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INTRODUCTION

We would like to welcome our friends and colleagues to the annual International Symposium on Logistics (14th ISL). It is 16 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, Hungary 2007) and four times outside Europe (Iwate, Japan 2000, Melbourne, Australia 2002, Bangalore, India 2004, Beijing, China 2006 and Bangkok, Thailand 2008). This year's event in Istanbul, Turkey continues with the tradition following the very successful and productive event held in Bangkok last year. As usual ISL 2009 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 14th International Symposium in Logistics is "**Global supply chains and inter-firