.e. apples, grapes, etc. Therefore, September, October and November are high season of the sales. Figure 3 shows the picture of the targeted *Sanchoku* store.



Figure 3. Akasawa Sanchoku store the research target.
(left: outside, right: inside)

Implementation of Information System

We have prepared two x86 servers for Sales and Inventory Management System and Contents Management Server respectively. We also setup a client PC and some Point Of Sales terminals inside the market and connect them to form a LAN. The LAN is also connected to the Internet. Through the Internet, e-mails are sent from the Inventory Management Server to each farmer. Currently the web server is set up in the University because of maintenance. Label printers are connected to client PCs to print out the price tag. These client PCs are set up in the backyard of the store as they are for farmer's use.

Figure 4 shows a screen shot of the developed Systems. Above left corresponds to top page of Contents Management System. Consumers can obtain current stock level for each product through the pages. Above right is Product Data Entry System. Considering use of senior farmers, large size fonts are used and touch screen interface is adopted. Furthermore, history data which is entered previously are utilized to reduce number of operations. Bottom right shows precise sales information for store manager. Sales data is retrieved from POS terminals periodically and manager can check the records to support his strategy. Bottom right is e-mail message from the system.



Figure 4. Screen shot of developed information systems.(above left: Web promotion, above right: Product data entering, bottom left: Sales records, bottom right: e-mail notification)

Analysis and Discussion

The implemented information system is introduced to the store. Function for consumer-store information sharing has been developed but is currently in test. Web pages are opened in January 2007. And data entry system has been started in April 2007. E-mail notification is started July 2007. Figure 5 shows progress of introduced system. Above table shows number of users who enter data once in the month and accumulated printed price tags. Note that high season of the store is deep autumn. Most of farmers are still in use of the systems. Bellow left shows number of visitors to the web pages. We can see the number is gradually reduced after the august. Main reason is assumed that there is less update in contents during high season. Some correspondence is necessary. One idea is introduction of consumer-store information sharing under development. Bellow right is comparison of relative sales between 2006 and 2007, where monthly sales of 2006 are set to 100. Here monthly sales of 2006 are set to 100. Here monthly sales differ for each month.

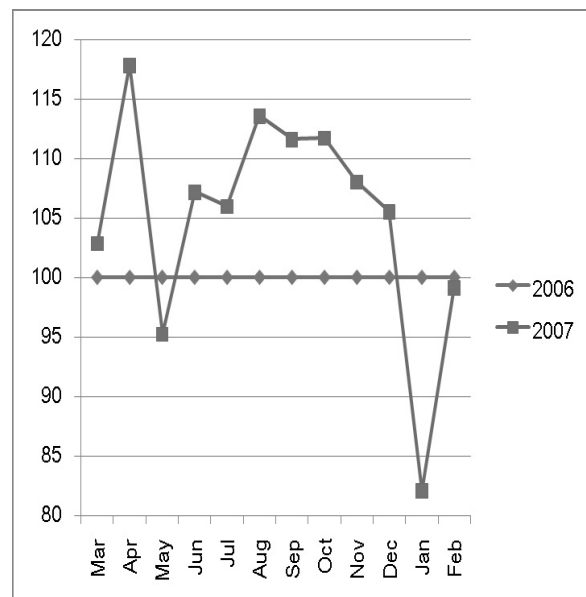
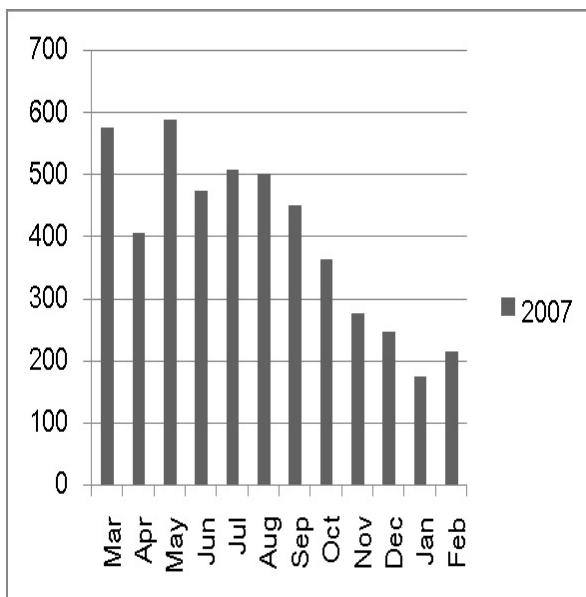
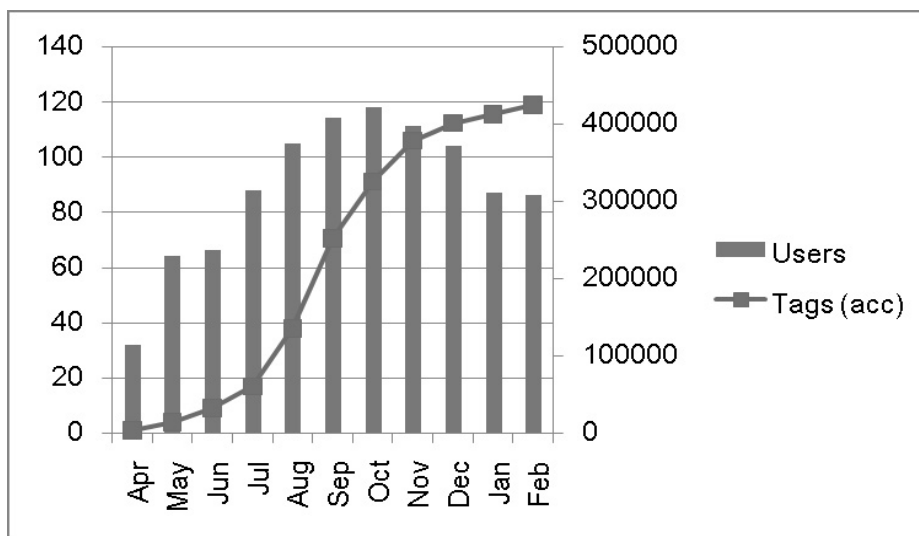


Figure 5. Outcomes of one year test of proposed model (above: number of users and issued price tags, bellow left: number of visitors to the web pages, bellow right: relative difference of monthly sales)

Total annual sale is increase of 10% than 2006. We can see proposed business model has certain effect on sales. However precise mechanism cannot be cleared. Another strategy is requires for further growth in *Sanchoku* store business. In 2007, the most of products are sold out. This causes reduction of sales in January. It is required to earn more sales by rising up each price and provide value-adding information that consumer can accept new price. As we have introduced information systems, we can monitor several performance indicators. To evaluate performance of the model, we are aiming to introduce some KPIs for *Sanchoku* store business. Furthermore, cultivation records for each product will enhance value of product from viewpoint of security. We also have a plan to extend our information system to treat cultivation records.

CONCLUSION

In this paper, we have introduced *Sanchoku* store and its role. We have presented a new business model for the store and information system supporting the model. The model is focused on inventory management for supply chain of farmer to consumer. The model and the system have been introduced to an actual *Sanchoku* store and achieved about 10% increase in annual sales. However, precise relation between introduce model and outcome revenue could not be described clear. This becomes further research subjects of this project. To evaluate the healthiness of business, we are going to propose some KPIs for *Sanchoku* business.

We are going to extend this model to another value-adding model. To achieve further advantage to the other distribution channel, food security will be important method to obtain consumers attention. We are planning to open the cultivation records to the public. Consumers are able to know precise information about the product on hand through Internet or mobile phones.

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THE STUDY OF SIMPLYFING THE BUSINESS IN AIR CARGO OPERATION

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ABSTRACT

This paper deals with simplifying the business processes in air cargo operation. The study of simplifying the business processes has been deeply introduced for the benefit from 'Paperless' through IATA 'e-freight Strategy'. Many of 3rd Party Logistics (3PL) providers requested their government entities to simplify logistics flow. Also there have been many areas where the adoption of this procedure has not been introduced. Compare to marine transport and land transport, air cargo operation deals with high price products such as semi-conductor, mobile phone, electronics products and etc. Also the transport container (e.g. unit load device or pallet) itself is expensive item and needs high level of management. As a key enabler for simplifying and automating the business, RFID is considered as a strong candidate by many airport cargos. In this paper, we present an RFID based cargo process and test procedure for introducing RFID to the air cargo operation.

Keywords: Air Transport, RFID, Air Cargo Operation, ULD.

INTRODUCTION

Major airports have been considering adoption of RFID technology for baggage handling process since 1999. Tests have been done at numerous airports/airline companies in US and Europe including Las Vegas, Jacksonville, Seattle, Los Angeles, San Francisco, Heathrow, Boston, New York and Rome. In the U.S. tests, it was turned out that RFID tags were far more accurate than bar codes when applied to baggage handling operation. Even though higher cost has prevented airports/airline companies from adopting RFID systems, US government's

requirement (after September 11) of screening all bags for explosives and reduced tag price has changed the situation (Collins, 2004). Boeing and air bus started to working together to promote the adoption of industry standard solutions for RFID on commercial airplane parts (Roberti, 2004). The two manufacturers believe that RFID could provide major benefits for the entire industry. The manufacturers believe that they will get more accurate information about their demand for parts. They expect the reduction of parts inventory and of repairing time for planes. Suppliers also expect the reduction of their inventory, improved efficiency in their manufacturing operations and want to use the technology to verify that parts delivered to Boeing and Airbus are genuine, thereby reducing the amount of unapproved parts that enter the supply chain. Airbus began RFID-tagging its ground equipment and tools four years ago and plans to implement similar RFID technology for maintenance and identification of removable parts on the A400M military transport aircraft. Also the world's largest commercial jet Airbus 380 will be equipped with 10,000 radio-frequency identification chips. The aircraft will have passive RFID chips on removable parts such as passenger seats, life vests, and brakes which will aid in maintenance of those parts (Malykhina, 2005).

Standards are being developed for the wide adoption of RFID in aviation industry. The International Air Transport Association (IATA) recently added an RFID standard to its SPEC2000, a comprehensive set of e-business specifications, products and services for the aviation parts industry. The standard calls for the use of ISO 15693 passive, read-write tags, which operate at 13.56 MHz. Federal Aviation Administration (FAA) certified the use of passive UHF RFID tags for parts that are used on planes.

With the adoption of RFID, a considerable amount of business cases and application developments are done as a part of simplifying the business initiatives such as 100% implementation of e-ticketing worldwide by mid-2008, implementation of Common Use Self Service (CUSS) kiosks worldwide, bar code standard for boarding passes, Radio Frequency Identification (RFID) for baggage management, paperless cargo environment (Figure 1). In this paper, we only focus on RFID application on the cargo operation as part of simplifying the business initiatives.

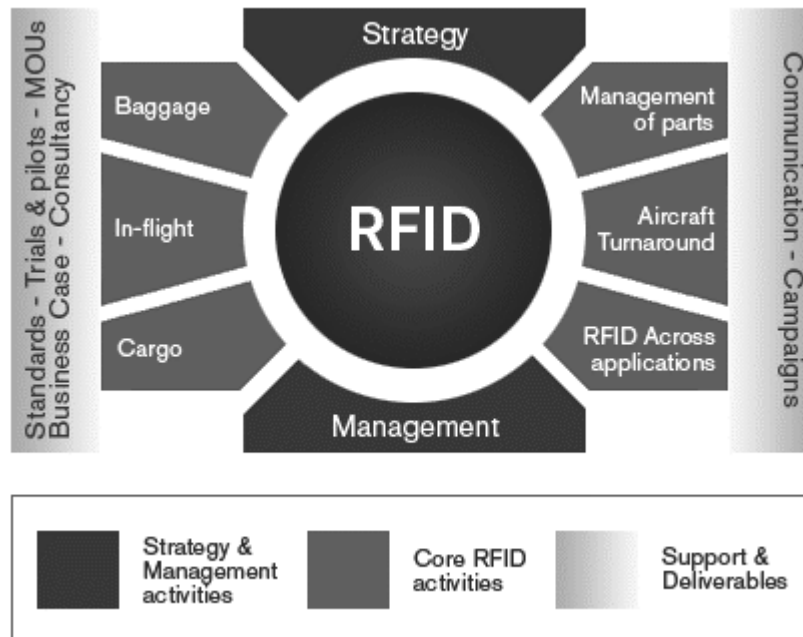


Figure 1. IATA' RFID initiative in the simplifying the business

IATA'S SIMPLYFYING THE BUSINESS IN CARGO

Currently there are three main RFID activities are ongoing in relation to the Simplifying the Business initiatives for in Cargo:

- Industry Knowledge is being developed to support a recommendation to the board. This is being done through a campaign to the airlines to understand the industry needs for ULD asset management.
- Jettainer and Airbus are two industry partners are working on the development of RFID in this area.
- Air France and KLM are trialing RFID tagging of containers although no Memorandum of Understanding(MoU) has been signed. IATA is working with ULD consolidators and airlines to bring structure to this area.

AIR CARGO OPERATIONS AND UNIT LOAD DEVICE (ULD)

Generally Air cargo operations consist of import area and export area (Nsakanda, 2004). The import area is dedicated to inbound freights while the export area is dedicated to outbound freights. The flow of goods through the terminal is either from the airside to the landside, from the landside to the airside, or from the airside to the airside via the terminal (for transfer). Air cargo operations (ULD process) and system consists of the following steps:

- Booking & receipt documentation: step for booking & check in by document (S/R-Shipping Request, HAWB-House Air Way Bill, MAWB-Master AWB, etc);
- Truck dock: Unloading transported cargo;
- Security Check Point: Dangerous cargo check. Except ULD unit entering cargo;
- B/U (Build-up): Loading cargo in ULD according to the MAWB;
- Storing (ETV): Storing ULD into ETV according to the flight schedule, in case of dangerous cargo which should be stored for 24hours;
- Weighting Scale: Before loading in airplane, weight a ULD for airplane's weight and balance;
- Apron : Before loading in airplane, ULD located in this place for a while;
- Loading/Unloading: Loading or Unloading ULD from airplane;
- Empty ULD control: Empty ULD keeping or supplying and demanding empty ULD;
- ULD Repair shop: Cleaning or repairing ULD.

It generally takes 4~24 hours (emergency cargo: 1.5hours) from entering of ULDs into the terminal to loading them to flight. All the baggage in the truck dock should be loaded 4 hours before the departure time; in case of animal and perishable, cargo should be entered terminal before 2.5 hours; and dangerous cargo should be stored 24 hours in terminal (Chang et al. 2004). By introducing RFID in cargo operation, we can simplify many processes by introducing RFID and reduce errors from manual input. Figure 2 shows a 'sequence diagram' of RFID based air cargo process and in this figure the entire message sequences (among objects) were represented by dimension and time.

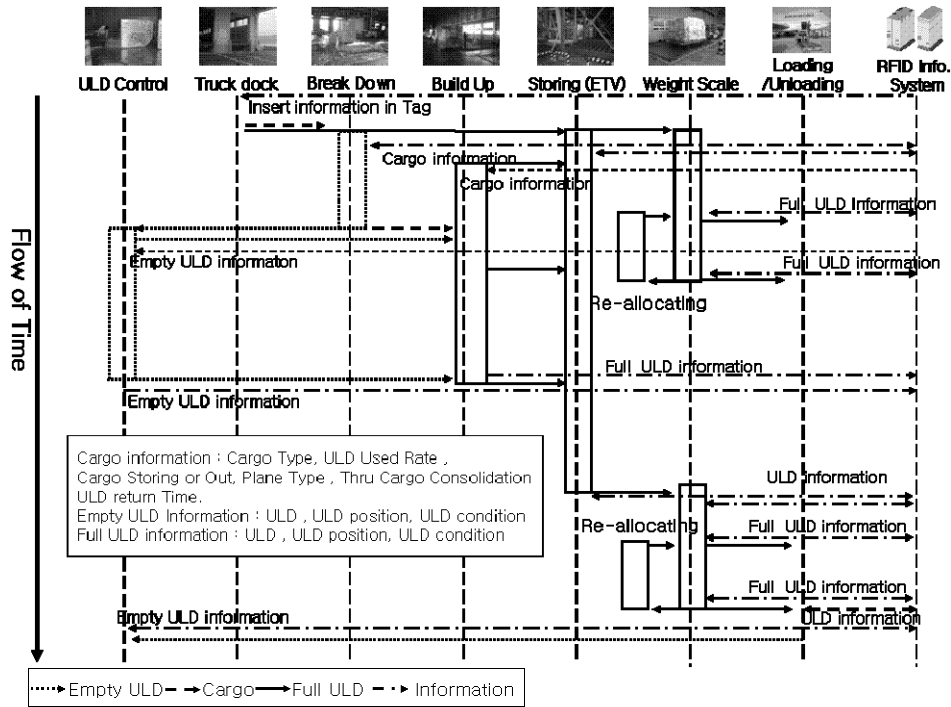


Figure 2. RFID based Cargo Process

In order to successfully implement RFID in cargo environment, it is considered that the following characteristics for air cargo operation should be considered and tested (Table 1).

Data size(bits)	Expected life(months)	Max/min humidity(RH)
Reading distance(mm)	Character length(bits/char)	Max/min temperature()
Batch read(number)	Certification (Cypto level)	Physical size(mm) ²
Time for identification(s)	Operating humidity(RH)	
Identification range(mm) ²	Operating temperature	

Table 1. Parameters for Choosing Right Technology

TEST METHOD AND PROCEDURE FOR RFID FOR CARGO OPERATION

Even though, RFID can be a key enable for simplifying cargo business, it is time consuming tasks to select RFID system and there is no standard procedure to choose proper RFID system. The following test steps are developed considering each cargo business step:

- Step 1: List general characteristics of system and test parameters. For example, Hardware dimension, mounting material/ read range, data rate, simultaneous reading, anti-collision
- Step 2: Define each business process as module. For example, Truck dock, 5 ton weighing scale, security check (X-ray machine), queue station, work station, ETV, by pass zone
- Step 3: Apply filtering values of technology for each business process. For example, reading range (3 meters), data rate (30kbps), simultaneous reading (10 tag/minutes)
- Step 4: Measure performance of test systems in real environmental module. By comparing filtering value and performance values, decide pass/fail

CONCLUSION

In this paper, we briefly introduced RFID based cargo process and test method for choosing hardware. We hope that our research will bring a guideline for test methods and can be used to support the success of RFID adoption in the air cargo operation which requires harsh and robust operating environments.

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SECTION 11

REVERSE LOGISTICS

ANALYTIC NETWORK PROCESS FOR WEEE REVERSE LOGISTICS NETWORKS

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INTRODUCTION

The increase in production of electrical and electronic devices in developed countries, along with the high rate of technological obsolescence and consequent processes of hardware upgrading, enhanced in the last years the problem of wastes. Newest estimates affirm that, only in Europe, the total amount of WEEE (Waste Electrical and Electronic Equipment) is about 7,5 million of tons/year, 50% of which are metal, with an annual rate of increase of 3-5%. Main environmental problems are related to toxic substances (Pb, Cd, Hg, Cr), non-biodegradability of devices and high risk of soil, air and water pollution.

Criticalities of WEEE pushed the European Union to assume relevant measures to prevent from uncontrolled dumping, to reduce the use of dangerous materials and to regulate the waste management. In particular, Directive 2002/96/CE (adopted with different national laws) introduced the following principles:

- WEEE differentiated collection is a duty of the producers;
- compulsory WEEE treatments, regulated by specific guidelines, have to be executed in authorized centres;
- recovery rate has to be progressively increased;
- producers have to finance WEEE management and spread information among users and disposers.

Directive gives the equipment producers the responsibility of dismissal at the end of its lifecycle, according to three alternatives of complete reuse (declassification), reuse of particular components, reuse of materials. The application of these rules has a significant impact on company policies and strategies, needing a new configuration of supply chains to introduce modern managerial issues and design integrated systems to control and prevent inaccurate customer behaviours (Pohlen & Farris 1992, Fleischmann et al. 2001, Spicer & Johnson 2002).

REVERSE SUPPLY NETWORK CONFIGURATION

In this context, reverse logistics assumes a great importance, in particular on the recovery of the highest possible percentage of components and materials, no more to consider as wastes. The target is to recuperate value from End Of Life (EOL) products and to allow an adequate disposal of consumed resources, as prescribed, at the same time reducing costs by the use of secondary raw materials. Given the interest of the customers in environmental issues, a correct management of reverse logistics can also give companies a key competitive asset, reinforcing the image on the market.

Compared to traditional logistics, the design of a reverse one presents different and complex aspects (Tibben-Lembke & Rogers 2002):

- in direct logistics, production and distribution are planned to reduce immobilizations. A wrong stock management generates higher costs and risks of obsolescence. In reverse logistics, instead, it's difficult to define and forecast the real demand of the products, depending on how and how

much they were used. The recovery can't be scheduled in time, with an high risk of fluctuation of infrastructures utilization, depending also on their saturation rates;

- a reverse chain needs many specialized service agents that can change depending on the different treatment the products need or the different possible EOL scenarios. Beyond producers, retailers, traditional distribution networks and end users, it's possible to find consortiums for special transportations and collection of wastes, recovery industries or landfills.

The number of levels of the closed loop chain (figure 1) depends mainly on the strategic approach of the producers. Having the responsibility of the EOL management, the company has to face a complex multicriteria problem to reduce reverse logistics costs and, at the same time, improve its environmental performances (Meade & Sarkis 1998, Ravi et al. 2005): for example, where a direct collection from the customers it's possible (i.e. electronic appliances), it tends to add end-of-mile echelons, granting a complete compliance to the law and offering opportunity of recycling and recovering while, at the same time, it points out the necessity of dedicated transportation means in terms of availability and saturation.

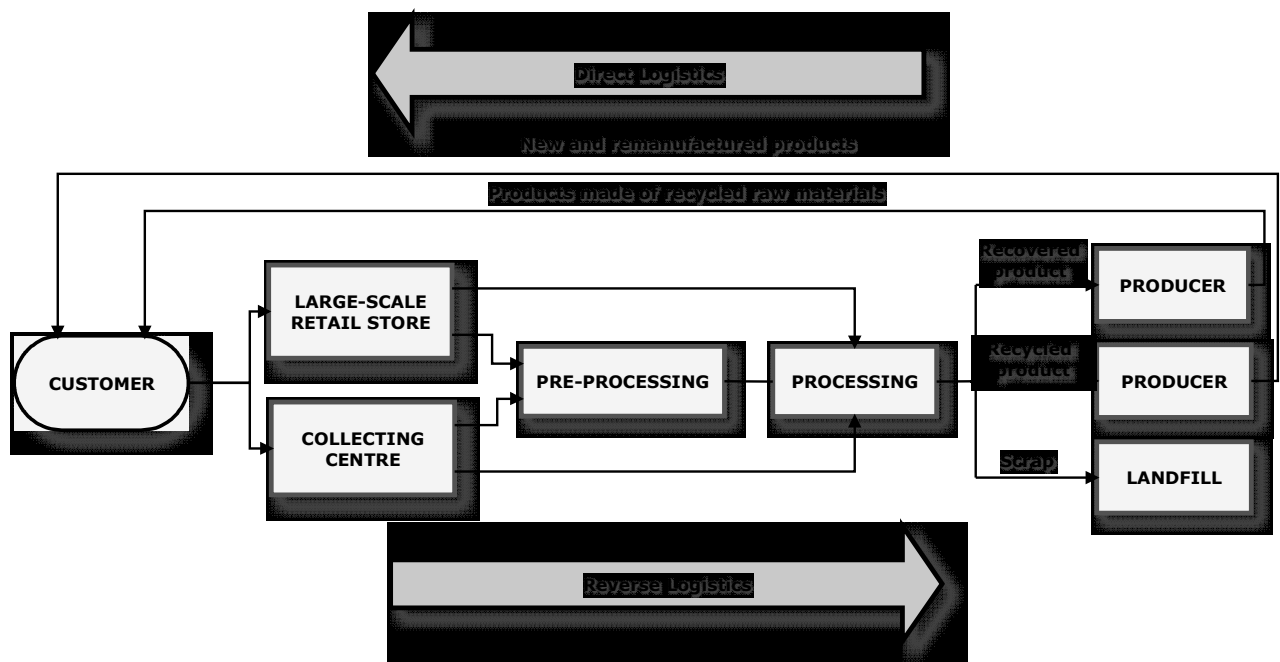


Figure 1 – Closed loop supply chain network

According to Fischer (1997) the configuration of supply chains has to balance efficiency and responsiveness depending on the different market environment and product characteristics as, for example, the sensitivity to time of their value. When defining a reverse logistic structure, the issues can be mainly be referred to positioning of test and processing centres and to collection strategies (Stock et al. 1998, Fleischmann et al. 2000).

When the target of the supply chain is the efficiency of the network, testing and processing agents have to be **centralized**. In this configuration, all the reverse

operations are effectuated in a centre that has to define the most opportune final destination of products and parts. Retailers or collectors are just used as connectors towards customers that can also carry EOL by themselves. This strategy, addressed as *postponement*, grants effectiveness of reparation, recovery of equipments, economy of scale but creates longer time of evaluation and queues, not compatible with time sensitive products.

When the target is the responsiveness to customers and reactivity of the network, testing and processing agents have to be **decentralized**. In this configuration, part of the reverse operations have to be processed directly in retail stores or in dedicated collection centres. This configuration, addressed as *preponement*, allows in advance a first evaluation of the EOL conditions: if it's unusable, it can be directly sent to dumping while, if it hasn't relevant damages, it can be regenerated, repaired or resold. The strategy allows a decongestion of test centres, reducing waits and response time, but it needs an accurate management systems and capillary investments in equipments for retailers.

Collection process consists of gathering and dividing, if possible with an accurate differentiation that starts from the awakening of the customers, the various typologies of products and transporting them to test and processing plants. This stage is particularly affected by the configuration of the network, the localization and capability of the agents, the market dynamics, the costs of infrastructures and management system in order to reduce global environmental impacts and grant more efficiency. Furthermore, the collection process depends on other factors as the accessibility of the infrastructures, dimensions of the products, its dangerousness and toxicity in an incorrect transportation and the possibility of turnover with an equivalent one. Two are the main possible strategies that can be implemented:

- **active collection**: the customer itself directly carries EOL to the opportune test centre, collection centres or retailers;
- **passive collection**: a specific logistic player, periodically or at defined quantities, is responsible of the process.

ANP

In order to handle multicriteria decision making, one of the widely used approaches is the Analytic Hierarchy Process (AHP). AHP, presented by Saaty in 1970s, is designed to structure a decision process in a scenario affected by multiple independent factors (figure 2). According to this method, complex problems can be divided into several sub-problems based on a hierarchical structure, where each level denotes a set of criteria or attributes related to each sub-problem. The top level of the hierarchy denotes the goal of the problem and the intermediate levels denote the factors of the respective upper levels, whereas the bottom level contains the alternatives or actions considered when achieving the goal.

Some decision problems cannot be structured hierarchically in a unidirectional relationship because of an inherent interdependence among decision levels. In these cases, the Analytic Network Process (ANP), a generalized approach of AHP, is more indicated to solve complex structures. The ANP feedback approach replaces hierarchies with networks (figure 2), in which the relationships between levels are not easily classified as hierarchical versus non-hierarchical, or direct versus indirect. In this case, for instance, not only does the importance of the criteria indicate the importance of the alternatives as in a hierarchy, but the

importance of the alternatives may affect the importance of the criteria of the decisional environment.

The ANP is composed of four major steps:

Step 1 - *Model construction and problem structuring*: the problem should be stated clearly and be decomposed into a network of clusters.

Step 2 - *Pairwise comparison matrixes and priority vectors*: pairs of decision elements at each cluster are compared with respect to their importance towards their control criteria. The clusters themselves are also compared pairwise with respect to their contribution to the objective. In addition, interdependencies among elements of a cluster must also be examined pairwise.

Pairwise comparisons express a relative judgement between two elements in a 9-degree scale of importance (1=equal, 3=moderate, 5=strong, 7=very strong, 9=extreme) where a reciprocal value is assigned to the inverse comparison ($a_{ij} = 1/a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the i-th (j-th) element).

$$\mathbf{A} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix}$$

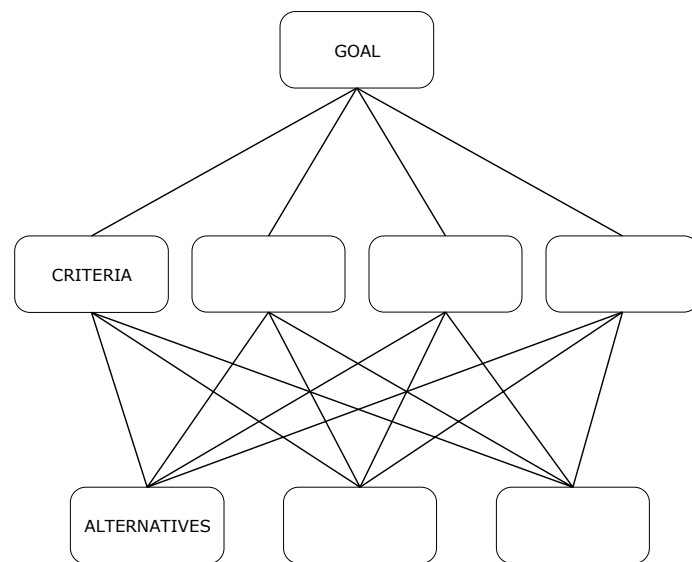
Pairwise comparison in ANP is performed in the framework of a matrix and a local priority vector can be derived as an estimate of the relative importance associated with the elements (or clusters) being compared by solving the following equation:

$$\mathbf{A} \times \mathbf{w} = \lambda_{\max} \times \mathbf{w}$$

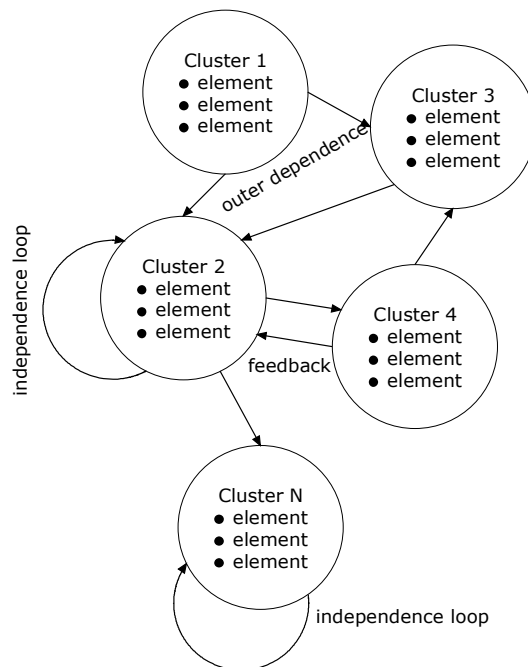
where \mathbf{A} is the matrix of pairwise comparison, \mathbf{w} is the eigenvector and λ_{\max} is the largest eigenvalue. The priority vector \mathbf{w} is often normalized by $\alpha = \sum_{i=1}^n w_i$. This ensures the uniqueness of \mathbf{w} and provides that α becomes unity. The consistency index (CI) of the derived weights could then be calculated by

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

In general, if $CI < 0,10$, satisfaction of judgments may be derived. With respect to any criteria, pairwise comparisons are performed in two levels, the element level comparison and the cluster level comparison.



HIERARCHY FRAMEWORK



NETWORK STRUCTURE

Figure 2 – Analytic Hierarchy Process and Analytic Network Process

Step 3 - *Supermatrix formation*: to obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a supermatrix (table 1) is actually a partitioned matrix, where each matrix segment represents a relationship between two clusters in a system. Let the clusters of a decision system be $C_k, k=1,2,\dots,n$ and each cluster k has m_k elements, denoted by $e_{k1}, e_{k2}, \dots, e_{km_k}$. The local priority vectors obtained in Step 2 are grouped and placed in the appropriate positions in a supermatrix based on the flow of influence from one cluster to another, or from a cluster to itself. A standard form for a supermatrix

is as shown in figure, where \mathbf{W}_{ij} is a block matrix consisting of priority weight vectors (\mathbf{w}) of the influence of the elements in the i -th cluster with respect to the j -th cluster.

Table 1 – ANP supermatrix

		C_1				C_2				...	C_N			
		e_{11}	e_{12}	...	e_{1n_1}	e_{21}	e_{22}	...	e_{2n_2}		e_{N1}	e_{N2}	...	e_{Nn_N}
C_1	e_{11}	\mathbf{W}_{11}				\mathbf{W}_{12}				...	\mathbf{W}_{1N}			
	e_{12}													
	...													
	e_{1n_1}													
C_2	e_{21}	\mathbf{W}_{21}				\mathbf{W}_{22}				...	\mathbf{W}_{2N}			
	e_{22}													
	...													
	e_{2n_2}													
...				
C_N	e_{N1}	\mathbf{W}_{N1}				\mathbf{W}_{N2}				...	\mathbf{W}_{NN}			
	e_{N2}													
	...													
	e_{Nn_N}													

Step 4: Selection of the best alternatives: once normalized the supermatrix, the alternative with the largest overall priority should be selected.

THE CASE STUDY

Due to rapid improvements in electronic manufacturing technologies, personal computers can be regarded as a short-life-cycle electronic product. The hazardous materials (i.e., phosphor coatings of cathode ray tubes and their high-lead content funnel glass, batteries, PCB capacitors, mercury-containing parts, plastics containing flame-retardant bromine, etc.) contained in computers may seriously pollute the environment if they are not properly disposed of. In addition to the hazardous materials, some valuable materials (i.e. copper-containing motors, plastic or iron parts, gold-, silver- and copper-bearing printed circuit boards, etc.) contained in scraps make them worth being recycled. Furthermore, a great part of EOL can be instead reused as new, at a very low cost, in many different operations that only need low performances and stability.

So, a reverse logistic network configuration problem for this kind of products has to face a very complex reality where all the different variables have to be accurately considered and all the possible alternatives can be investigated. An ANP application was developed according to the framework presented in figure 3 with a group decision making process, involving three logistic managers of the leader companies of the sector.

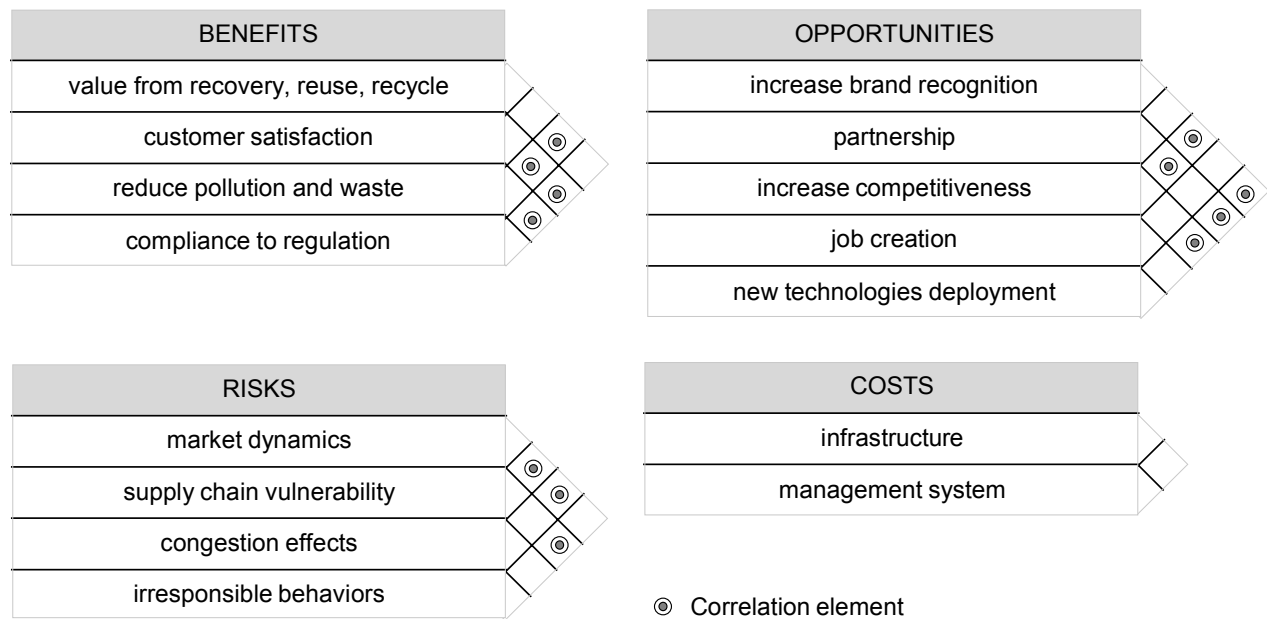


Figure 3 – ANP framework of analysis

According to the BOCR evaluation system (Benefits, Opportunities, Costs and Risks), the model was developed considering the following criteria and the correlations of their features (ANP):

- *Benefits*: an accurate selection of reverse logistics strategy may have positive impacts on the organizations and further extensions on customers, environment and other stakeholders (short-medium terms);
- *Opportunities*: the evolution of the market and competitiveness has an effect in opening new possibilities of collaboration and facilitate evolution and innovation processes (medium-long terms);
- *Costs*: an investment in supply chain configuration presents costs and immobilizations for dedicated infrastructures with related variable costs (short-medium terms);
- *Risks*: any intervention can be affected by uncontrolled events or unwanted effects that can harm company reliability (medium-long terms).

The criteria are AHP weighted, with highest priority given to short-medium term effects, to define their relative level of importance and finally aggregated according the standard formula of analysis in a Priority Index (P.I.):

$$P.I. = \frac{B \times O}{C \times R}$$

The alternatives in consideration are all the four possible combinations of positioning and collecting strategies (figure 4). In table 2 the results of the analysis present the different levels of preference.

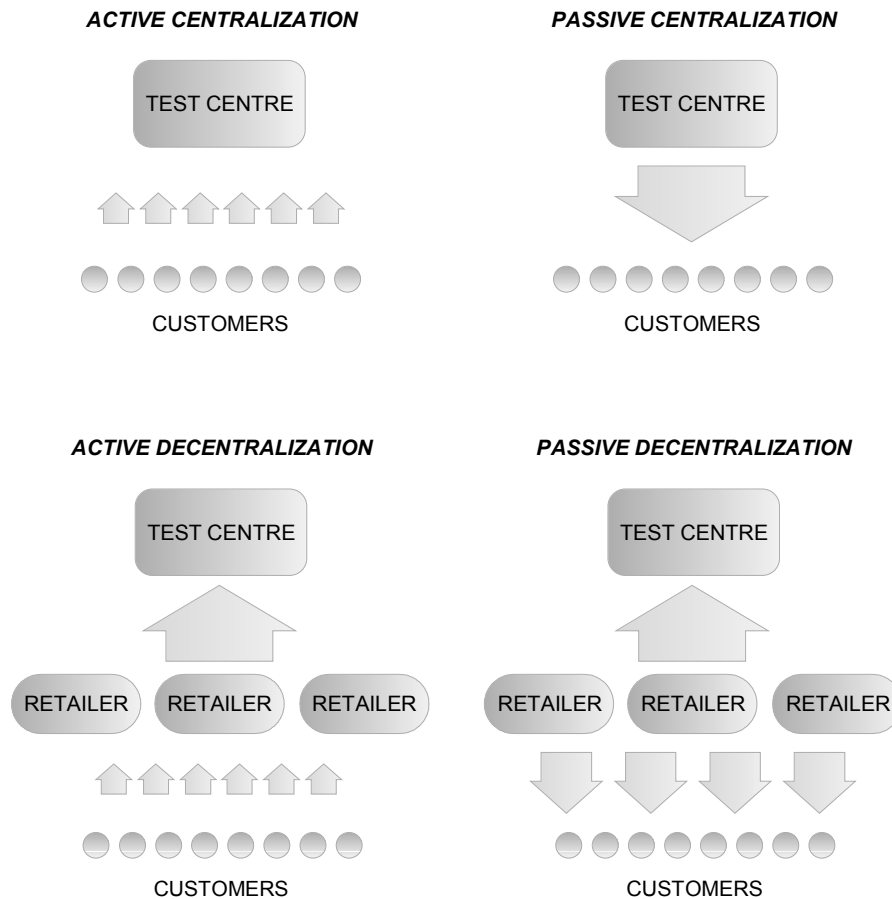


Figure 4 – Alternative strategies

Table 2 – BOCR model results

Alternatives	Criteria (relative weight)				Overall
	<i>Benefits</i> (0,375)	<i>Opportunities</i> (0,125)	<i>Costs</i> (0,375)	<i>Risks</i> (0,125)	
active centralization	0,059	0,191	0,059	0,323	0,130
active decentralization	0,146	0,219	0,157	0,217	0,206
passive centralization	0,259	0,295	0,243	0,152	0,455
passive decentralization	0,536	0,295	0,541	0,308	0,209

CONCLUSIONS

In the present work an ANP model has been proposed in order to choose the best reverse supply chain configuration for WEEE gathering and processing, according to the Benefits, Opportunities, Costs and Risks considered. By analyzing the pairwise comparisons it has been possible to prioritize the different alternative scenarios proposed for the computer collecting problem, making clear why one alternative should be preferred against another and in which measure. According to the model, the *passive centralization* strategy is the most suitable, whereas the *active* and *passive decentralization* seem to be equally judged.

Despite being simple in its application, the ANP approach enables the decision-makers to visualize the impact of various criteria in the final result and their interdependencies, which is of a fundamental importance in multicriteria decision problem. In the case of WEEE, the provided solution is of course a starting point for the reverse logistics project: after selecting the best alternative, a detailed feasibility study should be carried out, while the definition of its parameters of configuration can be again checked with a dedicated ANP model.

The model presents different possibilities of refinement that pass through tests on different types of WEEE (mobile phones and appliances) trying to identify and further detail the BOCR criteria and their correlations.

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A MULTIDIMENSIONAL APPROACH TO SUPPLY CHAIN FLEXIBILITY IN THE CONSTRUCTION SECTOR

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ABSTRACT

The paper explores the meaning of supply chain flexibility. It articulates a supply chain flexibility framework which identifies two key antecedents of supply chain flexibility: vendor flexibility and sourcing flexibility. We argue that dimensions of criticality of service, spend, regularity of demand and relationship type are important variables when considering vendor and sourcing flexibility. Using these dimensions, construction companies can segment their supply base into approved suppliers, preferred suppliers and framework agreement suppliers. These ideas are investigated through a number of construction case studies.

INTRODUCTION

As Oke (2005) has noted, the subject of flexibility can be complex and confusing. The plethora of research on flexibility has resulted in many perspectives and definitions. Ambiguity regarding terminology still exists, although fundamental ideas are the same (Naim et al., 2006). Manufacturing flexibility has been well addressed in the literature (Gerwin, 1993; Koste et al., 2004; Slack, 2005; Upton, 1994, 1995), but flexibility in the larger context of supply chain flexibility has received less attention. In this paper we propose a framework to rationalise supply chain flexibility and suggest a matrix to help consider vendor and sourcing flexibility in the construction sector. These are illustrated through case studies. Two key propositions are considered in this paper:

Proposition 1: Supply chain flexibility can be rationalised by considering two key antecedents of flexibility, sourcing and vendor flexibility.

Proposition 2: Dimensions of criticality of service, spend, regularity of demand and relationship type are important variables when considering vendor and sourcing flexibility.

LITERATURE REVIEW: A FRAMEWORK FOR SUPPLY CHAIN FLEXIBILITY

Flexibility is generally perceived as an adaptive response to environmental uncertainty (Gerwin, 1993). More specifically, it is a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance (Morlok and Chang, 2004; Upton, 1994). Hence, flexibility may be seen as a proactive attribute designed into a system, rather than a reactive behaviour that may in fact result in a detriment to time, effort, cost and performance (Naim et al., 2006). Flexibility may also be seen as having two distinct elements, those internal to the business, which describe system behaviour, and those that are viewed externally by customers, which determine the actual or perceived performance of the company (Oke, 2005).

Vickery et al. (1999) have defined supply chain flexibility as a amalgamation of product flexibility, volume flexibility, new product flexibility, distribution flexibility and responsiveness flexibility. Swafford et al. (2006) build on this and develop a

model that explores the interactions among flexibilities with respect to design, sourcing, manufacturing and logistics. Prater et al. (2001) identify speed and flexibility of sourcing, manufacturing and delivery as key determinants of supply chain flexibility. Tachizawa and Thomsen (2007) conclude that there are two main strategies that could be employed at supply chain level in order to increase the flexibility of a supply chain: improved supplier responsiveness and flexible sourcing. We build on this and make a distinction between 'vendor flexibility', which relates to the specific types of flexibility relating to individual vendors that support manufacturing, warehousing or transport operations, and 'sourcing flexibility', which relates the ability to reconfigure a supply chain network with little penalty in time or cost. The model presented in Figure 1 highlights two key inputs for supply chain flexibility, vendor and sourcing flexibility, and five key outputs, new product flexibility, volume flexibility, mix flexibility, delivery flexibility and access flexibility.

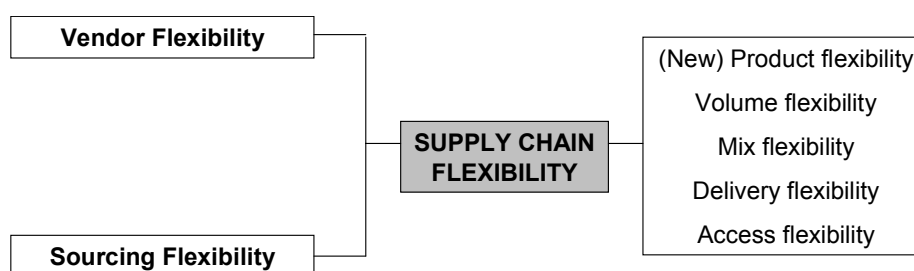


Figure 1: Framework for supply chain flexibility

Sourcing Flexibility

Tachizawa and Thomsen (2007) consider that flexible sourcing should involve the adoption of a larger supplier base and constantly redesigning and reconfiguring the supply chain, also known as adaptability (Easton and Rothschild, 1987). Gosain et al. (2005) refers to this as 'partnering flexibility', the ease of changing supply chain partners in response to changes in the business environment. In this case, the flexibility of the supply chain is determined by the ability of the leading firm to redesign the supply network quickly and at low cost. Chung et al.'s (2004) study of computer and peripheral firms highlighted the fact that companies retained the ability to easily switch partners, allowing for greater organisational flexibility.

Vendor Flexibility

Vendor flexibility refers to the collective types and flexibilities offered by different vendors in the supply chain. We argue that vendor flexibility comprises of manufacturing, warehousing and transport flexibilities. In a review of empirical research on manufacturing flexibility, Vokurka and O'Leary-Kelly (2000) highlighted 15 dimensions of manufacturing flexibility, most of them similar to those identified earlier by Koste and Malhotra (1999) (1999). Crowe (1992) lists various flexibility types defined by Browne (1984), Slack (2005) and Gerwin (1993) and Schmenner (1990). These have been summarised by Naim et al. (2006) as either internal flexibility types (machine, process, operation, capacity and re-routing flexibility) or external flexibility types (product, mix, volume, delivery and access flexibility).

Warehousing flexibility has also been discussed in the literature. This would include the ability of a system to cope with variable inventory volumes (Baker, 2006; Zhang et al., 2003), time window pressures (Abrahamsson et al., 2003; Barad and Even Sapir, 2003) and to offer additional value-adding services such as different forms of palletisation, packaging and cross-docking (Abrahamsson et al., 2003; Baker, 2006). Synthesising the literature on transport flexibility, Naim et al. (2006) identified key components of transport flexibility. In terms of the external flexibility types product, process, mix, delivery and access flexibility are identified. Nine internal flexibility types are offered. The first three, mode, fleet and vehicle flexibility, relate to the physical movement of the goods. Node, link and temporal flexibility are more closely aligned with the infrastructure provision. The final three internal flexibility types are capacity, routing and communication flexibility.

METHOD

The data for the case study was collected via a researcher being 'embedded' within a 'design-and-build' construction contractor for 10 weeks. The main contractor, which acted as the focal organisation for the case study has a turnover of £65 million, a workforce of around 550 employees and primarily serves the south of the UK. The key customers of the main contractor include housing associations, private housing clients and commercial developers. Data was collected via a number of techniques including observations, interviews, archival data and process mapping. In order to analyse different product delivery pipelines, the researcher was given access to a database of contact details for suppliers and subcontractors. A 'pipeline' survey was developed in-house by the authors to gather data about a supplier or subcontractor. This involved a mixture of telephone interviews, face to face interviews and site visits where appropriate.

VENDOR FLEXIBILITY IN THE CONSTRUCTION INDUSTRY

The role of vendor flexibility is highlighted via six different case studies. For brevity, the focus in this section will be placed on generic external flexibility types (as outlined in Figure 1) relating to different vendors. The intention is to highlight the importance of vendor flexibility in supply chain design. In the following section the importance of matching vendor and sourcing flexibility is addressed. A summary of the characteristics of the different case companies is shown in Table 1.

Elevators – Company A

New Product - Intelligent systems and technology is a big differentiator. Around 5-10% of business requires completely new engineering work. This often involves large scale commercial projects with frequent planning meetings and large numbers of elevators in unique layouts that are linked via intelligent systems.

Mix - The majority of elevators utilise standardized options for customers. A typical residential elevator, for example, offers a range of finishes, colours, capacities, dimensions, doors, panels lighting, rails and controls. All elevators are installed by an in-house team.

Volume - Production volumes are forecasted 6-12 months ahead to ensure that capacity can meet demand requirements. Based on relationships with clients, monitoring of construction investment and construction levels in different markets and analysis of business awards a 6-12 month forecast is usually accurate within +/-10% accuracy.

Delivery – Delivery, in the case of elevators, also includes the task of installation, which can take up to 4-6 weeks. Due to delays on site, storage for clients is commonplace and flexible labour installation plans must be revised daily. Key standardized modules and parts are held locally and centrally to help respond to urgent new installations or service requirements.

Access- With international operations, Company A is able to offer almost global coverage. Parts are consolidated in mainland Europe, where an in-house logistics function manages logistics.

	A - Elevator	B - Windows	C - Pre Cast Concrete	D - Roof Trusses	E - Metalwork Package	F - Brickwork Package
Employees	44000	20-30	350	150	30-40	N/A
Turnover	3.83bn	4.5mn	230mn	8mn	N/A	100mn
Typical Lead Time	16 Weeks	8 Weeks	6 Weeks	4 Weeks	4 Weeks	6 Weeks
Relationship with Main contractor	Framework Agreement	Preferred	Preferred	Preferred	Approved	Approved

Table 1: Summary of Supplier Characteristics. Adapted from Gosling et al (2007)

Windows – Company B

New Product – While many windows are produced to order very little, if any, are offered to the customer on an engineer to order agreements with new designs.

Mix - Customers are offered a wide range of standard choice for windows, including a variety of colours, sizes, locking mechanisms, acoustics, ventilation systems, sills, restrictors and glazing. Finished goods are held for the Swedish market, where the manufacturing is based, and products for the UK are typically made-to-order. Company B can also offer installation services.

Volume – Different quantity requirements can easily be built onto the planning system unless it is a very large project, which might increase the lead time.

Delivery – In addition to delivery, installation for windows is also required. Gangs of labour can install 40-50 windows per week into a structure if required. Logistics is outsourced to a third party who is able to rush through orders or offer stockholding either centrally, in northern Europe, or locally, at locations in the UK, if a due date is too early for a project.

Access – A third party logistics provider provides coverage of the UK and most of Europe.

Pre Cast Concrete – Company C

New Product – Typically each order has unique fixing and hole penetrations, along with unique dimensions, which are subject to a maximum and minimum. Special requests are considered on a project by project basis.

Mix - A range of standard depths for pre-cast concrete are offered which are set in 5mm increments. Widths and lengths can be cut to order, but a maximum is placed on both dimensions. Company C can also offer design, stock holding and installation services.

Volume – If the order book is full it is very difficult to increase volume at short notice as the manufacturing capacity is constrained by concrete pouring space.

Delivery – When pre-cast concrete is delivered both plant and labour are both required on arrival to install flooring directly into location on site. In the case of

rush orders it is possible to reduce the manufacturing lead time down to two weeks, but labour and plant must be available for site installation to make this worthwhile.

Access – Due to the size and difficulty of transporting concrete most of the market is in the south of the UK.

Roof Trusses – Company D

New Product – Products are rarely based on completely new orders but mix pre-existing designs for different requirements depending on size, preferred style and construction method. Plates, which bind the timber together, are the main obstacle to new product development as they are tied in with design software and are only available from a small number of suppliers in the UK.

Mix – For the majority of orders, Company D receives sizes and designs from design consultants and then designs the roof trusses within these guidelines. Most of these drawings are based on existing designs. No installation service is offered.

Volume – Very large orders may require a one or two week notice period.

Delivery – Company D can hold around two weeks worth of stock on site. Extra stock can be called off on a very short lead time unless there are very large volumes.

Access – 75% of business is in London or the south of the UK.

Metalwork Packages – Company E

New Product – Typically, responds to metalwork designs that are produced by design consultants and either responds with a competitive bid for the work or rejects the work if it is unsuitable.

Mix – Small design changes, which are fully specified by drawings, can be accommodated. A wide range of metalwork products are also offered including structural steel, architectural steel, balustrading, handrails, sheet metalwork and metal decking. Company E does not offer any design support services.

Volume – Company E is an SME and operates from a small site in the South East of the UK. Volume flexibility is, therefore, limited. The flow of make-to-order and buy-to-order products needs to be carefully managed to overcome capacity constraints.

Delivery – Due to the small premises there is limited space to hold stock. Once items have been produced there is little flexibility to hold these in storage in the case of project delays. Most items, however, can be held on site.

Access – Company E targets the south east of the UK as its primary market.

Brickwork Packages – Company F

New Product – New designs and technical specifications are difficult and expensive to implement but Company F is willing to liaise with manufacturers and designers to deliver such requirements.

Mix – A standardised list of brickwork based on aesthetic, technical specifications and cost is offered to customers. Company F acts as an agent among construction companies, manufacturers and design consultants, to encourage all parties to agree on a package that will have an overall cost, finish and specification to meet the needs of all stake-holders.

Volume and Delivery – Working stock availability at manufacturing locations determines the degree of delivery and volume flexibility. For more standardised bricks, Company F is able to search for available product from a range of manufacturers to satisfy late delivery or volume changes.

Access – With 24 sites in the UK, Company F offers coverage throughout the UK.

SOURCING AND VENDOR FLEXIBILITY IN THE CONSTRUCTION INDUSTRY

This section intends to show how sourcing flexibility and vendor flexibility can be combined in the construction industry to maintain a network of suppliers that are 'fit for purpose' (Cox and Thompson 1997). The 'strategic partnering' approach to construction has recently been promoted by UK government reports and government bodies, such as the Latham report (1994) and constructing excellence (Constructing Excellence, 2005), and there has also been a growing interest by researchers (Akintoye et al., 2000; Beach et al., 2005; Bresnen and Marshall 1999; Ireland 2004; Cox and Thompson 1997). However, in an industry dominated by 'one off' projects with a high degree of customisation, strategic partnerships need to be considered vis-à-vis flexibility requirements.

The total supply chain network, in the case study presented here, is managed by segmenting suppliers and subcontractors into three different categories: approved, preferred and framework agreement. These classifications are used to inform sourcing and procurement decisions for different projects. 'Approved' status refers to suppliers and subcontractors that have filled in a questionnaire and health and safety standards have been inspected and the organisation has been vetted with references. 'Preferred' status builds on this layer and is granted when an organisation successfully completes a number of projects and delivers consistently on key performance indicators (KPIs). Finally, 'framework agreement' is a formal recognition of a partnership and includes such activities as tender assistance at the pre-contract stage, periodic reviews and meetings and problems resolution frameworks. The vendors described in the previous section have been mapped onto figure 1.

In this case the main contractor holds a database of around 750 suppliers and subcontractors. 70 of these are recognised under a framework agreement. 180 are recognised as preferred contractors and 500 are approved suppliers. Figure 2 illustrates the classification. To better understand the rationale behind this framework, we have mapped the layers used by the case company onto three inputs that are critical to supplier analysis (criticality, spend, regularity of demand) and one output, the appropriate relationship type. We define these different dimensions as follows:

Criticality – The criticality of the output of a supplier or subcontractor to project success. Some products or services will have significant implications for cost and time if they fail.

Spend – We use this to refer to the proportion of total procurement spend that a service, supplier or subcontractor accounts for (Constructing Excellence, 2005).

Regularity of demand – the extent to which demand is low volume and project specific or high volume and applies to a number of different projects (Ireland, 2004).

Relationship type – A continuum of buyer-supplier relations is proposed ranging from loose, which will be characterised by one off, arms length transactions, to close relationships with repetitive transactions (Cox and Thompson, 1997).

We argue that different approaches to flexibility are required at different points in the model presented. For construction organisations to effectively compete they are required to redesign their supply chain quickly, and at little cost, for the different projects that they are currently engaged with or bidding for. Supply

chain flexibility has a crucial role in this task. The top left area of the model, where 'framework agreements' are utilised by the case company, demonstrates a recognition of the benefits of the strategic partnering approach for critical areas of the project that account for a high proportion of spend and are used frequently on different projects. The network co-ordinator will need to look carefully at both the external and internal flexibilities of these strategic partners with the aim of maximising vendor flexibility.

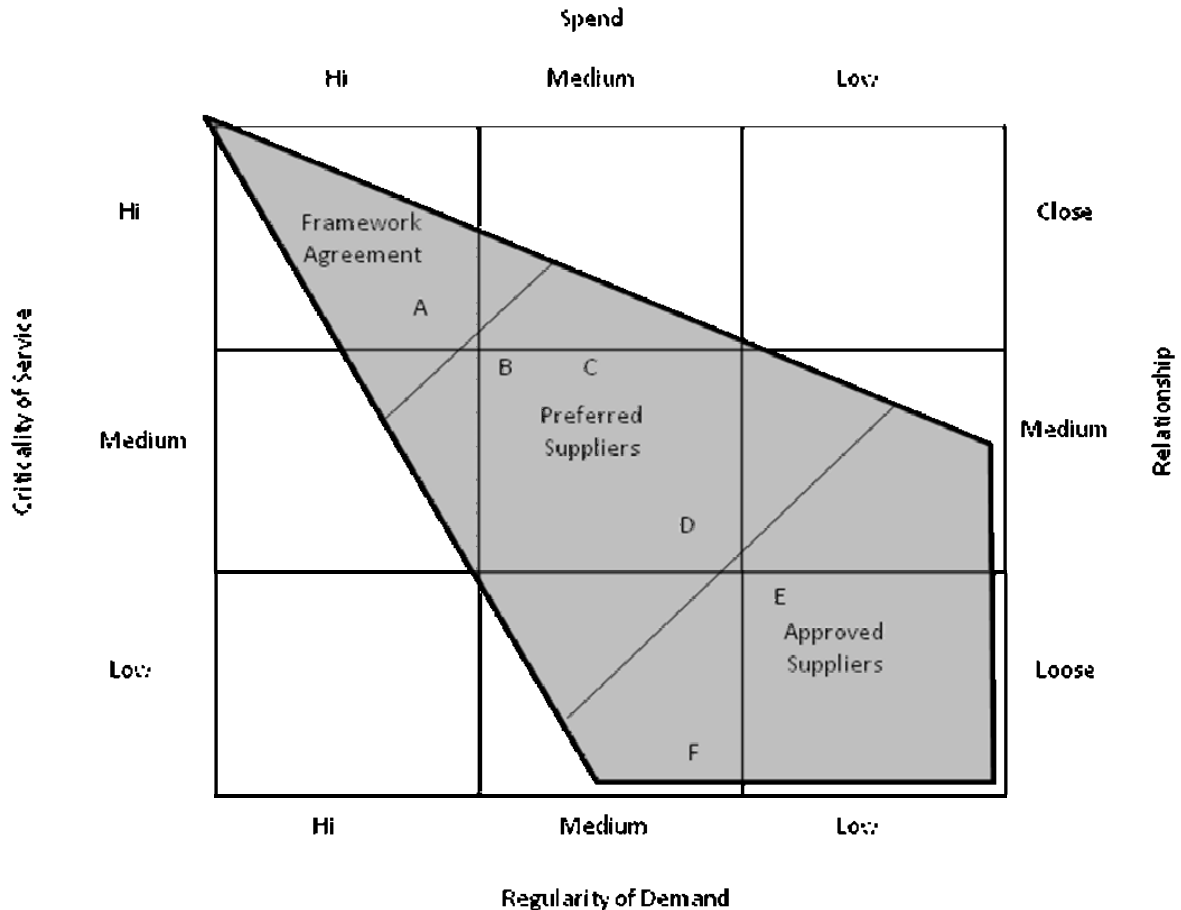


Figure 2: Dynamic matching of variables that influence flexibility

In the bottom right hand corner of the framework, where 'approved' suppliers are used by the case company, the network co-ordinator can switch between approved suppliers according to requirements of different project. Products or services will have a low level of criticality, low proportion of spend and a one off or irregular demand profile. Relationships are loose. The aim here is to maximise sourcing flexibility by minimising transaction costs and time when switching between suppliers. In contrast to framework agreements, the network co-ordinator may only wish to look at the external flexibilities offered by such vendors. The middle area of the model, where 'preferred' suppliers are used by the case company, a moderate amount of vendor flexibility is required and a moderate level of sourcing flexibility is offered to the network co-ordinator.

CONCLUSION

In this paper we have argued that supply chain flexibility can be rationalised by considering two key antecedents of supply chain flexibility, sourcing and vendor flexibility. This framework has been investigated by case studies from the construction industry. Dimensions of criticality of service, spend, regularity of

demand and relationship type have also been highlighted as important variables when considering vendor and sourcing flexibility.

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THE SUCCESSFULNESS INDEX OF RECYCLING LOGISTICS CHANNELS – AN EMPIRICAL STUDY ON A CHARITY ORGANIZATION IN TAIWAN

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ABSTRACT

The purpose of this paper is to measure the successfulness of two major municipal solid wastes (MSW) recycling channels, and using the IPA model to pinpoint the critical indices and sub-indices which have decisive influence on the successfulness of a recycling channel operated by a charity organisation in Taiwan.

Five indices and twelve sub-indices are employed to measure the successfulness of a TZRF (Tzu-chi Relief Foundation)-operated recycling channel and traditional dealer-operated recycling channel. The "education of EP awareness" is found to be the most important index in deciding the successfulness of a recycling system.

This research uses the posted survey firstly, and followed by several telephone interviews with some of the surveyees after most of the posted questionnaires are received and summarised. Two hundred questionnaires were distributed to the surveyees by post, and one hundred and forty two complete replies were received. Empirical findings indicate although the labour cost index influences the successfulness of a recycling channel, but most surveyees agree the successfulness of a recycling system depends largely on the performance of its non-economic indices (namely education and environment protection). The surveyees perceived a municipal solid waste (MSW) recycling channel operated by a charity organization has a better performance on both economic factors and non-economic factors than by a traditional recycling dealer/processor.

KEY WORDS – Successfulness Index, Recycling, Charity Organization, Municipal Solid Wastes (MSW), IPA Model.

INTRODUCTION

Western charity organizations, such as OXFAM international, do collect used goods (e.g., second hand clothes, shoes, and miscellaneous housing furniture) to resell them in their charity stores worldwide¹. Several Eastern charity organizations go a step further; they not only collect reusable clothes, but also recyclable valuable solid wastes, such as plastic bottles, tin cans, newspaper, and green glass bottles.

Tzu-chi Relief Foundation (TZRF) is one of the largest non-government organization (a Buddhist Compassion Relief Foundation) originated from Taiwan. TZRF has 44,700 registered environmental protection volunteers who involved in implementing the concept of environmental protection in their communities, sorting trash, and collecting recyclables. With the volunteers, community waste recycling operation becomes economically feasible. With more than 10 million

members and half million volunteers worldwide, Taiwan's Tzu-chi Relief Foundation (TZRF) operates more than 260 offices across 41 countries. TZRF's members are networked through a religious belief. Similar operations could be developed in the western world if religious communities can act as a recycling agent to set up community/university recycling stations voluntarily. By 2006, TZRF has made environmental protection as one of its eight major missions, it operate 8 major correspondence offices in Taiwan to coordinate more than 50,000 environmental protection stations (EPS)² volunteers at 4,500 EPSs across Taiwan. In addition, TZRF also operate similar EPSs in Canada, U.S.A, Thailand, Malaysia, and many other countries. TZRF has started its recycling campaign since August 1990. A major recycling station can even generate as high as 7,000 USD revenues from more than 200 ton waste it recycled each month for TZRF.

Recycling to generate income for charity foundation is not only ethical by helping many poor groups; it can also be used to reduce environmental pollution. Recycling aluminium is efficient and requires 95 percent less energy than creating aluminium from raw materials. It also reduces carbon emissions by 95 percent (Financial Wire, 2008). There are also many non-charity organizations involved in the solid waste recycling industry. For example, Texas Disposal Systems (TDS) engages in wood recycling logistics (Anonymous, 1997). Spiegel (2008) reported Alcoa of Pittsburgh intends to recycle 75 percent of North American beverage bottles by 2015.

In Taiwan, most schools have set up their solid waste/recycling operations. TZRF also has helped many universities organize their TZRF student clubs to encourage and educate students to participate in both recycling and emergency relief campaign.

LITERATURES REVIEW

Recycling is an important activity in both reverse logistics and green logistics. Green logistics encourages an industry consuming less natural resource during the forward and backward handling of goods between suppliers and consumers. One of the major topics in green logistics is reverse logistics which include the return of products, reusing products, and the recycling of waste (Figure 1). Comparing to the backward flow of products, consumer waste can generate a very low unit income for the recycling operators and demand heavy labour to handle the waste. Thus, labour cost is one of the most important factors influencing the successful operation of a recycling logistics system (Figure 2).

Sarkis et al. (2004) draw a schematic figure of operational logistics and supply chain model to taxonomize the logistics system into forward logistics and reverse logistics. The reverse logistics system includes reusable, remanufacturable, and recyclable materials and components. Larsen (2000) notes that reverse logistics is a concept connected with recycling, reusing and reducing the amount of materials used. Reverse logistics mainly deal with retrieving value from the returned items and to reduce its negative externalities on environment. Activities of returned products can include disposed products that are to be recycled/remanufactured to products that are sent back due to consumer's dissatisfaction (Salema, Pova, and Novai, 2006). The Council of Supply Chain Management Professionals defines reverse logistics as the "... role of logistics in product returns, source reduction, recycling, materials substitution, reuse of

materials, waste disposal, and refurbishing, repair and remanufacturing ...” (Richey, Tokman, Wright, and Harvey, 2005).

Zhu et al. (2008) study Chinese manufacturing firms and indicate GSCM (green supply chain management) includes both inbound logistics and outbound logistics management. Green logistics comprise all links from the manufacturer or raw materials to the end users and include products, processes, packaging, transport and disposal (Larsen, 2000). According to Murphy et al. (1996), green logistics mainly investigate environmental issues in logistics. Murphy and Poist (2000) makes clear that green logistics strategies includes recycling materials, reducing consumption, and reusing materials. Srivastava (2008) categorizes GrSCM into green operations, green design, and importance of GrSCM and green operations may include waste management, reverse logistics (RL) & network design, green manufacturing & remanufacturing. Efendigil et al. (2008) indicate reverse logistics plays an important role in achieving “green supply chains” by providing customers with the opportunity to return the warranted and/or defective products to the manufacturer. The relationship between green logistics management, reverse logistics operation, and recycling logistics operation is summarized as Table 1 and Figure 1.

Table 1 Taxonomy of Green Logistics Management

	Sarkis et al. (2004)	Authors	Srivastava (2008)	Murphy & Poist (2000)	Efendigil et al. (2008)	Murphy & Poist (2003)	Larsen, (2000)	
		Sub criteria						
Taxonomy of Green Logistics Management	Reverse Logistics	Reduce	✓			✓	✓	
		Reuse (materials)	✓	✓		✓	✓	
		Recycle(materials)/waste Management	✓	✓		✓	✓	
		Return or Remanufacture (warranted/defective products)	✓		✓			
	Forward Logistics /Traditional Logistics	Reduce (consumption)	✓	✓				✓
		Reduce Finished Products Packaging						✓
		Reduce Transport						✓
		Reduce Raw Material Used / Redesign				✓		✓

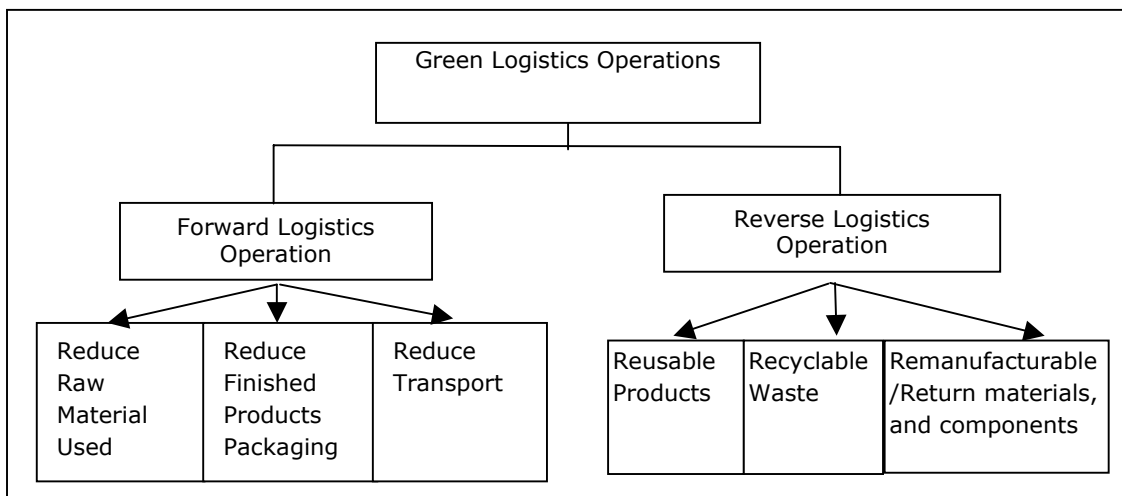


Figure 1 Taxonomy of green logistics operations

KEY SUCCESSFUL FACTORS (KSF) OF A RECYCLING SYSTEM

According to author's knowledge, an empirical research on municipal solid waste (MSW) recycling channel by charity organizations is not existed. However, applications of MCDM (multi-criteria decision methodology) on dealing with recycling activities are reported by Gomes et al. (2008), Erkut et al. (2008), Pati et al. (2008), and Liamsanguan and Gheewal (2008). Liamsanguan and Gheewal (2008) employed a simple addition and subtraction methodology to study Phuket's MSW (Municipal Solid Waste) management system, and find incineration system is superior to landfilling system when both energy consumption and greenhouse gas emission are taken into consideration. Gomes et al. (2006) employ MCDM techniques to compare the pros and cons between six different waste recycling channels in Brazil, and find waste disposal should not solely based on economic factors but also on environmental factors. Gomes et al.'s (2006) research also argued MCDM is a valuable technique to help decision-makers make a decision that affects the environment.

Pati et al. (2006) employ a mixed integer goal programming (MIGP) model to study paper recycling logistic system in India, and indicated a recycling logistics system should take the following factors into consideration, (1) reduction in reverse logistics cost; (2) product quality improvement through increased segregation at the source; and (3) environmental benefits through increased wastepaper recovery. Erkut et al. (2008) solve the location-allocation problem for MSW management system at the 13 regional levels in Greece by a multicriteria MIGP model, and suggest a MSW management system should be composed of transfer stations, material recovery facilities, incinerators and sanitary landfills. Erkut et al. (2008) argue a site selection for waste facilities should not be only cost effective but also environmentally and socially acceptable.

Murphy and Poist (2003) compare U.S. and non-U.S. firms' green logistics practices, and suggest eleven strategies to deal environmental issues in a logistics system, namely, (1) reduce consumption, (2) reuse materials, (3) recycle materials, (4) redesign logistical system components, (4) reject suppliers who lack environmental concerns, (5) increase education and training of company personnel, (6) encourage greater governmental involvement, (7) publicize environmental efforts, (8) promote industry cooperative efforts, (9) conduct environmental audits, (10) use outside or third parties to management environmental issues, and (11) hire/promote more environmentally conscious.

To sum up, the Key Successful Factors (KSF) of a Recycling System is shown in Table 2 and exhibited in Figure 2.

Table 2 Key Successful Factors (KSF) of a Recycling System

	Gomes et al. (2006)	Indices	Authors					
			Sub-Indices	Simpson (1994)	Murphy & Poist (2003)	Pati et al. (2006)	Erkut et al. (2008)	Liamsan-guan & Gheewal (2006)
KSF of a Recycling System	Economic Indices	Labor Cost Control	Volunteers' cost	✓				
			Paid workers cost					
		EPS construction cost control	Community EPS cost	✓				
			On-Campus EPS cost			✓	✓	
		Equipments/Facilities Costs control	Stowage facility cost	✓	✓			
			Conveyors Cost				✓	
	Trucks cost							
	Non-Economic Indices	Environmental protection (EP) improvement	Pollution Reduced			✓	✓	
			Resources Reused					
			Resource Recycled					
Education to improve EP awareness		Students' Awareness		✓				
	Community Residents' Awareness				✓			

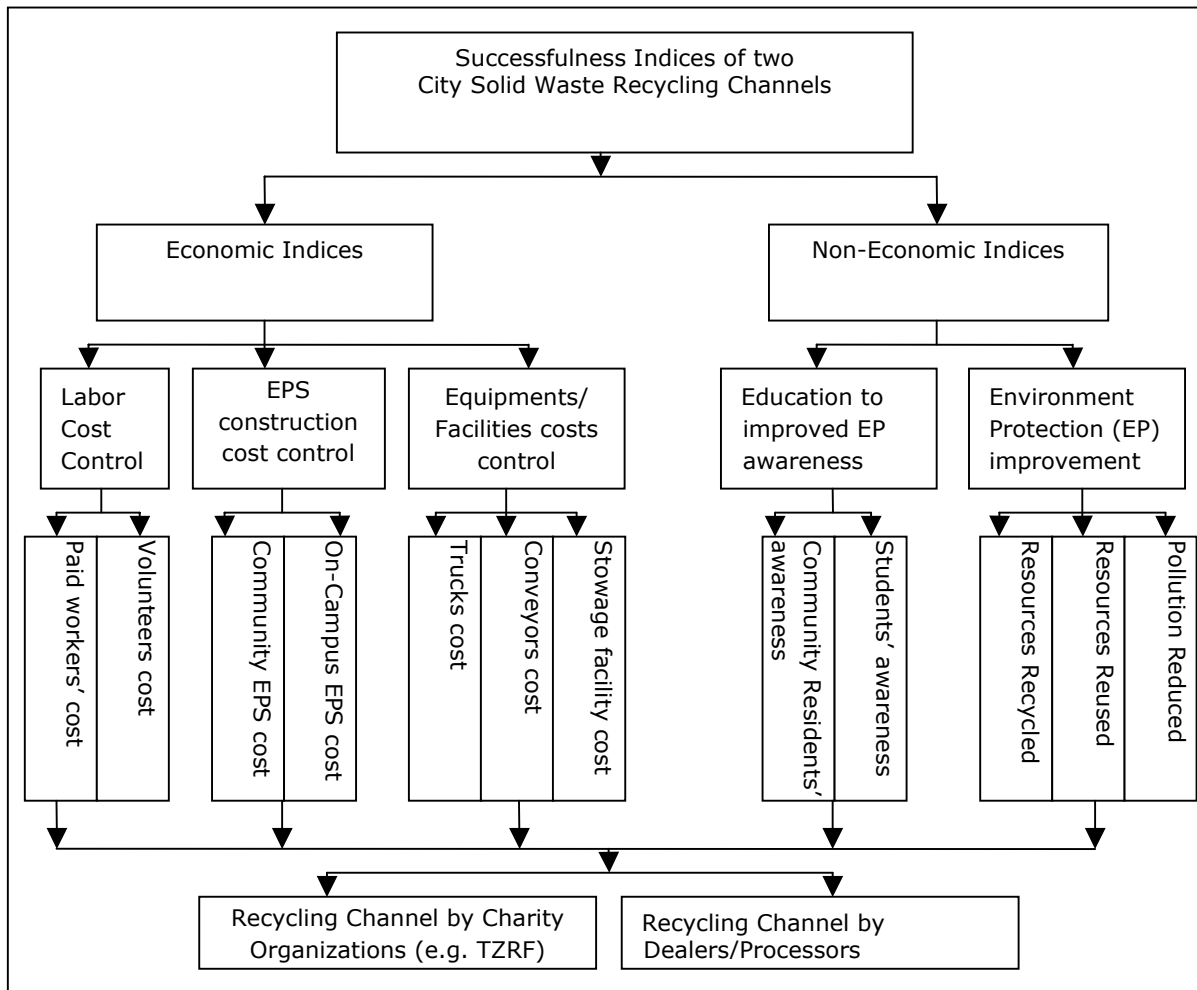


Figure 2 Key Successful Factors (KSF) of a Recycling System

RESEARCH METHODOLOGY AND RESEARCH PROCESS

Current researches on reverse logistics are mainly focused on green supply chain management (GrSCM) and reverse concepts and practices from private enterprises' viewpoints (Srivastava, 2008; Hong et al., 2008; Efendigil et al., 2008). Rubio et al. (2008) systematically study the articles on reverse logistics published in the most relevant journals within the period 1995-2005, and find less than 5% of these articles employed survey methodology. While survey methodology is a very useful tool to carry out academic research, which is very need in the reverse logistics research area. Verstrepen et al. (2007) indicated reverse logistics become an area to improve performance for both enterprises and non-profit organizations, and the extant empirical research on the non-profit organisation's reverse logistics operation through a survey is simply not available. This research sends 200 copies of questionnaires using a five-point Likert scale to academicians, recycling dealers, and TZRF members in Taiwan, and 142 copies of the returned questionnaires are completely answered. An IPA (importance-performance analysis) model is firstly used by Martilla and James (1977) to measure attribute importance and performance for an effective marketing program. The IPA model is employed in this research to find critical attributes that have higher degree of importance and lower degree of performance on the successfulness of MSW recycling operations in Taiwan.

RESEARCH FINDINGS

The empirical research results are shown in Table 4, it indicates "Education to improve EP awareness" should have a more influential power over the successfulness of a community solid waste recycling channel than the other indices. When the two different types of recycling channels (i.e. TZRF charity foundation and recycling dealers) are compared, TZRF charity foundation has a better performance over the recycling dealers on 8 of the 12 recycling logistics successfulness sub-indices. TZRF greatly outperform recycling dealers on the "education to improve EP awareness" index.

It is found "TZRF recycling" channel has a better overall performance than the "traditional recycling dealers" channel, and finding the critical indices/sub-indices to be improved in the TZRF channels is also highly desired. An importance-performance analysis (IPA) technique is employed to find out the critical sub-indices which are exhibited in Figure 3. In the TZRF recycling channel, conveyor cost is the sub-index perceived to have a higher degree of importance and has a below-average degree of performance, which indicates it can be used to highly influence the successfulness of a recycling channel. On the other hand, TZRF can reduce their investment on the sub-indices in the "overshooting quadrant". Conveyors are one of the major facilities perceived to be very important but TZRF has a poor performance on this sub-index. The recycling volunteers in TZRF are mostly senior citizens who need a conveyor to sort the recyclables without bending their backs. However not many TZRF EPSs in Taiwan are currently equipped with this facility.

Table 4 Factors importance of a recycling logistics successfulness index and performance of two types of recycling channels

Importance	Indices	Sub-indices	Importance Average/Ranking	TZRF Performance Average	Recycling Dealers Performance Average
Cost Factors	Labour Cost Control	1. Paid Workers' cost	3.34/(10)	4.53	4.23
		2. Volunteers' cost	3.75/(7)	3.76	2.94
	EPS construction cost control	3. On-Campus EPS	3.04/(12)	4.32	3.5
		4. Community EPS	4.26/(3)	4.16	3.55
	Equipments/Facilities Cost	5. Stowage facility cost	3.81/(6)	3.77	3.88
		6. Conveyors cost	4.22/(4)	3.2	4.39
		7. Trucks cost	3.62/(8)	3.82	4.07
Non-Cost Factors	Education to improve EP awareness	8. Students' awareness	4.39/(2)	4.08	3.01
		9. Community Residents' awareness	4.6/(1)	4.49	3.81
	EP Improvement	10. Pollution reduced	3.06/(11)	3.82	3.42
		11. Resources reused	3.43/(9)	4.16	3.33
		12. Resources recycled	4.14/(5)	4.42	4.7

Note: 1. TZRF: Tzu-chi Relief Foundation (Taiwan). 2. The higher the score in this table, the more important the factor and the better the performance the surveyees perceive.

CONCLUSIONS AND SUGGESTIONS

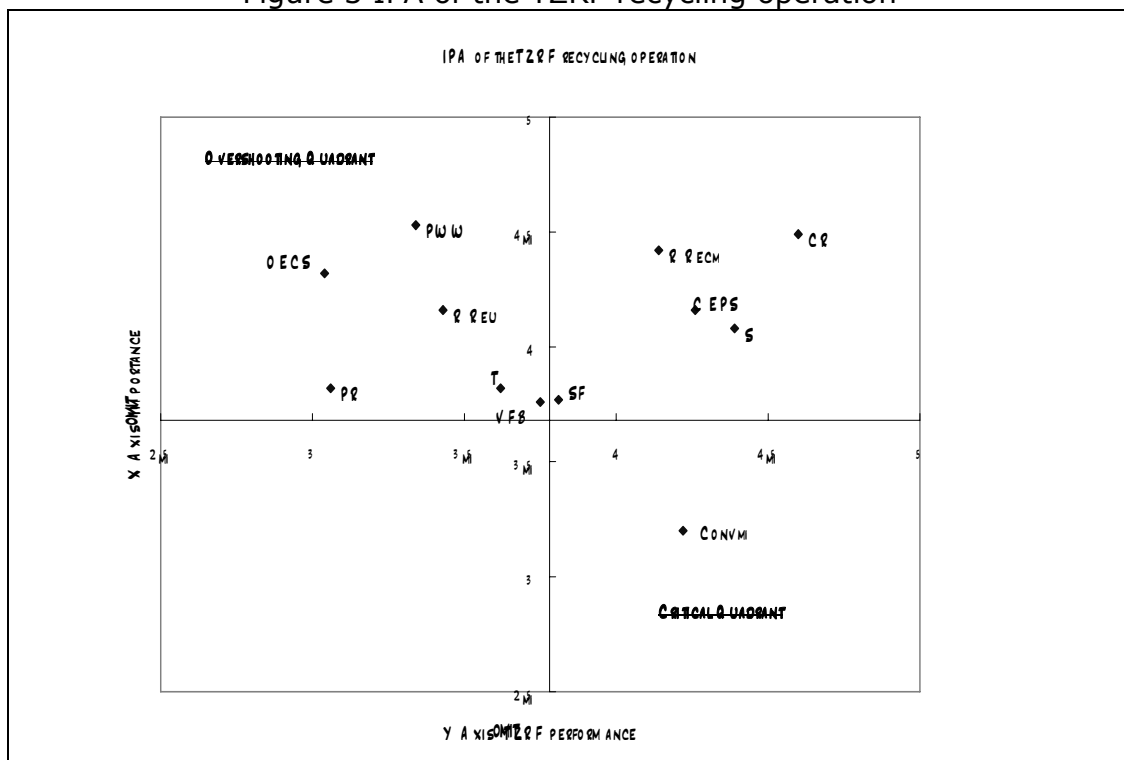
Although the revenue of municipal solid waste (MSW) recycling industry mainly comes from the refuse it recycled, the successfulness of a recycling channel is depended much more on whether it can improve the stakeholders' EP awareness effectively than on the amount of recyclables it recycled. All recycling activities are started firstly from each individual at home. Increasing each individual's EP awareness can generate a major driving force to increase his/her willingness to engage in recycling activities. EP awareness education can be promoted by schools, charity organizations, and private recycling dealers as well, although the latter is not keen to engage in improving its stakeholders' EP awareness.

The four-tiered hierarchical structure of the successfulness indices and sub-indices of the MSW recycling channels are also suitable to use the AHP (Analytic Hierarchy Process) technique to measure the relative importance and performance of different recycling channels. AHP is a very useful tool to improve group decision making quality (Saaty, 1977), thus, the AHP technique is suggested to be used to compare the successfulness of different recycling channels in the future.

A cross-country recycling channels research is strongly suggested, as cultural background differences may result in different critical sub-indices that influence the successfulness of a recycling operations. In addition, many poor homeless and poor people may generate very thin income through collecting the recyclable wastes on the streets. The TZRF's operation to recycle recyclables nationwide

can result in very negative impacts and ethical risks on the low income family. A research on this topic is also strongly suggested.

Figure 3 IPA of the TZRF recycling operation



Note: Conv: Conveyors, CR: Community Residents Awareness, C EPS: Community EPS, OC EPS: On-Campus EPS, PR: Pollution Reduced, PW W: Paid Workers Wage, R Red.: Resources Recycled, R Reu.: Resources Reused, S: Students Awareness, SF: Stowage Facility, T: Trucks, VFB: Volunteers Fringe Benefits.

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¹ According to Northern Echo (2006), Co-Operative Group (including Travel Care) also recycled used mobile phone and cartridge ink to raise fund for Oxfam in Dec. 2006.

² An environmental protection station (EPS) is a building designed to receive recyclable waste stream refuse and sort each item so that it can be transported to material recovery and processing facilities. Simpson (1994) calls the EPS as transfer stations.

UNDERSTANDING THE FACTORS INFLUENCING REVERSE CHAINS IN THE CHINESE METAL INDUSTRY

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ABSTRACT

There are many factors influence the sustainability of closed-loop supply chain, in terms of industrial operation flows and environmental perspectives. This research aims to identify these factors in order to provide a better understanding of the process flows and interactions between the primary and secondary metal manufacturers and remanufacturers. In particular, it focuses on the influences of the Customer, Environment and Technology (CET) factors. Qualitative case studies were performed in seven companies in the Pearl River Delta region of South China. These are Small and Medium Enterprises of primary metal manufacturers, secondary metal remanufacturers, dismantlers, and third party (reverse) logistics providers. Data and information were collected through semi-structure interviews and observations on sites, in order to analyse the process flows. This study evaluates the specific approaches and techniques which the Chinese metal manufacturers and remanufacturers adopt in order to achieve sustainable development. The key findings include how companies deal with various qualities and quantity of supply materials, and their management of within the context of the closed-loop supply chain.

KEYWORDS – Sustainable Closed-Loop Supply Chain, Customer, Environment, Technology, Metal, China

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INTRODUCTION

There are many factors that have influences on the industrial developments. These include the implications of economic, social, political, policies, the understanding and acquisition of industrial skills, knowledge, science, and technology development. This research focuses on the interactions between the factors of Customer, Environment and Technology (CET) on the supply chain management, as illustrated in Figure 1.

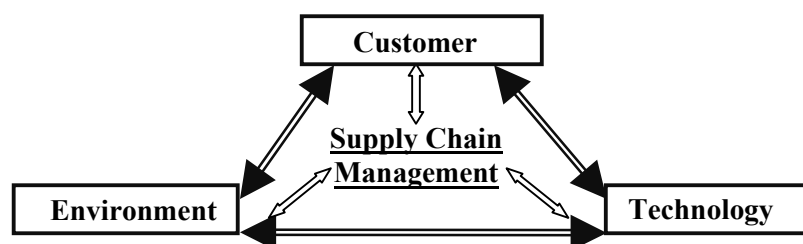


Figure 1: Supply Chain Management and the CET Factors

There are interactions between the CET factors. On the issues of pollution and damages caused by the production of goods and services, as well as customer consumption and post consumption activities, there have been changes in the relationships of supply chain and the CET factors. The environmental issues of climate change and global warming due to rapid industrial expansion and human activities development have become one of the most important subjects for research and improvement in the 21st century. Governments and enterprises are

responsible for taking into account the impacts of national and international economic development activities for their future sustainability.

Hence, this research is proposed to find the balance between the supply chain management and the CET factors, in order to identify factors that influence the development of sustainable supply chain. The issues of sustainability and closed-loop supply chain will be discussed to provide theoretical background, prior to the examination and evaluation of the uncertainties of the closed-loop supply chain and the impacts on the industrial practices.

SUSTAINABLE SUPPLY CHAIN

The sustainable supply chain is the “management of raw materials and services from suppliers to manufacture or service provider to customer and back with improvement of the social and environmental impacts explicitly considered” (Jorgensen and Knudsen, 2006). In particular, as there are developments of industrialisation in the expanding global markets, there are concerns on the growing consumption of natural resources which lead to resource reduction or even extinction.

In addition, there are inevitable emission, wastes and scraps during the processes of production, as well as End-of-Life (EOL) and used products after customer consumption. If these products and parts are being collected and recycled for reuse, it would increase the utilities of the resources and reduce the need for primary input materials. Subsequently, the processes of collecting and remanufacturing of waste materials and used products for resource recovery form the waste manufacturing industry. This research investigates the processes of reverse flow of materials through the waste manufacturing processes, and identifies the factors and issues involve, in order to develop sustainable closed-loop supply chain.

CLOSED-LOOP SUPPLY CHAIN

The waste manufacturing processes consist of remanufacturing, refurbishing, recycling and disposal activities which deal with the wastes and returns from industrial manufacturing processes and customer consumption (Thierry, 1995). These activities are described as the processes of reverse logistics, which is defined as “the process of products, either purchased or used, returned by customers back to the point of origin, i.e. manufacturers or suppliers” (Rogers and Tibben-Lembke, 1998). The need for reverse logistics processes is to recover and utilise the inevitable waste, left-over and scrap materials from the supply chain operations, as well as collecting and reusing of those EOL or used products which would otherwise be disposed in landfills, generating pollution and damages to an unsustainable environment.

Ginter and Starling (1978) identified that the recycling and the operation of reverse channels of distribution are appropriately receiving increased attention because rampant solid waste pollution, frequent energy shortages and serious materials scarcity are recognised as realities of the modern age. The majority of the researches tend to look at reverse logistics from a large-scale, by identifying the general flows within the distribution channel. Kopicki, et al., (1993) identified two basic types of reverse logistics systems: an open-loop system where products do not return to the original producers. These products will either be

recovered by other parties willing and able to reuse the materials or products, or be disposed in landfills (Andel, 1997). On the other hand, there is the closed-loop system in which materials are returned and reused by the same originator, as the supplier or the manufacturer brings product back in, remanufactures it, refurbishes it then resells it. This research focuses on the closed-loop system of supply chain (Figure 2). It should be noted that there are third party collectors and dismantlers who are participating in the reverse logistics operations for remanufacturing processes, helping the manufacturers to deal with the returns.

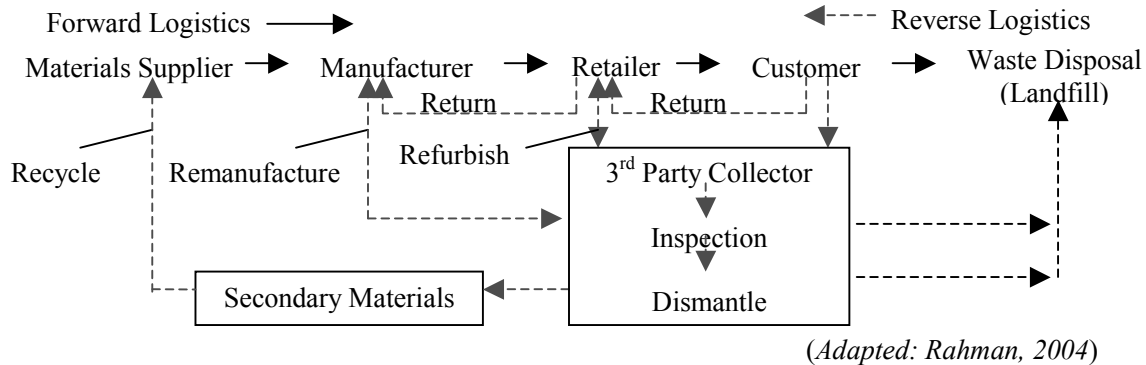


Figure 2: Closed-Loop Supply Chain

Factors such as economic, legislation, corporate social responsibility and technology, are the driving forces for waste, left-over, scrap materials, as well as the EOL products and used products to be returned to manufacturers and retailers. As pointed out by Zikmund and Stanton (1971), the ultimate customers who recycle their waste materials must undergo a role change. The customers become the first link in the channel of distribution rather than the last. Hence, the operating flow in the closed-loop supply chain becomes very complex. In order to deal with these returns efficiently and effectively, parties in the supply chain need to integrate their operations internally for the forward and reverse flow of materials and products. In addition, they have to understand and cooperate with their upstream and downstream partners along the supply chain to develop sustainable closed-loop supply chain operations.

In the research of Guide Jr. (2000), it identified areas of remanufacturing that have not been fully addressed, or that have not been investigated at all. It described several complicating characteristics of production planning and control activities for remanufacturing firms. These include the uncertainties in timing and quality of return, the demand and supply of secondary materials, the complication and requirement of reverse logistics network and the remanufacturing processes and operations. More research on these issues should be performed in order to provide better understanding and guidance for closed-loop supply chain operations.

RESEARCH GAP

Since the mass production of goods and services in global consumer markets, there are considerable amount of waste, left-over and used products and materials flowing backward at different stages of the supply chain. Referring to the existing case studies and research in the field of reverse logistics, the majority of the investigations focus on the products, components, packaging and parts returned to the point of origin. There are still areas for exploration

particularly in waste and residue recovery for sustainable development. It is important to investigate both forward and reverse logistics flows in order to develop comprehensive research for sustainable closed-loop supply chain.

In addition, the large percentage of existing research are done mainly in developed countries throughout Europe and North America, which provide good resources for reverse logistics system operations and implementation, strategic decision making, legislation and processes guidance. On the other hand, limited amount of research has been performed in developing countries, where the implementation of the recycling and remanufacturing processes is falling behind. Especially for the emerging economies in countries such as Brazil, Russia, India and China which are experiencing fast growing manufacturing and economy development in recent decades. Not only the forward logistics structure, but also the reverse logistics development should be examined to provide better guidance for their current and future sustainable development.

RESEARCH APPROACH AND CASE STUDY

In order to identify and develop a holistic view of the closed-loop supply chain operation, the related processes of primary and secondary metals in the context of China have been investigated and reported in this paper. Qualitative research method of case study including interviewing, participant observation and studying related materials were performed. The qualitative approach of multiple-case study is considered to be the most appropriate method for the exploratory research purpose (Yin, 2003). Hence, a general picture of the existing closed-loop supply chain can be captured, and attentions are raised with the concerns of the uncertainties in manufacturing and remanufacturing processes for sustainable development. Issues with regard to the CET factors are examined and evaluated in particular.

With regard to the aim and objectives of this research, field work and case studies were performed in the Pearl River Delta (PRD) region in South China between 2005 and 2007. This region is a concentrated area for metal production and recovery processes of waste, used and scraps metals and materials. The case study research was carried out in seven Small and Medium Size (SMEs) companies, investigating in their approaches and techniques in dealing with the forward and reverse flow of supply chain for metal manufacturing and remanufacturing. A total number of 60 managers and operators from these companies were interviewed with a list of semi-structured questions and at least 168 hours were spent for the interviews and observations. The case information is listed in Table 1.

	Company Type	Code	Field of Operations	Turnover (GBP)	No. of Employees	Production Capacity / yr
1	Logistics Provider	L _{3PL}	Distribute secondary metal	< 8m	< 150	555,000 tons
2	Remanufacturer (Metals)	R _{M1}	Recycle and remanufacture metals	< 4m	< 80	50,000 tons
3	Manufacturer (Metals)	M _M	Manufacturer of various metal hardware	< 3.5m	< 100	100,000 tons

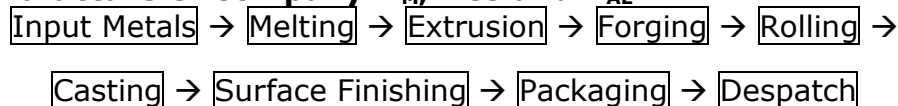
4	Remanufacturer (Aluminium)	R _{AL}	Manufacture aluminium bars /Remanufacture of aluminium residue materials	< 8m	< 150	800,000 tons /36,000 tons
5	Remanufacturer (Metals)	R _{M2}	Recycle secondary metals	< 4m	< 50	100,000 tons
6	Manufacturer (Stainless Steel)	M _{SS}	Manufacture stainless steel pipes	< 4m	< 150	300,000 tons
7	Reverse Logistics Service Provider	L _{3PRL}	Third party reverse logistics service provider	<10m	< 500	500,000 tons

Table 1: Case Study Company Background Information

ANAYLSIS

The case study companies in this research can be grouped according to their nature of operation, and their basic process flows are illustrated as in Figure 3.

Metal Manufacturers: Company M_M, M_{SS} and R_{AL}



Metal Remanufacturers: Company R_{M1}, R_{M2}, and R_{AL}

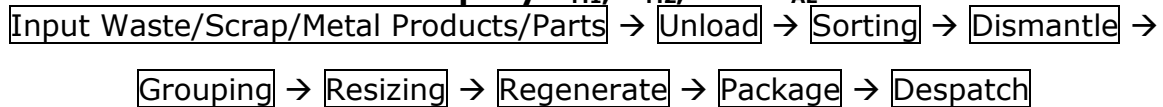


Figure 3: Process Flows of Metal Manufacturing and Remanufacturing

COOPERATION BETWEEN METAL MANUFACTURERS AND REMANUFACTURERS

In the context of Chinese metal industry, due to the fact that the legislation for proper disposal of production waste and residues are not as strict as those in the developed countries, the main driving force for metal collection and recovery is the economic benefit. Remanufacturers pay manufacturers for the waste, left-over and scrap metals, at around 1/3 of the price of the final remanufactured metals. Hence, manufacturers reduce the total costs of production, while remanufacturers gain profits from selling the recovered secondary metals through the remanufacturing processes.

The cooperating relationships between the case study metal manufacturers and remanufacturers enable the smooth flow of secondary metals within the supply chain. For metal remanufacturing operation, metal wastes and scraps are moved from Company M_M to R_{M1}, from Company M_{SS} to R_{M2}. Company L_{3PRL} is a third party reverse logistics provider which collects the waste, left-over and scrap materials mainly from the large automotive and metal manufacturing companies in the region. These metal remanufacturers help local manufacturers to recover those wastes and scrap metals from their production, which would otherwise become valueless materials and would be wasted and piled up in landfills. However, these operations only take up a small percentage of the remanufacturing capacities. More than 70% of the secondary input metals at

Company R_{M1} and R_{M2} are imported from overseas metal collectors, the cargo containers are delivered to site through distributors such as Company L_{3PL} . According to the production manager of Company R_{M1} ,

"It is very important that we can have stable supply of materials from our suppliers, from local and overseas, so we can schedule our operations more efficiently. We want to get good quality used or waste materials so we can sell them for higher prices after the dismantling, resizing and remanufacturing processes. That is why most of our materials are imported from developed countries, from which the used materials or products are with better reusable quality."

However, due to the fluctuation of metal prices and demand in the market, there are risks and uncertainties when transporting and remanufacturing these secondary inputs. In addition, dealing with the mixture of secondary metals imported from overseas increases the complexity of the remanufacturing operations. In the words of the operations manager in Company R_{M2} ,

"It is so much easier when dealing with those incoming scraps parts and materials which we get more information of their characteristics. Then we can simply group them together, resize them and sell them to our customers. That is why we are working well with Company Mss in dealing with its stainless steel scraps. The scraps can be quickly sorted and sold onto the remanufacturers for re-melting, or to other stainless steel manufacturers for their operations."

COMPARISON BETWEEN METAL MANUFACTURERS AND REMANUFACTURERS

In order to motivate companies to participate in the closed-loop supply chain operation, there must be the development of applicable technology which assists those process operation and requirements. It should be pointed out that the first action for metal manufacturers to contribute in the sustainable closed-loop supply chain would be reducing the level of wastes in their production processes. In Company M_M , M_{ss} and R_{AL} , more than 70% of the process operations are performed by machineries. There have been increases in productivities and efficiency during their operation and their production capacity reach 800 to 2,200 tons per day. Higher level of technology also helps to minimise production defects and wastes, as the scrap rates in these companies are controlled to be less than 2%.

On the other hand, the application of technology in Company R_{M1} , R_{M2} and L_{3PRL} are very limited, more than 80% of their operations are strongly relying on manual labour. The daily production capacities are only between 135 to 1,300 tons. It can be argued that these SMEs metal remanufactures benefit from the low costs of labour and flexibility of manual operations especially when sorting and dismantling complex products or parts, and the applicable technology can be very expensive. However, the implementation of technology would help to drive up the level of remanufacturing efficiency and productivities. For example, in the case of Company R_{AL} that produces aluminium bars and pipes. It has been working with researchers in the local University and developed an operation system that remanufactures the hazardous waste residues $[Al_2O_3]$ from its production into non-hazardous material $[Al(OH)_3]$, which can be sold and used for ceramic manufacturing. 80% of the processes are operated through machinery systems they developed.

THE CET FACTORS AND THE SUSTAINABLE CLOSED-LOOP SUPPLY CHAIN

There are issues with regard to the CET factors which influence the sustainable closed-loop supply chain operations, as illustrated in Figure 4.

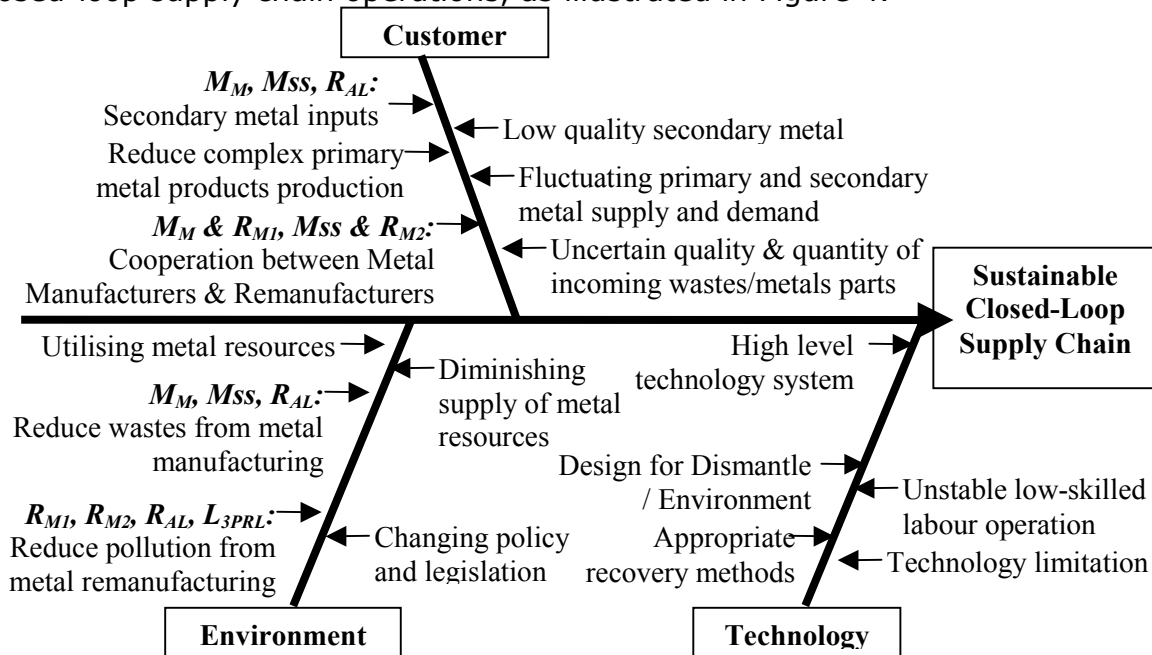


Figure 4: Factors Influencing Sustainable Closed-Loop Supply Chain

Some of the points can be discussed in details. First of all, from the customer perspective, manufacturers can use good quality secondary metals for their production which are cheaper alternatives to primary metals. For example, in the case of producing keys and metal hardware, Company M_M applies secondary iron and copper in order to reduce costs. Hence, the supply chain becomes a closed-loop system as secondary metals re-enter the operation flow. In addition, it is essential to reduce the complexity of the primary metals products, which would ease the sorting and dismantling processes. Furthermore, establishing good cooperation between these players is important for better information sharing and process flows. As in the case of Company M_M and R_{M1} , M_{SS} and R_{M2} , their information sharing and support help to reduce the uncertainties of supply and demand, quality and quantity of the waste metals within the closed-loop supply chain.

Secondly, from the environment perspective, Company M_M , M_{SS} and R_{AL} face the increasing price and diminishing supplies of metals for their operations. Hence, they are anticipating in utilising materials, reducing production wastes, and applying secondary metals for production. At the mean time, Company R_{M1} , R_{M2} , R_{AL} and L_{3PRL} are developing better methods for their remanufacturing processes. As a result, not only the waste and EOL products and parts, but even the hazardous waste residue can be recovered and reused. These help to reduce pollution and develop sustainable supply chain in the long term.

Last but not least, application of higher level technology system and machineries for manufacturing and remanufacturing processes, and the appropriate recovery methods and techniques also help to develop sustainable closed-loop supply

chain. Although as in the case studies for Company R_{M1} , R_{M2} , and L_{3PRL} , they are benefiting from the flexible manual labour operations for the sorting and dismantling operations, the long term development requires high technology system for their operations. Especially when handling hazardous waste and used products and parts with higher safety aspects and efficiency. Moreover, the implementation of technology also include the initiative of applying Design for Dismantle and Design for Environment at the early manufacturing product design stage, which would simplify the processes of remanufacturing at the end of the product life cycle. Consequently, metal products and parts can be handled efficiently by machinery systems and higher skilled labour operation.

CONCLUSION

The interactions between the metal manufacturers and remanufacturers in the PRD region are analysed and examined. Managers of metal manufacturers and remanufacturers must be aware of factors such as customer, environment and technology that influence the development of sustainable closed-loop supply chain. As metal manufacturers are expanding their production, they are facing the increasing price of input materials and level of wastes and pollution from their production and end products. Hence, one of the solutions is to develop cooperation with remanufacturers in order to reduce production costs by utilising primary and secondary metals. Although the current remanufacturing industry in China is largely based on manual labour operations, the implementation of higher level technological operations would increase the quality and quantity of secondary metals handled. Not only the waste, left-over and scrap metals can be recovered and utilised, but even hazardous and waste residues can be remanufactured and reused. The additional profit incentive motivates both metal manufacturers and remanufacturers within China and overseas to develop the sustainable closed-loop supply chain further in the long term future.

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SECTION 12

ORGANISATIONAL AND MANAGERIAL ISSUES IN LOGISTICS

WORKPLACE VALUES IN THE JAPANESE PUBLIC SECTOR: A CONSTRAINING FACTOR IN THE DRIVE FOR CONTINUOUS IMPROVEMENT?

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ABSTRACT

A comparison is drawn between Japanese private and Japanese public sector workers using a research instrument which captures both personal life values and existing workplace values. The aim of the research is to test whether the values present within public sector organisations can help to explain the reported difficulties in implementing and practicing continuous improvement within the Japanese public sector, despite the assumed national 'cultural fit'.

INTRODUCTION

The philosophy of continuous improvement (CI) has been widely shown to have the potential to positively contribute to a company's performance (Bessant and Francis, 1999; Jha et al., 1996). The subject of supply chain management is among the many areas where CI was established to have a positive influence, with the philosophy providing organisations with a mechanism to exploit the knowledge that is located with their supply chains. For example, Jabnoun (2001) emphasised that, drawing on Oakland (1997), CI's focus on external cooperation provides organisations with a means to address given problems more effectively.

"A greater variety of complex problems may be tackled, which are beyond the capability of any one individual, one department or even one organization, by the pooling of expertise and resources."

Oakland (1997)

While previous research in the area of CI predominantly placed the emphasis on how its implementation and effective practice can be achieved within private sector organisations, there is an increasing level of interest in applying the continuous improvement principles within the public sector (Loomba and Spencer, 1996). This comparatively recent perspective on the subject has mainly been argued to stem from an increasing pressure on public institutions to become ever more accountable to the public they serve (Ovretveit, 2000; Magd and Curry, 2003). Yet, this drive for CI within public sector organisations has been shown to often be constrained by workplace values that are specifically attributable to the characteristics of public, rather than private, sector organisations (Yang, 2003; Taveira et al., 2003).

Difficulties with the implementation and practice of CI within the public sector were also reported to have been experienced by public organisations in Japan, a country whose high CI success within its private sector organisations has widely

been attributed, in part, to the characteristics of its national culture (Imai, 1997; Hofstede, 1991).

It was thus hypothesised that while private and public sector workers in Japan share the values that are conducive to the practice of CI in their private life, the workplace values present within public sector organisations undermine CI efforts, unlike those found within their private sector counterparts. This hypothesis is graphically illustrated in figure 1 below.

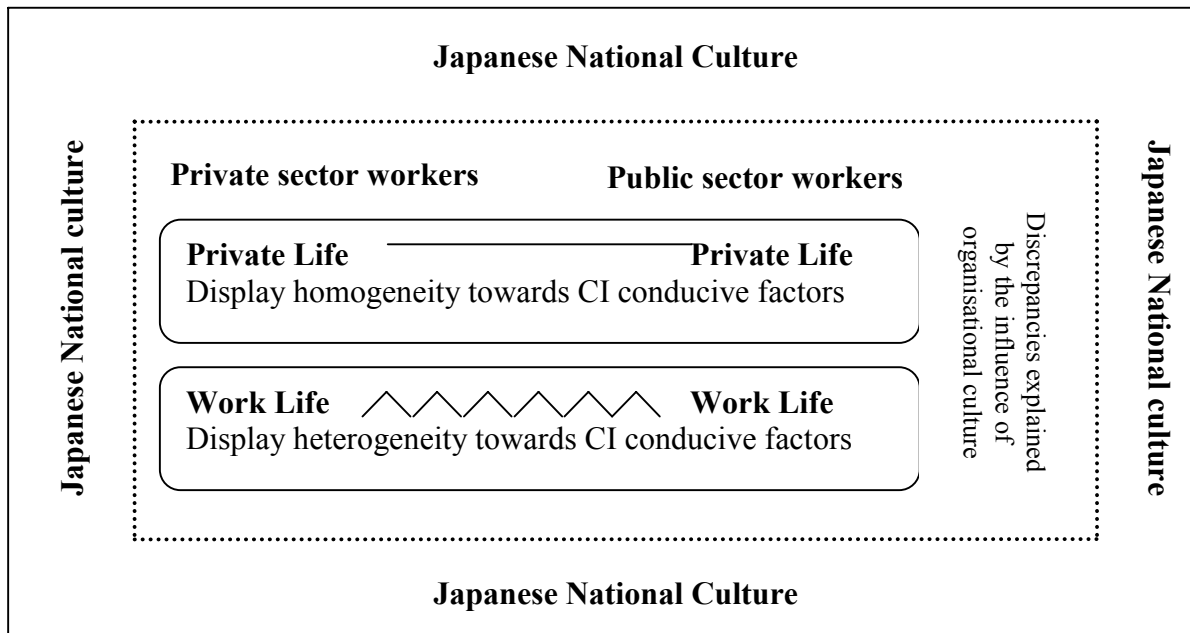


Figure 1: Graphical illustration of research hypothesis

CONTRIBUTION

The main contribution of this paper lies in establishing whether, as hypothesised, workplace values present within public sector organisations in Japan are found to be less 'CI nurturing' than those present within private organisations, and whether these respective findings can thus be used to explain why public organisations in Japan have reportedly found it comparatively difficult to implement the CI philosophy. Although this study has exclusively obtained its findings from primary research undertaken among private and public sector workers in Japan, it is nevertheless believed that these findings could be used to widen the understanding of the practice of CI within public organisations outside the context of Japan. This view is strengthened by Sako and Sato's (1997) view that public institutions in Japan were designed after US models following the second world war, and by the view expressed by Child (cited in Pizam et al., 1997) that public sector organisational characteristics "are similar, if not identical, across nations".

METHODOLOGY

In order to test the research hypothesis, a review of the literature was conducted in respect to the dimensions that were found that have an impact upon the successful implementation and practice of CI, and which, in turn, could subsequently be researched from both a personal life and workplace perspective.

While it lies outside the scope of this paper to describe each individual dimension in detail, table 1 below provides an overview of the 22 dimensions that were identified to be applicable to this investigation.

Empowerment	Teamwork
Pride	Experimentation
Task ownership	Openness to learning
Respect	Waste reduction
Empathy	Perceived climate
CI vs. BPR	Appreciation
Uncertainty avoidance	Cost vs. quality focus
Open communication	Trust
Process vs. results focus	Openness to change
Feeling of control	Performance measurement & evaluation
Parochial vs. professional orientation	Long- vs. short-term orientation

Table 1: Dimensions impacting upon the successful practice of CI

A structured survey was designed around these dimensions, with respondents being asked to state their level of agreement on a 7 point Likert scale in relation to statements that drew upon these dimensions in terms of their own personal values and in terms of the values that they perceive to exist at their workplace. The two statements below, for example, show how the 'open communication' dimension was addressed within the survey.

"It is important to me to be able to exchange views and ideas with others."

"At my workplace, colleagues are encouraged to exchange views and ideas among each other."

The personally held values and the perceived workplace values were researched in two different sections of the survey in order to ensure that the respondents are not unintentionally 'guided' in the answering process. Similarly, both positively and negatively worded statements were used to further avoid the danger of biasing responses.

The research instrument was translated using the 'back-to-back' method to ensure that the originally intended meaning was being upheld, and was subsequently made available to respondents using a web-based format to overcome geographical constraints.

As can be observed from table 2 below, the survey was conducted within 9 private and 4 public sector organisations, from which 565 and 193 respondents completed valid surveys. All responses were obtained from workers who do not occupy management positions, as it was feared that the inclusion of management level responses could introduce bias to the data pool.

The obtained results were analysed to establish whether statistically significant differences were found: between the responses of private and public sector workers in respect to both the personal life and workplace values, and between

the responses given by both private and public sector workers in respect to their personal life values and the values that exist at their respective workplaces.

Organisations – Private sample		N	Organisations – Public sample		N
Chemist chain		57	Police		48
Food service supplier		76	Post Office		48
Car parts distributor		85	Council offices		49
Hair salon chain		64	Public facilities maintenance		48
Metal coating		53			
Metal treatment		56			
Industrial oil manufacturer		55			
Furniture manufacturer		51			
Nursing home operator		68			
Total		565	Total		193

Table 2: Organisation types and no. of responses contained within sample

FINDINGS AND ANALYSIS

An independent-samples t-test was conducted to establish whether the survey responses show statistically significant differences between the personal values of private and public sector workers and between the workplace values of their organisations respectively. Table 3 provides an overview of the dimensions where statistically significant differences were found. Mean scores and effect sizes (eta squared) are displayed to inform about the extent of the differences, with Cohen's (1988) guidelines on effect sizes having been adopted to further contextualise the findings. A higher mean score indicates a higher positive orientation towards a given CI dimension. As can be observed from table 3, private and public sector workers have shown statistically significant differences in relation to 8 CI dimensions out of a total of 22 in relation to their personal values. However, the effect sizes show that differences have, with the exception of the 'parochial vs. professional orientation' CI dimension, been very small. Because of this finding, and because no statistically significant differences are established to exist for the majority of CI dimensions in respect to the personal values of private and public sector workers, it must be concluded that the hypothesised homogeneity in terms of personal life values does indeed exist.

	Personal life values			Workplace values		
	Mean Private	Mean Public	Eta squared	Mean Private	Mean Public	Eta squared
Long-term orientation				4.31	3.88	.014*
Employee empowerment				4.08	3.62	.019*
Pride				4.58	4.18	.018*
Task ownership	4.43	4.19	.008*	4.35	4.05	.011*
Respect (customers)				5.11	4.89	.007*
Empathy (customers)				4.82	4.21	.040*
Empathy (colleagues)				4.45	4.20	.009*
Trust (management)				4.22	3.42	.060*

Trust (colleagues)				4.64	4.43	.007*
Open communication	5.46	5.10	.026*	4.46	3.98	.026*
Teamwork	4.02	3.69	.014*			
Experimentation	5.57	5.30	.015*	4.56	3.71	.077*
Waste reduction				4.65	3.98	.053*
Perceived climate	5.63	5.27	.021*			
Cost vs. quality focus	4.59	4.33	.009*	4.28	3.87	.021*
Uncertainty avoidance				4.05	4.66	.039*
Process vs. results focus	4.52	4.25	.009*	4.29	4.04	.008*
CI vs. BPR				4.56	4.03	.036*
Feeling of control				4.75	4.29	.029*
Openness to change				3.54	3.16	.020*
Parochial vs. professional orientation	5.29	4.58	.055*	4.77	4.31	.033*
*Determines effect size .01=small effect, .06=moderate effect, .14=large effect						

Table 3: Significant differences established in independent-samples t-test

This picture of homogeneity cannot, however, be drawn from the findings of the comparison between the workplace values of the private and public sector organisations. As can be observed from table 3, statistically significant differences were found on numerous occasions, with effect sizes also being of a comparatively larger nature. It must thus be argued that the findings show that the workplace values present within the private organisations are of a more supportive nature in respect to CI. With the exception of the 'uncertainty avoidance' dimension, private organisations consistently achieved higher mean scores in those areas where statistically significant differences were found. For example, the dimensions of 'experimentation', 'trust towards management', and 'waste reduction' have been all been considerably better addressed by private sector workplace values.

It is furthermore important to note that the personal values of private and public sector workers in relation to the CI dimensions are not tightly aligned with those values present at their workplaces. Table 4 shows the results obtained through a paired-samples t-test, and highlights that statistically significant differences were established for the majority of CI dimensions between personal and workplace values. Effect sizes were in some instances very large indeed, with the 'experimentation' and 'open communication' CI dimensions for example being given far less emphasis at the workplace than both private and public workers place on in their personal lives. Such instances where personal values that are beneficial to CI are not reflected in the values at the workplace must be regarded as a potential that could be exploited by organisations.

One could further make the argument that negative responses on the part of workers can indeed be invoked if a situation exists in which workplace values are in contradiction with their personal values.

	Private sector workers			Public sector workers		
	Mean Personal life values	Mean Workplace values	Eta squared	Mean Personal life values	Mean Workplace values	Eta squared
Long-term orientation	3.93	4.31	.033*			
Employee empowerment	4.83	4.08	.182*	4.85	3.62	.345*
Pride				4.81	4.18	.126*
Respect (colleagues)	5.64	4.50	.306*	5.59	4.41	.301*
Respect (customers)	5.64	5.12	.084*	5.59	4.89	.166*
Empathy (customers)	4.53	4.82	.027*	4.56	4.21	.046*
Empathy (colleagues)				4.56	4.20	.052*
Trust (management)	3.82	4.22	.074*	3.77	3.42	.050*
Trust (colleagues)	3.82	4.63	.280*	3.77	4.43	.021*
Open communication	5.46	4.46	.296*	5.09	3.98	.321*
Teamwork	4.02	4.37	.044*	3.69	4.52	.217*
Experimentation	5.57	4.56	.341*	5.30	3.71	.505*
Openness to learning	5.13	4.60	.093*	5.07	4.41	.128*
Waste reduction	5.12	4.65	.094*	4.99	3.98	.287*
Appreciation	4.25	3.84	.052*	4.23	3.85	.037*
Cost vs. quality focus	4.59	4.28	.035*	4.33	3.87	.075*
Performance measurement	4.13	4.38	.021*	4.27	4.53	.028*
Uncertainty avoidance	3.72	4.05	.052*	3.75	4.66	.265*
Process vs. results focus	4.52	4.29	.024*			
CI vs. BPR				4.08	4.56	.100*
Feeling of control	4.88	4.29	.099*			
Openness to change	2.98	3.54	.118*			
Parochial vs. professional orientation	5.29	4.78	.117*	4.58	4.31	.275*

*Determines effect size .01=small effect, .06=moderate effect, .14=large effect

Table 4: Significant differences established in paired-samples t-test

CONCLUSION

It must be concluded that the primary research findings support the notion that difficulties of implementing and practicing CI within Japanese public sector organisations could in part be explained by the presence of workplace values that are not as nurturing of CI as those found within the private sector. Public organisations in Japan that wish to implement and practice CI would thus be advised to establish whether their current norms and values at the workplace are in contrast to those values that facilitate CI.

Importantly, the research findings also highlight the point that both private and public organisations in Japan could strengthen their practice of CI by exploiting the existing personal values on the part of their workers through closely aligning the workplace values with them respectively.

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MANAGERIAL INCENTIVES IN DUOPOLY WITH PRIVATE AND PUBLIC FIRMS

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ABSTRACT

This paper studies managerial incentives in a duopoly market with one private firm and one public firm. We consider a two-stage game in which each of the two firms has an owner and a manager and each owner gives an incentive contract to its manager. In the private firm, the owner designs an incentive contract based on a linear combination of profits and sales revenues. In the public firm, the owner designs an incentive contract, about which we assume the two schemes. One is based on a linear combination of social welfare and profits. The other is based on a linear combination of social welfare and its own sales revenues. We show that the government chooses the incentive contract based on a linear combination of social welfare and profits. We also show that the owner of the private firm motivates its manager toward sales revenues at subgame perfect equilibrium. On the other hand, the owner of the public firm motivates its manager toward profits.

INTRODUCTION

This paper studies managerial incentives in a duopoly market with one private firm and one public firm. We consider a two-stage game, in which each of the two firms has an owner and a manager and each owner gives an incentive contract to its manager. In the first stage, each owner of the two firms gives an incentive contract to its manager simultaneously. In the second stage, each manager of the two firms determines its output simultaneously. In the private firm, the owner maximizes profits and designs an incentive contract based on a linear combination of profits and sales revenues. In the public firm, the owner, who is a government, maximizes social welfare and designs an incentive contract, about which we assume the following two schemes. One is based on a linear combination of social welfare and profits. The other is based on a linear combination of social welfare and its own sales revenues.

This paper was motivated by the recent advancement of regulatory reforms in Japan. One observes public firms compete with private firms in such industries as job placement services and nursing care services, since the Japanese Government started the Program for the Advancement of Regulatory Reforms in 2001.

The paper is related to the following two strands of literature. One is the literature regarding managerial incentives in an oligopoly market with private firms. Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987), among others, analyze a two-stage game, in which each private firm has an owner and a manager and the owners choose incentive contracts strategically. The other is the literature regarding a "mixed oligopoly" market with private and public firms. Cremer, Marchand, and Thisse (1989) and De Fraja and Delbono (1989), among others, examine a one-stage game, in which each of private and public firms has an owner-manager and the firms compete in a

product market. In this paper, we combine these two settings to analyze managerial incentives in a "mixed duopoly" market.

We show that social welfare under the incentive contract based on a linear combination of social welfare and profits is higher than that under the incentive contract based on a linear combination of social welfare and sales revenues. Hence, the government chooses the incentive contract, which is based on a linear combination of social welfare and profits. We also show that for the private firm, the incentive weight on profits is less than one at equilibrium. The owner motivates its manager toward sales revenues. For the public firm, on the other hand, the incentive weight on social welfare is less than one at equilibrium. The government motivates its manager toward profits.

The paper is organized as follows. Section 2 describes the model. In Section 3, we analyze two cases of incentive contracts for the public firm. In case 1, we assume an incentive contract for the public firm is based on a linear combination of social welfare and profits. In case 2, we assume it is based on a linear combination of social welfare and sales revenues. Then, we compare the managerial incentive contracts at subgame perfect equilibrium. In Section 4, we conclude.

MODEL

We examine a homogeneous good market with one private firm and one public firm. Let firm 1 represent a private firm and firm 2 a public firm. Let q_i denote firm i 's output quantity with $i = 1, 2$ and c_i denote firm i 's constant unit cost with $0 < c_1 < c_2$, implying that the private firm has lower unit cost than the public firm. The inverse demand function is given by

$$p = a - (q_1 + q_2),$$

where p is the market price. The two firms, each of which has one owner and one manager, play a two-stage game. In the first stage, each owner simultaneously determines an incentive contract for its manager. In the second stage, each manager determines its quantity of output simultaneously.

Firm 1's profits Π_1 is written as

$$\begin{aligned}\Pi_1 &= (p - c_1)q_1 \\ &= (a - c_1 - q_1 - q_2)q_1.\end{aligned}$$

An incentive contract for its manager W_1 takes the following form. We assume that the manager is rewarded by the owner according to a linear combination of profits Π_1 and sales revenues R_1 . That is

$$\begin{aligned}W_1 &= \alpha_1 \Pi_1 + (1 - \alpha_1)R_1 \\ &= (a - q_1 - q_2)q_1 - c_1 \alpha_1 q_1,\end{aligned}$$

where α_1 is an incentive weight on profits.

An owner of firm 2 maximizes social welfare S ,

$$S = \frac{1}{2}(q_1 + q_2)^2 + (p - c_1)q_1 + (p - c_2)q_2.$$

We assume two forms of incentive contracts to the manager of firm 2. One takes the following form. The manager is rewarded according to a linear combination of social welfare S and profits Π_2 . That is

$$\begin{aligned} W_2^\Pi &= \alpha_2^\Pi S + (1 - \alpha_2^\Pi)\Pi_2 \\ &= \alpha_2^\Pi \left[\frac{1}{2}(q_1 + q_2)^2 + (p - c_1)q_1 \right] + (p - c_2)q_2, \end{aligned}$$

where α_2^Π is an incentive weight on social welfare. The other incentive contract takes the following form. The manager is rewarded according to a linear combination of social welfare S and sales revenues R_2 . That is

$$\begin{aligned} W_2^R &= \alpha_2^R S + (1 - \alpha_2^R)R_2 \\ &= \alpha_2^R \left[\frac{1}{2}(q_1 + q_2)^2 + (p - c_1)q_1 \right] + (p - \alpha_2^R c_2)q_2, \end{aligned}$$

where α_2^R is an incentive weight on social welfare.

ANALYSIS

First, we consider a one-stage game, in which each of private and public firms has an owner-manager determining its output simultaneously (see, e.g. De Fraja and Delbono (1989)). This one-stage game corresponds to a special case in which both parameters α_1 and α_2 of incentive contracts equal one in our model. Then, at equilibrium, we obtain

$$\begin{aligned} \bar{q}_1^* &= c_2 - c_1 \\ \bar{q}_2^* &= c_1 - 2c_2 + a \\ \bar{p}^* &= c_2 \\ \bar{\Pi}_1 &= (c_2 - c_1)^2 \\ \bar{\Pi}_2 &= 0 \\ \text{and } \bar{S} &= \frac{(a - c_2)^2}{2} + (c_2 - c_1)^2. \end{aligned}$$

Next, we consider a two-stage game under the separation of ownership and management. In case 1 we analyze the incentive contract with W_2^Π and in case 2 that

with W_2^R . We assume that $-3c_1 + 4c_2 < a$ and $2c_2 < a$ in order to have positive quantities at equilibrium:

$$q_1 > 0 \text{ and } q_2 > 0.$$

Case 1

We find firm 1's and firm 2's reaction functions are as follows: $q_1 = \frac{-c_1\alpha_1 + a}{2} - \frac{q_2}{2}$ and $q_2 = \frac{a - c_2}{2 - \alpha_2} - \frac{q_1}{2 - \alpha_2}$. From these reaction functions, we have

$$q_1 = \frac{-2c_1\alpha_1 + c_1\alpha_1\alpha_2 - a\alpha_2 + c_2 + a}{3 - 2\alpha_2}$$

$$\text{and } q_2 = \frac{c_1\alpha_1 - 2c_2 + a}{3 - 2\alpha_2}.$$

In the first stage, the owner of the private firm maximizes Π_1 and the owner of the public firm maximizes S . We obtain

$$\alpha_1^{*\Pi} = \frac{-2a - 3c_1 + 8c_2}{3c_1}$$

$$\text{and } \alpha_2^{*\Pi} = \frac{a + 6c_1 - 7c_2}{a + 3c_1 - 4c_2}.$$

The equilibrium quantities are given by

$$q_1^{*\Pi} = \frac{2a - 2c_2}{3}$$

$$\text{and } q_2^{*\Pi} = \frac{a + 3c_1 - 4c_2}{3}.$$

Hence, we obtain

$$q_1^{*\Pi} + q_2^{*\Pi} = a + c_1 - 2c_2$$

$$p^{*\Pi} = 2c_2 - c_1$$

$$\Pi_1^\Pi = \frac{4(c_2 - c_1)(a - c_2)}{3}$$

$$\Pi_2^\Pi = \frac{(c_2 - c_1)(a + 3c_1 - 4c_2)}{3}$$

$$\text{and } S^\Pi = \frac{(a + c_1 - 2c_2)^2}{2} + \frac{(c_2 - c_1)(5a + 3c_1 - 8c_2)}{3}.$$

Note that

$$\alpha_1^{*\Pi} < 1 \quad \text{and} \quad \alpha_2^{*\Pi} < 1.$$

This result says that the owner of the private firm rewards its manager for sales revenues, $1 - \alpha_1^{*\Pi} > 0$, and that the owner of the public firm rewards its manager for profits, $1 - \alpha_2^{*\Pi} > 0$. We summarize these findings in the following proposition.

Proposition 1 *At subgame perfect equilibrium of the above two-stage game, the owner of the private firm gives an incentive for sales revenues to its manager and the owner of the public firm gives an incentive for profits to its manager.*

Case 2

We find firm 1's and firm 2's reaction functions are as follows: $q_1 = \frac{-c_1\alpha_1 + a}{2} - \frac{q_2}{2}$ and $q_2 = \frac{a - c_2\alpha_2}{2 - \alpha_2} - \frac{q_1}{2 - \alpha_2}$. From these reaction functions, we have

$$q_1 = \frac{-2c_1\alpha_1 + c_1\alpha_1\alpha_2 - a\alpha_2 + c_2\alpha_2 + a}{3 - 2\alpha_2}$$

and $q_2 = \frac{c_1\alpha_1 - 2c_2\alpha_2 + a}{3 - 2\alpha_2}$.

In the first stage, the owner of the private firm maximizes Π_1 and the owner of the public firm maximizes S . We obtain

$$\alpha_1^{*R} = \frac{-2a - 3c_1 + 10c_2}{3c_1}$$

and $\alpha_2^{*R} = \frac{a + 6c_1 - 8c_2}{a + 3c_1 - 5c_2}$.

The equilibrium quantities are given by

$$q_1^{*R} = \frac{2a - 4c_2}{3}$$

and $q_2^{*R} = \frac{a + 3c_1 - 2c_2}{3}$.

Hence, we obtain

$$q_1^{*R} + q_2^{*R} = a + c_1 - 2c_2$$

$$p^{*R} = 2c_2 - c_1$$

$$\begin{aligned}\Pi_1^R &= \frac{4(c_2 - c_1)(a - 2c_2)}{3} \\ \Pi_2^R &= \frac{(c_2 - c_1)(a + 3c_1 - 2c_2)}{3} \\ \text{and } S^R &= \frac{(a + c_1 - 2c_2)^2}{2} + \frac{(c_2 - c_1)(5a + 3c_1 - 10c_2)}{3}.\end{aligned}$$

To see whether α_1^{*R} or α_2^{*R} is larger than one, we need to consider the following two cases.

When $2c_2 < -3c_1 + 5c_2 < a$, we have

$$\alpha_1^{*R} < 1 \quad \text{and} \quad \alpha_2^{*R} < 1.$$

This result says that the owner of the private firm rewards its manager for sales revenues, $1 - \alpha_1^{*R} > 0$, and that the owner of the public firm rewards its manager for profits, $1 - \alpha_2^{*R} > 0$.

When $2c_2 < a < -3c_1 + 5c_2$, we have

$$1 < \alpha_1^{*R} \quad \text{and} \quad 1 < \alpha_2^{*R}.$$

This result says that the owner of the private firm penalizes its manager for sales revenues, $1 - \alpha_1^{*R} < 0$, and that the owner of the public firm penalizes its manager for profits, $1 - \alpha_2^{*R} < 0$.

Comparison

First, we compare the equilibrium market price and total output in case 1 with those in case 2. We obtain the following proposition.

Proposition 2 *At subgame perfect equilibrium of the two-stage game, the market price and the total output in case 1 are the same as those in case 2: $p^{*\Pi} = p^{*R}$ and $q_1^{*\Pi} + q_2^{*\Pi} = q_1^{*R} + q_2^{*R}$.*

Next, we compare the equilibrium market price and total output in the above two-stage game with those in the one-stage game described above. We obtain the following proposition.

Proposition 3 *The equilibrium market price in the two-stage game is higher than that in the one-stage game: $p^{*\Pi} = p^{*R} > \bar{p}^*$. The equilibrium total output in the two-stage game is smaller than that in the one-stage game: $q_1^{*\Pi} + q_2^{*\Pi} = q_1^{*R} + q_2^{*R} < \bar{q}_1^* + \bar{q}_2^*$.*

Finally, we compare social welfare in case 1 with that in case 2. We obtain the following proposition.

Proposition 4 *At subgame perfect equilibrium of the two-stage game, social welfare in case 1 is higher than that in case 2: $S^{\Pi} > S^R$.*

This proposition says that the government chooses an incentive contract based on a linear combination of social welfare and profits.

CONCLUSION

In this paper, we have examined managerial incentives in a duopoly market with one private firm and one public firm. We consider a two-stage game, in which each of the two firms has an owner and a manager and each owner determines an incentive contract to its manager. We have shown that the government chooses an incentive contract based on a linear combination of social welfare and profits rather than a linear combination of social welfare and sales revenues. We have also shown that the incentive weight on profits for the manager of the private firm is less than one at equilibrium. Hence, the owner of the private firm rewards its manager for sales revenues. On the other hand, the incentive weight on social welfare for the manager of the public firm is less than one at equilibrium. Hence, the owner of the public firm rewards its manager for profits.

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INCREASING SHAREHOLDER VALUE THROUGH SUPPLY CHAIN MANAGEMENT - RESULTS OF A EUROPEAN WIDE EMPIRICAL INVESTIGATION IN LOGISTICS

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PURPOSE OF THIS PAPER

The statement that supply chain management (SCM), defined as; *"the integration of business processes from end user through original suppliers that provide products, services and information that add value for customers"* (Cooper, Lambert, Pagh 1997, p.1-14) contributes to making companies more customer-oriented, competitive and effective is nowadays widely accepted (Li, 2006, p.107-124). Management also agrees that a direct connection between supply chain performance and financial results (market capitalization) exists. In fact, virtually all winning business strategies have supply chain strategies as their core strategies (D'Avanzo, 2003, p. 40-47)

Up to date supply chain management does not show the correlations between actions taken and the overall supply chain performance, competitiveness and increase in shareholder value (Lambert, 2001, p. 1-19). In order to eliminate this problem supply chain management should be linked to Shareholder Value.

The value-driven SCM approach in this paper uses EVA™. EVA is defined as the residual wealth calculated by subtracting the cost of capital from operating profit after taxes. If residual wealth is positive, the operational business can cover total costs including the cost of all capital employed. (equity and liabilities). If EVA is negative, value is being destroyed and the company faces the flight of capital and a lower stock price (Stewart, G.B. 1991).

In this paper a concept for linking SCM and VBM via value drivers will be presented. Afterwards the results of the empirical investigation, which has studied the value driver development between 1995 and 2004 will be shown. By interpreting the results, it will be tried to draw conclusions regarding effectiveness and efficiency of supply chain management in European companies.

In summary, this paper should investigate the following questions:

- How can SCM and VBM be linked?
- Which value drivers have to highest impact on shareholder value?
- How have the value-drivers evolved in Europe and which conclusions can be drawn from this evolution relevant to SCM?

VALUE BASED MANAGEMENT

Today, on global stock markets shareholders request competitive returns from their investments and force executives to create shareholder value. Accordingly, the need for management concepts and instruments that link SCM and shareholder value increases. Value-driven supply chain management views SCM

in a new light: as a powerful tool affecting all drivers of financial performance growth, profitability, and capital utilization - not just as a technique for lowering operating costs.

In order to operationalize the rather abstract demands for value creation, numerous ratios and concepts have been developed. These ratios try to form a framework for value oriented planning, management and control in daily business as well as in strategic projects. Shareholder value ratios measure the absolute amount in which the value of a company has increased in a specific period of time in monetary terms (Ewert/Wagenhofer, 2000). Typical shareholder value ratios are for example Economic Value Added (EVA®), Cash Value Added (CVA), Discounted Cash Flow (DCF), Cash Flow Return on Investment (CFROI) and Return on Capital Employed (ROCE). The large variety of ratios stems from different approaches of authors (e.g. cash-flow orientation vs. profit orientation) on the one hand but is also a consequence which derives from the need for differentiation of consulting firms.

In this paper the author uses EVA as it is very common. EVA is defined as the residual wealth calculated by subtracting the cost of capital from operating profit after taxes. If residual wealth is positive, the operational business can cover total costs including the cost of all capital employed (equity and liabilities). If EVA is below zero, value is being destroyed and the company faces the flight of capital and a lower stock price (Hostettler, 1998).

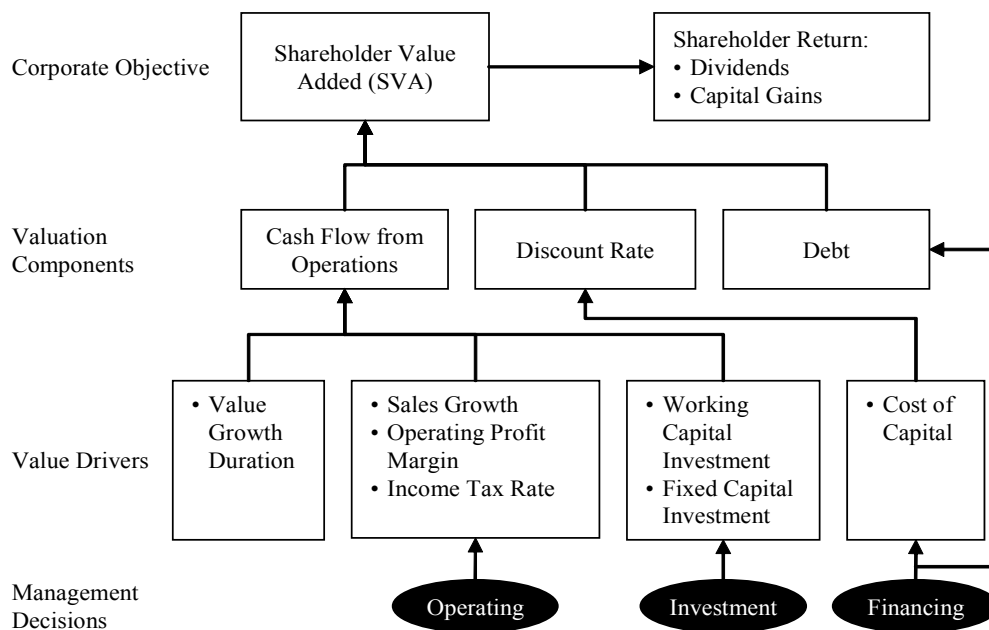


Fig. 1. Shareholder value network (Rappaport, 1999).

OPERATIONALIZING THE CONCEPT

Value drivers and value driver hierarchies take a key role in operationalizing the goal of increasing SV. Their significance results in the necessity to create further financial and non-financial key figures in order to be able to communicate the goals on all company levels (Weber/Bramsemann/Heineke/Hirsch, 2004).

Rappaport shows in his shareholder network the connection between creating shareholder value, value drivers and the main management decision areas. Growth in sales, profit margin and tax rate are linked to operational business, investments in fixed and current assets to the investment area and capital costs are linked to financing decisions (Fig. 1).

While the shareholder value network shows the linkages in a more qualitative manner, the value driver tree of EVA shows the linkages between EVA and value drivers in a quantitative manner. The different elements of EVA are broken down according to the well-known DuPont scheme (Fig 2).

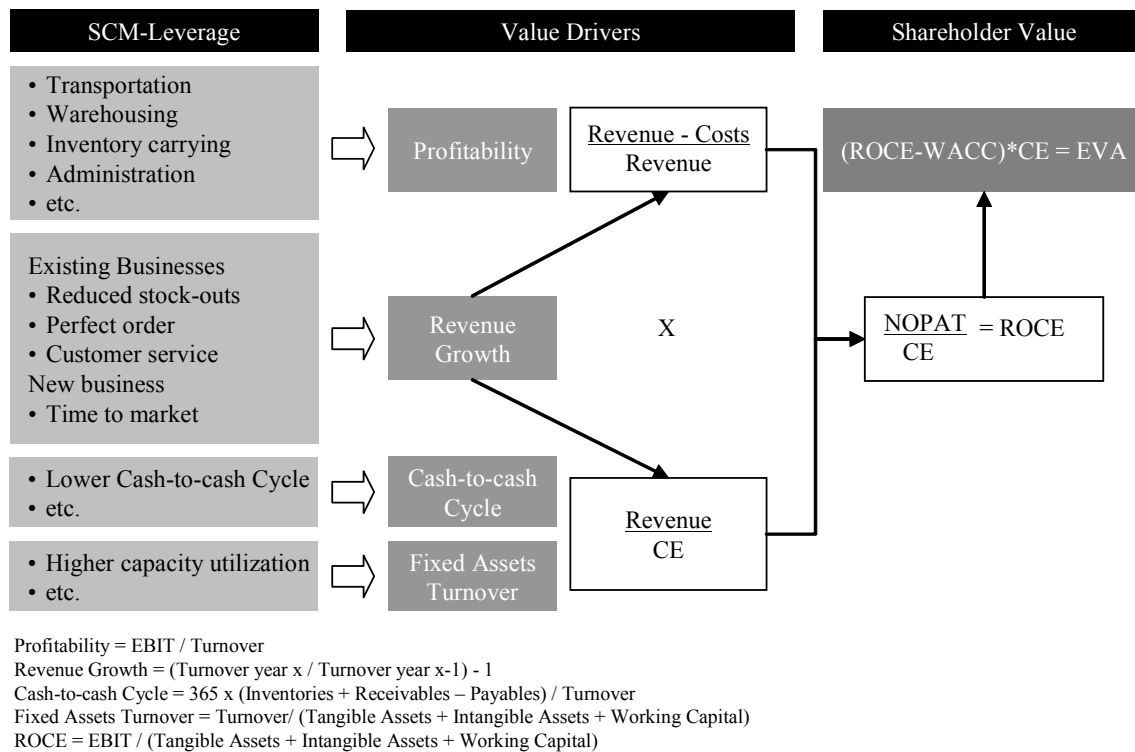


Fig. 2. EVA value driver network.

In this paper the following value drivers are defined for linking SCM-leverages to EVA: Profitability, revenue growth, cash-to-cash cycle (C2C) and fixed assets turnover. Profitability as a ratio of EBIT and revenue gives an impression of the cost and revenue situation within a company. The value driver revenue growth is an indicator of a company’s ability to achieve growth. C2C measures the interval between the time, cash expenditures are made to purchase inventory for use in the production process and the time that funds are received from the sale of the finished product (Schilling, 1996). With this value driver the change in working capital can be determined. The value driver fixed assets turnover as a ratio of revenue and capital employed shows, the turnover ratio of fixed assets. It is therefore an indicator for the efficiency in asset utilization. In this paper, capital employed is defined as the sum of tangible assets, intangible assets and working capital. This definition emphasises the operational oriented influence of the SCM-levers on positions on the balance sheet.

Further in this paper the results of the value driver analysis will be presented. Therefore, EVA will be used as the basic conceptual framework. Since interest rates for capital costs were not available for the empirical investigation, the development of ROCE as a key component of EVA has been analyzed.

RESULTS OF EUROPEAN VALUE DRIVER INVESTIGATION

METHODOLOGY

The current study was conducted with the Amadeus Top 250,000 database which covers approximately 250,000 companies from all over Europe. Selection variables included revenue, operating profit, tax, tangible assets, intangible assets, inventories, accounts receivables, accounts payable and working capital. Companies with incomplete data for the selected variables in the period 1995 – 2004 were removed from the dataset. This resulted in a usable set of 7,455 companies. Value drivers are calculated according to the equations presented in Fig. 2.

It should be noted that the data may be limited in several ways. Firstly, companies often manipulate the numbers that are reported at the end of accounting periods. For example, companies can emphasize on inventory reduction at the end of a specific accounting period. Secondly, the accounting standards differ in European countries. In order to present the records in the Amadeus database in a common format, they have to be adjusted. Some variables can differ from the original annual reports.

Thirdly, the results of the study depend on the available records in the database. For the period 1995 – 2004 a dataset of 7,455 companies with complete variables has been extracted. All results imply that these companies are representative for the European basic population.

The basic population primarily depends on disclosure requirements in each European country. For instance, in Austria only public limited companies (PLC) and large limited liability companies (LTD) are obligated to fully publish their annual reports. For the classification of sectors the American Standard-Industry-Classification (SIC) sector code was used.

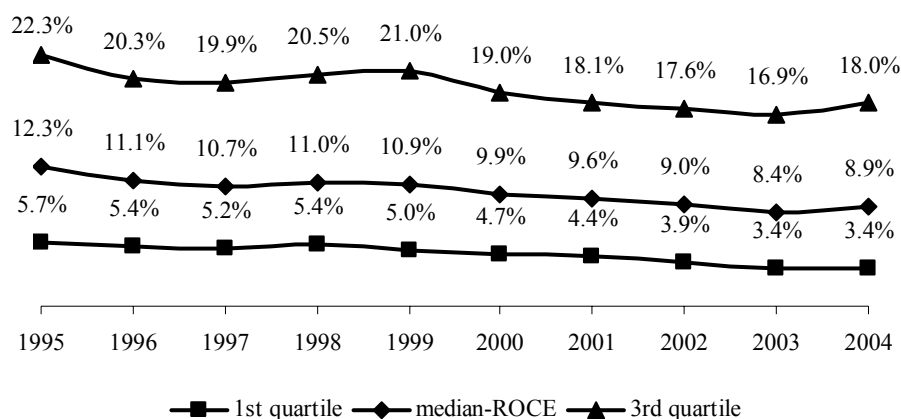


Fig. 3. Overall ROCE development.

OVERALL VALUE DRIVER DEVELOPMENT

Between 1995 and 2004 median ROCE decreased from 12.3 percent to 8.9 percent. This reduction results from a stronger increase of capital employed in comparison to operating profit. This disproportionate increase of capital employed (consisting of tangible assets, intangible assets and working capital) indicates high investment activities within the European companies, which were not able to deliver adequate returns. From the shareholder’s view, a decreasing return does not increase the shareholder value of European countries (Fig. 3). Future SCM plans should consider this by taking an increasing efficiency of business processes on the agenda. Lean processes can contribute to increasing operating profits. By decreasing inventory (as a function of lead time) and optimized utilization of plants and machinery, in-vested capital can be lowered at the same time.

The difference in ROCE for European companies between the first quartile, median and the third quartile shows that top companies have been able to generate a considerably higher result on the invested capital in comparison to the average company as well as to the latecomers.

In order to analyze the development of the value drivers more in detail, the basic population was split in two groups. Companies with ROCE above 12 percent were placed in the group la-belled “High Performers”. Companies who had a ROCE below were placed in a group labeled “Low Performers” (Fig. 4).

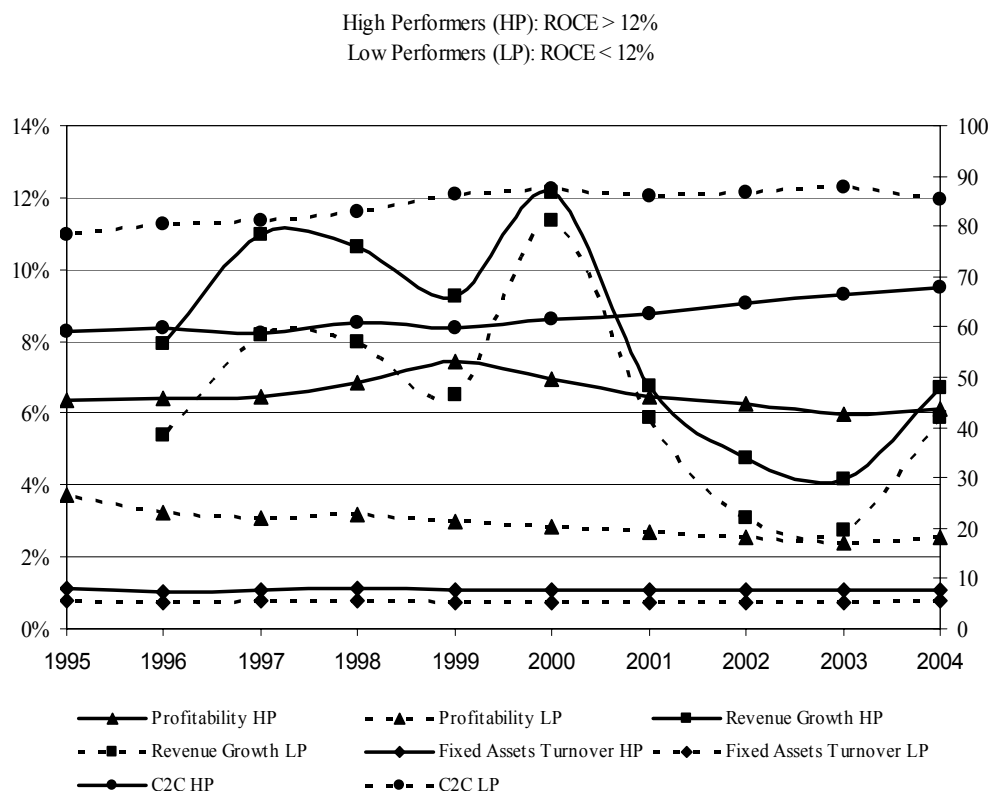


Fig. 4. Value driver development.

The time series comparison of the value drivers shows that the European companies during the time of observation were only able to marginally change their value drivers:

- Profitability of both high and low performers decreased. The median of the sample decreased with one percent from 4.7% to 3.7%. The high performers also experienced a slight decrease in annual profitability from 6.3% to 6.1%. This development underscores the future role of SCM as innovative service offers for customers, such as short and stable delivery times, or higher flexibility can increase sales volumes. At the same time the efficiency of the business process must be put to the test in order to achieve customer value without increasing costs or being less efficient.
- The value driver cash-to-cash cycle (C2C) increased in the observation timeframe from 69.3 days to 77.4 days. The low performers even had to record an increase from 78.4 days to 85.3 days. Since cash-to-cash cycle is seen as a key indicator of SCM success (Farris/Hutchison, 2002), the development of this value driver in the European companies shows that there still exists a large room for improvement. Besides the levers for designing the payment targets which can be influenced by SCM (e.g. through shorter delivery times, higher delivery reliability and quality), the main focus should be placed on reducing inventory. In order to prevent that inventories are only moved within the supply chain, SCM must take a holistic view on the whole supply chain. Isolated inventory reduction generally prevents the reduction of supply chain C2C cycle and should be avoided.
- While efficiency of current assets has been lowered, the efficiency of fixed assets has been increased: Fixed assets turnover could be raised from 6.4 to 6.6 in total. Though the figure experienced a slight decrease from 8.0 to 7.7 for high performers, the low performers experienced a slight increase from 5.6 to 5.7 instead. The future increase of the value driver through SCM should be based on mutual numerator and denominator initiatives. Shorter lead-times, higher utilization in the bottlenecks or increased equipment availability contribute to better numerator management. Denominator optimization bases on increasing the value offers for the customer (as described).
- The development of revenue growth is linked closely to the overall development of European GDP. The GDP of the EU 15 also reached a high in 2000, in order to decrease after the burst of dot-com bubble in 2003 (EU, 2007). For the basic population the value driver decreased from an annual growth of 6.4 to 6.2 percent.

The very parallel development of all pairs of value drivers (high and low performer) indicates that high performers and low performers both resort similar projects and initiatives. In comparison high performers are in a position where they can utilize the initiatives in a more effective and efficient way.

Next, the connection between increasing or decreasing ROCE and changing the value drivers (or a specific combination of value drivers) was investigated. Considering one single value driver shows that profitability and ROCE development are linked closely. 76.6 percent of all companies which were able to increase this value driver were also able to increase ROCE. In 87.6 percent of all

cases where Profitability decreased a decrease of ROCE also can be measured (Table1).

		Value driver ↗		Value driver ↘	
		ROCE ↗	ROCE ↘	ROCE ↘	ROCE ↗
1 VD	Profitability	76.6%	23.4%	87.5%	12.5%
	Fixed Assets Turnover	50.4%	49.6%	72.9%	27.1%
	Cash-to-cash Cycle	51.3%	48.7%	70.2%	29.8%
	Revenue Growth	42.2%	57.8%	62.9%	37.1%
2 VD	Profitability & Fixed Assets Turnover	87.2%	12.8%	94.9%	5.1%
	Profitability & C2C Cycle	88.7%	11.3%	93.9%	6.1%
	Profitability & Revenue Growth	76.9%	23.1%	87.9%	12.1%
	Fixed Assets Turnover & C2C Cycle	62.1%	37.9%	80.4%	19.6%
	Fixed Assets Turnover & Revenue Growth	54.0%	46.0%	75.2%	24.8%
	C2C Cycle & Revenue Growth	55.5%	44.5%	71.4%	28.6%
3 VD	Profitability & Fixed Assets Turnover & C2C Cycle	94.3%	5.7%	97.7%	2.3%
	Fixed Assets Turnover & C2C Cycle & Revenue Growth	66.8%	33.2%	81.9%	18.1%
	Profitability & Fixed Assets Turnover & Revenue Growth	88.6%	11.4%	95.3%	4.7%
	Profitability & C2C Cycle & Revenue Growth	88.8%	11.2%	93.9%	6.1%

Table 1. Connection between development of value drivers and ROCE.

The analysis of value driver combinations underlines the influence of profitability on ROCE development. 87.2 percent of the companies which raised profitability and fixed assets turnover at the same time were also able to increase ROCE. The increase in the three value drivers profitability, fixed assets turnover and C2C cycle proves to be the most successful way to increase ROCE.

Cost management combined with efficient use of assets thereby indicates to be the most successful way to increase ROCE. Better impact of combined value driver optimization on ROCE in comparison to single value driver optimization shows the need for holistic VBM. Through holistic shareholder value planning, controlling and evaluation trade-offs between value drivers can be taken into consideration. Holistic management increases shareholder value.

CONCLUSIONS

In this article a framework for shareholder value management was presented. Afterwards, value drivers were introduced. The empirical results point out the importance of holistic SCM. SCM as a cross-functional and cross-company discipline has to consider trade-offs in designing and managing supply chains efficiently. In order to maximize the impact on shareholder value, SCM should take the whole chain into consideration.

It should be noted, that value driver development is the result of different micro- and macro-economical factors. The empirical results should therefore only give a first impression about the potentials of value creation that can be achieved by SCM. To isolate the impact of SCM on shareholder value further research in existing supply chains has to be conducted.

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SPATIAL CLUSTERS OF LOGISTICS-RELATED EMPLOYMENT – A CASE STUDY OF BRISBANE-SOUTH EAST QUEENSLAND, AUSTRALIA

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ABSTRACT

The purpose of this paper is two-fold. First it maps the spatial distribution of logistics-related employment (LRE) and second it identifies the spatial clusters and patterns of LRE across a large urban region – South East Queensland in Australia. The results from the Gini Coefficient and Lorenz Curve indicate the presence of spatial inequality in the distribution of LRE; however this inequality has stabilised over the last decade. Use of Global Moran indicates the spatial dependency in the distribution (i.e. suburbs with high values are surrounded by high value suburbs); whilst the measure of local Moran has identified three main spatial clusters of the LRE around major activity hubs such as the Brisbane airport, Port and the CBD.

Key words: Logistics Related Employment, spatial econometrics, spatial autocorrelation, and GIS.

INTRODUCTION

With the advent of globalisation, and the concomitant change in the pattern of international trade, national firms are increasingly been transformed into international and global co-operations and alliances. Under the global business environment, the role of geographically localised processes on locational behaviour of firms appears to become less significant. It has been argued that the greater connectivity, telecommuting, and improved transportation provisions might have further changed the way multinational and trans-national co-operations manage their global trade in the international market (Rodrigue et al. 2005). Globalisation and internet technologies might have reduce the importance of localised geographical factors in the location decision choices as *places* are increasingly becoming more connected to global business around the world and *people* and their mobility patterns are now more likely to be liberated from spatial constraints such as distance and proximity.

Contrary to this view, the agglomeration and cluster theories (Porter 2000; Rosenthal et al. 2003; Van Soest et al. 2006) argue that the process of globalisation has in fact accelerated the clustering tendency of firms around those areas that have comparative and competitive advantage. Globalisation has made the businesses more 'location dependent' rather than 'location free'. The localised geographical processes such as accessibility have further reinforced this tendency of co-location (Woundsma et al. 2008) wherein firms are clustered to take advantage of economies of scale, low transport costs, and closeness to larger corporations for business. These theories were predicated on the basis of the assumption that employment generally exhibits a tendency to cluster in

specific areas that have relative advantage of offering 'optimal' outcomes in terms of profits, cost, or other criteria depending upon the type of industry. The theory of clustering is now well established in regional science literature. Porter (2000) defines a 'cluster' as a group of interrelated companies and associated institutions that cooperate and compete to generate wealth located within a geographic area. Cluster theory establishes that competitive advantage may arise from agglomeration economies – co-location of buyers, sellers and relevant others that minimise operating cost structures, encourage sharing technology, and develop business networks (Porter 1998).

The distributional aspect of logistics and supply chains is a geographic phenomenon (Rodrigue et al. 2005). It holds explicit locational attributes (e.g. geographic references) as passengers or freight is to be transported across a given geographic space. The movement of freight and the resulted spatial interactions vary due to the relative differences in resources distribution; the location of logistics provisions such as storage and warehousing facilities thus tends to adjust according to the accessibility to transportation hubs and ports (Woudsma et al. 2008) so that the areas of production and consumption can be linked more economically. The question to what extends logistics firms and companies exhibit the clustering tendency around areas of comparative advantage has however attracted very little attention. A number of studies (Waddell and Shukla 1993; Szivas et al. 2003; Chhetri et al. 2008) have investigated location choices for retail and business services employment, however the industry that manages supply chain networks and provides infrastructure support (e.g. storage and transport provisions) on which other types of industry are directly and indirectly dependent for resource acquisition and distribution has largely been ignored in the literature.

It is evident in several studies (Waddell and Shukla 1993; Woudsma et al. 2008; Chhetri et al. 2008) that the tendency of clustering often encourages firms to co-locate along major activity centres such as CBD, urban corridors and transport hubs so that the economies of scale can be achieved and transport costs can be reduced. Since there is so much of spatial heterogeneity embedded within any supply chain between the origin and the destination or multiple destinations, unevenness in the distribution of LRE across a geographic area is expected to exist. This paper purports to address the distributional aspects of logistics-related employment for one of the rapidly growing city regions in Australia – the South East Queensland region; thus aims to fill this gap in the literature. The nature, location and relationships of spatial clusters, particularly for logistics related employment, in the information or knowledge driven economy, will be evaluated before the cluster theory can be more widely transmuted into policy and action.

There are three main objectives set out for this paper.

- First, we will describe the distribution of logistics-related employment across the SEQ region including the identification of areas that are either emerging or declining in transport and warehousing industries over the last decade (between 1991-2001). The number of people employed in those industries is considered as a surrogate measure for logistics related industries. That means, higher the employment, greater the number of firms and companies.

- Second, we will quantify the degree of inequality in the distribution of these jobs at a global level using measures of inequality such as the Gini coefficient and Moran's I.
- Third, the spatial association and clustering of jobs will be identified using the measure of the measure of local Moran so that spatial patterns and structures of the LRE can be quantified.

The novelty of this research is two fold. First, it investigates logistics related employment at a spatially disaggregate level (e.g. suburb) to provide a local perspective to decision choice process. Second, a number of techniques including more advanced methods of spatial econometric are applied to analyse the spatial dependence of the LRE.

The remainder of this paper is structured into four sections. The next section introduces the study area, which is then followed by section three that describes the datasets to be used for the analysis. Results of statistical analysis are presented in section four, and the paper concludes with a summary of the major findings in section five.

STUDY AREA

The South East Queensland (SEQ) region of Australia, which includes the Brisbane, Gold Coast and Sunshine Coast, has been experiencing rapid socio-economic and demographic changes (e.g. inter-state migration, tourism growth) over the last two decades. The growth in population combined with burgeoning economic activity has placed considerable stress on the modal and Intermodal infrastructure facilities. The ability of the metropolitan road network to meet growing demand for cross-town movement of freight, commercial and commuter traffic is critical to the region's long-term development. Congestion is more increasingly impacting the network efficiency and performance and this problem is expected to increase over the next 20-25 years as the population and commercial activities increase (Queensland Government 2006). Freight across Queensland is also forecasted to double by 2020 (Queensland Government 2006). With the expanding import and export activities around the Port of Brisbane, the road and rail transport corridors that service the Australia Trade Coast area might struggle to manage the anticipated flow and volume of traffic in the future.

DATASETS

The employment data used for the analysis have been extracted using Census Journey to Work (JTW) dataset (ABS 2001). The JTW data provide information about where people live and work, what industry they work and what transport modes they use. The types of industry in the JTW data were classified using the Australia and New Zealand Standard Industrial Classification (ANZSIC). ANZSIC codes were used to identify logistics-related employment. As it is difficult to identify logistics-related employment on the standard ANZSIC classification, therefore one-digit industry sector '*Transportation and Warehouse*' has been used as a surrogate measure for representing logistics-related employment. The data comprises 289 Statistical Local Areas (referred as suburbs in this paper), which hold information about the number of people employed in the transportation and warehouse industry.

STATISTICAL ANALYSIS

Two sets of methods are applied to employment data in this paper; the first relates to the measurement of the spatial distribution and the associated patterning of TRE using the Lorenz Curve and the Gini Coefficient, and the second set of methods employed are applied to measure the spatial autocorrelation to reflect both global and local patterning and clustering of jobs.

Lorenz Curve and Gini Index

The degree of inequality in the distribution of a phenomenon such as wealth can be measured using the Lorenz Curve and the Gini Coefficient. To calculate the Lorenz curve, the data on employment in logistics sector were first ordered and then proportionally cumulated by their size. Since the Lorenz Curve is a comparative measure, the distribution of all jobs is used as a comparative scale to measure the degree of inequality. In terms of interpretation of the curve, if all observations (e.g. suburbs) are of the same size (e.g. the number of people employed in the logistics sector), the curve will form a straight diagonal line that is termed 'the line of equality'. In case of unequal distribution of employment in a sector, the curve will either be over or under the line of equality.

The Lorenz Curve and the Gini Coefficient were calculated for three census time intervals: 1991, 1996 and 2001. The results indicate that the LRE across the SEQ region is unequally distributed (see figure 1). The distribution depicts a high spatial concentration of LRE in suburbs that are either located in close proximity to industrial areas or the Brisbane Port. City – Inner, Pinkenba-Eagle Farm, City Remainder, Acacia Ridge and Ipswich were among the top five suburbs in 1991, whilst the order and ranking have changed slightly with the Pinkenba-Eagle Farm leading the list of top performers with others being City – Inner, Hemmant-Lytton, Acacia Ridge and Bowen Hills in a descending order in 2001. The suburbs with high concentration of LRE are either located in close proximity to Brisbane Port and CBD or they are industrial areas (e.g. Acacia Ridge, Archerfield and Rocklea). The concentration of logistics-related employment is also evidenced in the Lorenz Curve. In 1991, for example, 50 percent of the total jobs in the logistics related sector were located only in 56 suburbs out of a total of 289; while the degree of job concentration didn't change much in 2001 with a total of 57 suburbs accounting for 50 percent of the LRE employment.

Figure 1 shows the relationship between the cumulative proportion of logistics-related employment and total employment using the Lorenz Curve. Each year (1991, 1996 and 2001) displays a wide disparity in the distribution of LRE; however, over the three census periods there is an indication of the degree of inequality in the distribution of LRE across the SEQ region has not changed much. While a stable pattern over the last decade is evidenced on the Lorenz curves, the magnitude of that inequality is still unknown. Using the Gini Coefficient measure, the magnitude of the inequality can be further explored through a single measure of the distribution.



Figure 1: Lorenz curves for three census periods: a) 1991, b) 1996, and c) 2001)

The degree of inequality (e.g. the extent to which the curve deviates from the line of equality) can be computed using the Gini Coefficient, which is the ratio between the area enclosed by the Lorenz curve and the line of equality, and the area under the line of equality within the given triangle. Since the data is arranged by the size of the observations in ascending order, the Gini Coefficient is computed as:

$$G = \frac{\sum_{i=1}^n (2i - n - 1)x'_i}{n^2 \mu} \quad (1)$$

Where, μ is the mean size, n is the number of observations.

The Gini coefficient ranges between 0 and 1, where 0 reflects complete equality (every suburb has equal number of jobs) whilst 1 corresponds to a perfect inequality (a single location/suburb has all the jobs).

The results show that the Gini Coefficient has slightly increased from 0.33 in 1991 to 0.35 in 1996 and remain the same (0.35) in 2001, indicating the large disparities in the distribution of LRE inequality over the last 10 years. Despite the existence of inequality across the region, there is indication that the gap between the core and peripheral areas has remained unchanged. The spatial pattern (e.g. distinct pockets of low and high concentrations) and dispersion of logistics-related employment and the underlying clustering at the local level however could not be explored through the global measure of Gini Coefficient. Further investigation is thus needed that provides insights into the growth patterns that then may enable the identification of 'hotspots' and 'coldspots' of logistics led employment for the region.

Spatial autocorrelation methods

One commonly used technique to calculate the degree of spatial autocorrelation in the observations is the Moran's I statistic (1950). This index can be based on binary contiguity between spatial units. In the binary weight matrix spatial connectivity is expressed as either a 1 or 0. That is, if two spatial units have a common border of non-zero length then they are considered to be 'neighbours' and assigned a value of 1, otherwise attributed a value of 0 (not neighbours).

This idea of a binary weight matrix can be extended to a more general spatial weight matrix. A general spatial weight matrix uses a combination of distance measures to express the proximity between spatial units. For instance, one such method is to define W where the i, j th element is defined as follows:

$$w_{ij} = \begin{cases} \exp(-cd_{ij}), & \text{for } d_{ij} \leq D_{\max}, \\ 0, & \text{otherwise,} \end{cases} \quad (2)$$

where d_{ij} is the distance between unit i and unit j D_{\max} is the maximum allowable distance between any i and j before spatial proximity becomes redundant, c is the decay parameter. A high value of c indicates that regional

interactions are very proximate whilst a lower value would suggest that interactions are more spread out over the state space.

Once the potential spatial interactions are defined, the next step is then to detect any global and local patterns of spatial autocorrelation.

The Moran's I statistic (Moran 1950) is the most common test to measure global spatial autocorrelation by combining each observation over all pairs of locations, this test statistic takes the form:

$$I = \frac{N}{(N-1)S^2} \sum_{i=1}^N \sum_{j=1}^N w_{ij} (x_i - \bar{x})(x_j - \bar{x}), \quad (3)$$

where w_{ij} is an element of the spatial weight matrix W , x_i is observation $i=1, \dots, N$ and $S^2 = (N-1)^{-1} \sum_{i=1}^N (x_i - \bar{x})^2$. Moran's I is positive when there exists a positive correlation between sites, negative for a negative correlation and zero when no spatial autocorrelation exists. Inference from this statistic can proceed via permutation tests, such as Monte-Carlo test. Furthermore, by using the asymptotic distribution of I , a normal test for the null hypothesis of no spatial autocorrelation can be performed on the standardised test statistic. It must be noted that Moran's I is quite sensitive to changes in the mean, and Moran's I can only be reasonably interpreted when there is a globally constant variance.

Localized Indicators of Spatial Autocorrelation (LISA) statistics are another useful diagnostic tool (Anselin 1995). LISA statistics enable the detection of: regions where autocorrelation is unusually different; clusters of positive or negative autocorrelation; and abnormal observations in the data.

A common measure of localised spatial autocorrelation is the local Moran's I statistic which is defined as:

$$I_i = \frac{N}{(N-1)S^2} (x_i - \bar{x}) \sum_{j=1}^N w_{ij} (x_j - \bar{x}). \quad (4)$$

As with the global statistic, a value close to one indicates positive spatial autocorrelation, a negative value suggests negative correlation and zero indicates no autocorrelation.

Spatial patterning, in terms of clustering, randomness or dispersal of employment, can be quantified using the bi-variate measure of Moran's (I). To calculate the Moran's I , the spatial interconnectedness of regions has been calculated. A spatial weighting matrix was computed using the 'first-order contiguity', where areas (i.e. suburbs) with common borders are defined as neighbours.

The significant Moran's I index evidenced the presence of positive spatial autocorrelation for the logistics-related employment for all three census periods. In other words, the suburbs that are close together have similar values to those that are located further apart. The Z scores indicate that there is less than 1 percent likelihood that these clustering could be the result of random chance. The Moran's I index calculated for TRE for 1991 is 0.482 without the outliers

(City-Inner and Pinkenba-Eagle Farm). For 1996, the Moran's I decreased to 0.453 excluding the outliers. The Moran's I for the 2001 census period continued to decline to 0.442 ($p < 0.001$).

From the results two main conclusions can be drawn from the spatial dependence of TRE for the region. First, the jobs across the region are not randomly distributed as the spatial pattern emerged to be spatially correlated with the presence of spatial clusters. Second, since 1991 the clustering pattern has not changed much. Suburbs with high values (i.e. the number of jobs) are surrounded by high values; whilst suburbs with low values have neighbours with low values.

The Moran's I index is a global measure (i.e. measures which assess the whole dataset) and therefore it does not indicate the local specific change or association of LRE processes on logistics related employment at a particular locality. To explore this, the Local Indicators of Spatial Association (LISA) is applied that decomposes the global measure into contributions for each suburb. The Local Moran I statistics enable the spatial clustering of similar or dissimilar values to be mapped for every observation across a geographic space. Using the outputs from LISA, spatial clusters can be identified and their significance mapped at a smaller unit of analysis.

The relationships has also been explored using the Moran's scatter plot (Anselin 1995) that maps the difference from the average number of jobs for each suburb against the number of jobs of its nearest geographic neighbour. The plot illustrates each suburb's difference from the average number of employment against their spatial lag, - that is a weighted average of the total employment of neighbouring suburbs. Four quadrants can be conceptualised to interpret the results. *Quadrant 1* represents those suburbs that have low concentration of logistics-related employment surrounded by suburbs with high concentration of jobs. These are: Corinda, Herston, Kangaroo Point, Moggill, Kelvin Grove, Labrador and Broadbeach. *Quadrant 2* consists of those suburbs with high concentration of LRE surrounded by suburbs with high values. These include: Acacia Ridge, Archerfield, Bowen Hills, City-Remainder, Fortitude Valley; Hendra; Hamilton, Wacol, Ipswich, and Hendra. *Quadrant 3* contains low concentration of LRE in suburbs as well as in their neighbours. The quadrat 3 consists a large number of Brisbane suburbs (Fig Tree Pocket, Highgate Hill, Indooroopilly, Kenmore, Keperra, Kilcoy, Laidley, Caloundra, Noosa). *Quadrant 4* encompasses high concentration suburbs with low concentration of LRE neighbours. Suburbs in this quadrant are Darra-Summer, East Brisbane, Geebung, Toowong, Upper Mount Gravatt, Gatton, and Capalaba, to name a few.

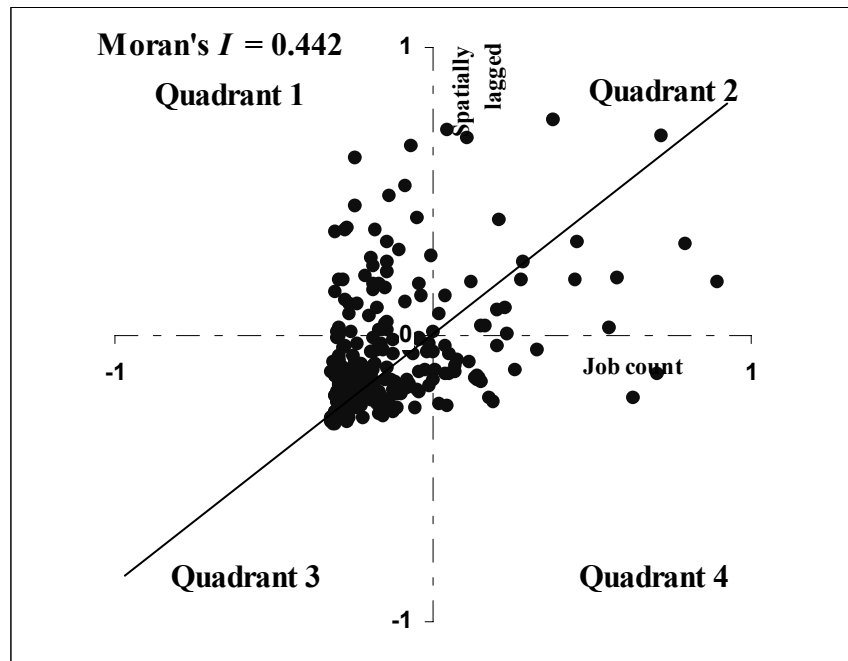


Figure 2: The Moran scatter plot

Figure 3 depicts the results of local indicators. Suburbs depicted in darker shades are statistically significant 'hot spots' wherein areas with high (above average) concentration of LRE are surrounded by areas with similar high values. Three major hotspots are identified on the map, they include:

- **CBD-based cluster** includes City-Inner, City-Remainder, Fortitude Valley, Milton and Spring Hill.
- **Port-based cluster** comprises areas such as Banyo, Hamilton, Hendra, and Northgate.
- **Industry-based cluster** consists Acherfield and Coopers plains.

Poorly performing suburbs are those situated in cold spots where they have low (below average) concentration of jobs surrounded by similarly low values. These suburbs with low-low concentration of logistics-related jobs are typically located in outer suburban area of Brisbane. The pockets include suburbs of high socio-economic status with low concentration of manufacturing industries (e.g. Pullenvale, Bellbowrie, Chapel Hill, Kenmore Hills, Pinjara Hills, Upper Brookfield and The Gap).

The two other types of clusters (i.e. high-low and low-high) have negative spatial autocorrelation where suburbs with low or high values surround suburbs with high or low concentration of jobs respectively. Few suburbs (i.e. Nudgee Beach, Nudgee, Nundah, Wynnum, Herston, Ascot and Newstead) have emerged as areas of statistically significant low-high concentration. They have relatively low values of job concentration though suburbs with relatively high values surround them. These suburbs are close to either Brisbane Port (with direct access to a beach or coast) or are situated close to Brisbane CBD.

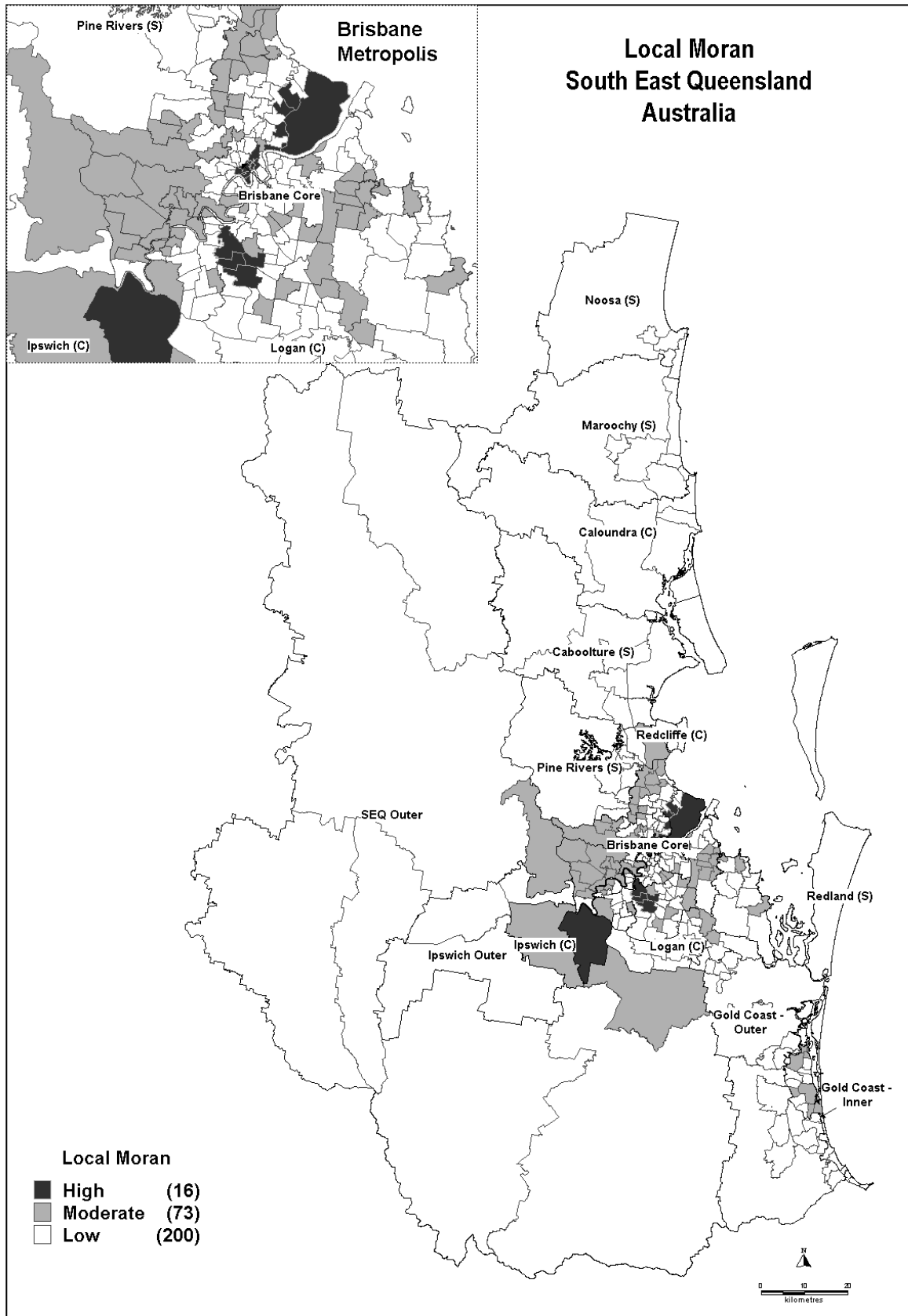


Figure 3: The local Moran score

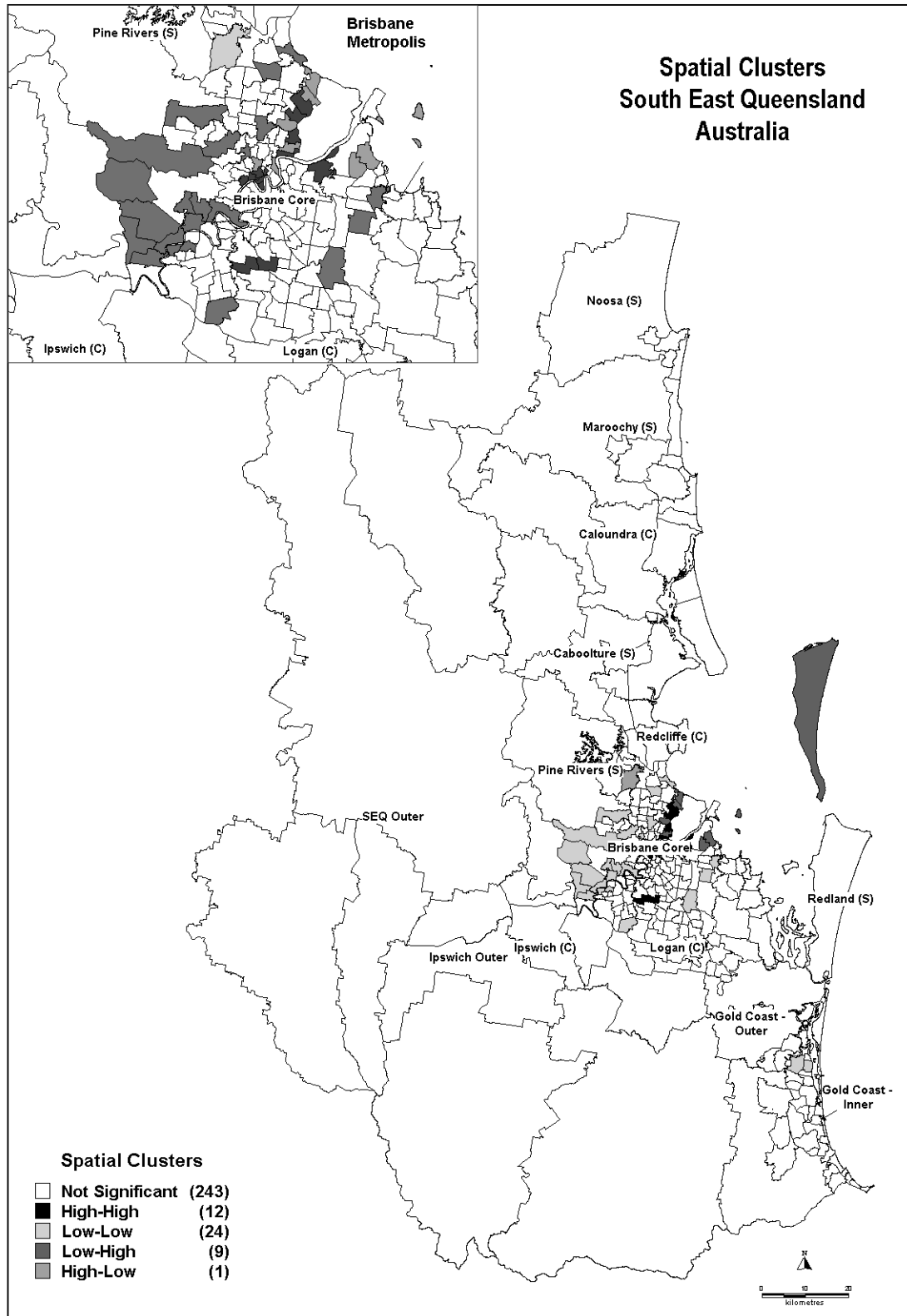


Figure 4: The spatial clusters of spatial association

CONCLUSIONS

This paper applied a number of techniques to explore the distribution and spatial reflection of the logistic related employment. The main findings of this paper can be summarised as following. First, the Lorenz Curve and the Gini Coefficient show that the degree of inequality in the distribution of LRE does exist. Over the last decade, this inequality however has been not changed. The results indicate that the gap between the core areas of logistics and warehousing and peripheral areas has remained stable, which may suggest that logistics-led employment might not have started to permeate across less developed parts of the region. The clustering and agglomeration effect might have encouraged the disparity in the distribution of LRE. Second, using measures of spatial autocorrelation both global and local indicators, spatial dependency of LRE whereby areas with high values (i.e. the number of jobs) are surrounded by high values and suburbs with low values have neighbours with low values has been detected. Significant spatial clustering across the metropolis was identified whereby LRE tends to congregate around transport terminals such as Brisbane airport and port. Three major spatial clusters were identified when the local Morans were mapped. These include the Port-based, CBD-based, industry-based clusters. Closer examination of the last two clusters indicates the 'supportive role' of logistics in facilitating the administrative (CBD based) and circulation (i.e. transportation and storage based) of goods and services for other industries. For the Port-based Cluster, logistics related employment might be considered as 'core activity' in terms of providing freight movement and transshipment facilities.

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THE PROCESS OF EXECUTION OF SUPPLY CHAIN FUNCTIONAL STRATEGY: A REVIEW OF KNOWLEDGE OF CONTENT AND PROCESS

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ABSTRACT

This paper examines relevant knowledge on the process of execution of supply chain (SC) strategy by business partners, as part of a new research project. Much previous work has defined the content (e.g. Skinner, 1978; Hayes and Wheelwright, 1984; Roth, 1996) and process (Hill, 2000; Platts & Gregory, 1992; Sadler & Hines, 2002; Fabioulas, 2007) of operations and supply chain strategy formation (Gattorna 1996; Bowersox, 1999; Frazelle 2002). But execution of such strategy has barely been researched.

The aim of the overall project is to develop a good process to support managers of SC partners during the execution, or implementation, of functional strategy by partners in at least three links, or echelons, of the supply chain. This process has the potential to achieve benefits in the areas of alignment, turnover and reduced time to execute. Because the execution process is not well known even in the strategic management literature (Bossidy & Charan, 2002; Hrebiniak, 2005) and even less so in SC management (Sadler, 2006), this paper examines in depth the literature across surrounding management areas to determine the extant knowledge and its gaps. The existing applications of SC strategy execution are examined. A number of useful processes are found which our research will use to support SC companies in their strategy execution. We anticipate a superior execution process will emerge from the research.

LITERATURE REVIEW

The review starts with an explanation of business strategy execution according to key academic contributors. Secondly, it addresses the driving factors of successful strategy, showing that execution of logistic strategy is poorly known. Thirdly, the review examines the state of practical application of the execution concept.

Explanation of strategy execution

This section examines the main knowledge about strategy execution, which is limited to corporate and business levels. Bossidy & Charan [B&C], (2002) addressed the definition of execution as follows:

Execution is a systematic process of rigorously discussing 'hows' and 'whats', questioning, tenaciously following through, and ensuring accountability. It includes making assumptions about the business environment, assessing the organisation's capabilities, linking strategy to supply chain operations (and the people who are going to implement that strategy), synchronising those people and their various companies and disciplines, and linking rewards to outcomes. It also includes mechanisms for changing assumptions as the environment changes and

upgrading the partner companys' capabilities to meet the challenge of an ambitious strategy.

Execution is better known in the business world than in research circles although it is essential to the success of companies and organisations. B&C say there are three core processes: people, strategy and operations (ibid, p 9). Operations, and its key subsidiary logistics, are important because they comprise one of these three core processes. This process is relevant because it is essential to the design, production and delivery of products, and services, to the company's end customers (Slack, Johnson and Chambers, 2001).

The 'planning' view of strategy as a pattern of decisions and actions designed to take the organisation towards its goals (Mintzberg, 1996) is adopted. Most researchers argue that strategy is required to enable management to synchronise the use of equipment and people resources in providing new and existing products to satisfy customers (Ansoff, 1984; Kaplan & Norton, 1996). Given that strategy is required at functional levels as well as the business level, we will research the execution of functional strategy within this umbrella, using the foregoing paradigm.

The main academic work on (business) strategy execution appears to be Hrebiniak's (2005):

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

Our reference to execution process corresponds to Hrebiniak's 'logical approach'. Since Hrebiniak has done much groundwork, his model of strategy execution is reproduced with 'Supply chain strategy' taking the place of 'Corporate Strategy' in Figure 1 (ibid p 35). With the strategy of collective companies partnered in the SC taking the place of Hrebiniak's 'corporate strategy' ellipse, the amended model comprises 'supply chain strategy' driving 'business strategy and operating objectives' for those partners. This in turn drives 'incentives and controls'. In practice the business strategy of the partners will also drive chain strategy.

Hrebiniak bases his model on extensive surveys of executives who have undertaken his executive programs. He derives a list of twelve obstacles to strategy execution. The top five obstacles are listed as a guide to the most important areas from the practitioner point of view (ibid p 17).

- Inability to manage change effectively or to overcome internal resistance to change
- Trying to execute a strategy that conflicts with the existing power structure
- Poor or inadequate information sharing between individuals or business units responsible for strategy execution
- Unclear communication of responsibility for execution decisions or actions
- Poor or vague strategy

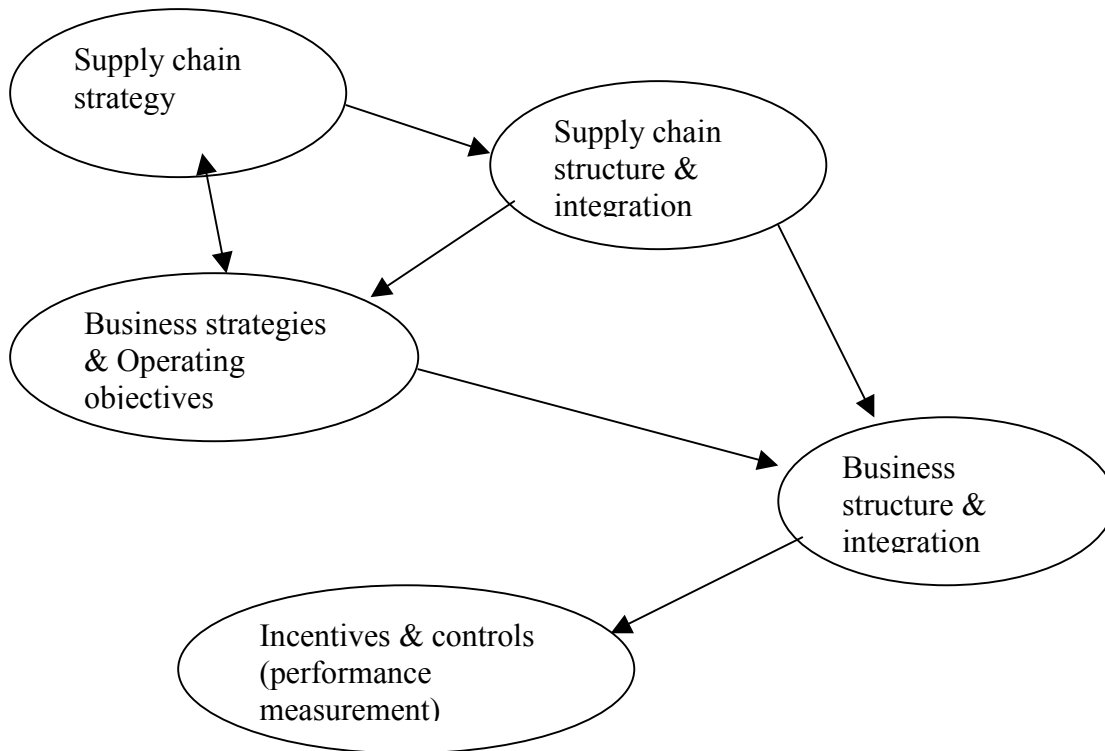


Figure 1 Executing supply chain strategy (After Hrebiniak, 2005)

Recent work confirms that supply chain integration, including strategic relationships, mainly affects performance when internal business conditions are complex, which are considered to result from a high level of uncertainty of demand and its mix, complex operations, high product variety and small production batches (van Donk *et al.* 2007).

Driving Factors and Strategic Decision Areas

The literature on SC strategy (Gattorna 1996 p 200, Sadler 2006,) suggests that the three driving factors of successful strategy are content, process and execution. The spectrum of *content* of operations and supply chain strategy is well known (Hill, 2000; Roth 1996, Bowersox, 1999). Content in the present context means examining important SC strategy decisions within and between SC partners, comprising a focal provider, a supplier and a distributor (or retailer). We also argue that the content emphasis for a particular firm and chain must be carefully selected within a comprehensive spectrum. Considerable research on *formation* process over the last fifteen years has provided acceptable support to strategy-forming teams (e.g. Platts and Gregory 1992; Sadler and Hines 2002). The main remaining challenges in process are to provide sufficient management input and to tailor the process to the needs of the firm and its chain. This leaves *execution* as a component which is poorly understood in the real world and relatively unknown in operations management research (Power, 2005). At the moment, execution is essentially *ad hoc*: it needs to be measured and have the functions which nurture it identified.

An interesting alternative view of the driving factors, or implementation variables, is provided by Okumas (2001) from his assembly of previous work and

his research in the hospitality area. He identifies the following four groups of variables, with the key variables which each contains:

- Strategic Content, comprising strategic decision, multiple project and implementation
- Context, which comprises environmental uncertainty, organisational structure, organisational culture and organisational learning
- Strategic Process, which contains operational planning, resource allocation, communication, people, monitoring and feedback and external partners, and
- Strategic Outcomes, which contains the tangible and intangible results of the project.

Focusing strategy execution for one company, Freedman (2003) outlines five key elements when implementing/ executing a strategy:

- Communicating the strategy
- Drive planning
- Align the organisation
- Reduce complexity
- Install an issue resolution system

Freeman also provides an interesting 'Communications Matrix' to suggest what elements of the strategy should be communicated to which stakeholder. This matrix aims to ensure that both internal and external stakeholders have full knowledge of the firms' strategy, thus supporting the implementation/ execution phases.

Practical Applicability

This section explores pieces of research in which some progress on strategy execution has been made. It then examines reasons for execution failure.

The operationally focused work of Kumar et al. (2006) discusses strategy execution within an industrial service setting. Using two case studies, the service strategy execution process that Kumar develops provides a simplistic model that can be applied to SC Strategy. The process is very suitable for SC Strategy because it focuses upon the intrinsic execution imperatives of the strategy. Using Hewlett Packard as a primary case study, the work of Feurer et al. (1995) discusses the strategy formulation and implementation process. The method for implementation/ execution utilises a standardised process termed 'Hoshin-Kanri' that explicitly reveals the objectives that support the corporate and business level objectives. In a further application, the use of the Balanced Score Card (Kaplan and Norton, 1996) by 16 energy companies in Finland, revealed that linking the strategic vision to measurable and executable tasks enabled effective strategy execution) (Haapasalo et al., 2006).

Widening the focus to supply chains, Varma et al. (2006) discuss strategy implementation issues within a SC environment, although they are concerned with a single firm. Their research provides a framework for executing strategy in a single firm. They acknowledge the extra complexity associated with executing strategy throughout an entire Supply Chain Strategy.

A number of studies examine failure of strategy execution and methods to avoid failure. Liedtka (2006) focuses upon the strategy as being merely window

dressings with little or no substance, thus lacking executable qualities. Sterling (2003) looks at the basis for strategy failure and methods to avoid such failures. Sheehan (2006) isolates 'levers' that improve strategy execution, by controlling and aiding the strategy execution process.

KNOWLEDGE GAPS AND RESEARCH QUESTIONS

Drawing on the literature review, this section examines the gaps in knowledge and the research areas which are to be pursued. The final section then develops a preliminary possible process to support SC strategy execution.

This literature review has covered both content, the areas in which strategic decisions are required, and process, the steps and support which best assist managers of SC organisations in their formulation and execution of strategy. From these areas, the review has derived the gaps in knowledge and formed research questions. There is almost no specific knowledge of the best process of strategy execution for a focal company and its key partners in the functional area of supply chain management. Processes for strategy formation are reasonably well known and processes exist for micro-areas of companies (Waddell *et al.* 2000) but it remains to be shown to what extent these apply to SC strategy execution. It is considered that qualitative research should start in one industry area, food, and proceed to test perceived relevance to, or variations required for, other companies, products and industries.

In response to Bossidy and Charan's (2002) argument that the three core processes are people, strategy and the operating plan, the work proposed to bridge this gap can be expressed as

Developing knowledge of strategy (including design), operations and people business processes within the function of operations, which is responsible for the fulfilment of business, customer and supply chain aims.

Hence initial research questions are:

- What are the main constituents of an execution process which will give good support to a focal company and its SC partners?
- What process will enable collaborative partner companies in a supply chain to have the best chance of successful execution, resulting in achievement of their objectives, such as turnover, execution speed and stakeholder satisfaction?
- What are the minimum and preferred conditions of strategy team members, inter-organisational structure and information systems for superior execution of SC strategy?

It is considered that a review of process to start to answer these questions might examine:

- Formal, and semi-formal, strategy action lists possessed by the SC partners
- Determine whether such SC strategy fits the 'long-term' goals and order-winners of each company and its SC.
- What action, during an extended period of months/ years, is taken by the partners on each required task?

- If action is not taken, is this due to lack of execution or because the action is no longer advantageous?
- How successful is the execution over a period of time of at least a year, quarter by quarter, to give a 'mark out of 10'.

PRELIMINARY PROCESS TO SUPPORT SC STRATEGY EXECUTION

The foregoing literature review shows that careful management is required to execute a Supply Chain Strategy. In particular, the managers responsible need to be made aware of the tasks that are to be completed. Whilst there is no literature on support mechanisms to aid a SC strategy, there are examples in single firms. A novel approach reveals a web-based collaboration support mechanism that gives the status of strategic actions and provides a forum for members of the firm to collaborate about them (Russell *et al.*, 2004). An example of strategy visualisation and performance measurement is the application of "Hoshin-Kanri" to strategy formulation and implementation activities at Hewlett-Packard (Feurer *et al.*, 1995).

In an operations application, Platts and Tan (2004) provide three fundamental tools for strategy visualisation, performance profiling, strategy charting, and TAPS (Tool for Action Plan Selection). Performance profiling is effective in the design and formulation phases of the strategy process (Hill, 2000). Strategy charts allow practitioners to view the activities required and illustrates the link from the future implementation elements up to business objectives and back to realised strategy (Mills *et al.*, 1994). The advantage of strategy charting, lies within the clear presentation of the actions that are required to execute the strategy. The third tool, the TAPS visualisation device, allows those managing the strategy process to review the variables within the strategy and identify the fit between actions that underpin the strategy.

Our work is intended to draw on the above process supports and use the following areas:

- Action research has been applied to social situations in education and hospitals (Pettigrew, 1995)
- Lean value stream mapping probably comes closest to the execution of operations strategy (Womack and Jones, 1996). By making all the players in the chain map business processes at system-wide and micro-levels, it provides the opportunity to stream-line the costs and operations of the product supply chain.
- The Strategic Operations and Logistics Planning process sets out a feasible, practical procedure by which companies in a supply chain may form SC strategy (Sadler & Hines, 2002)

CONCLUSION

This paper has reviewed the extant knowledge on strategy execution in strategic management and supply chain areas. The considerable research into company strategy execution is argued to have some wide application in supply chain strategy.

A model is derived to link sc strategy with execution incentives and outcome measures. A research program is outlined to determine a good process for sc strategy implementation and examine the support which managers require.

The paper finishes with some comments on the process which the researchers intend to use to explore this important, novel area.

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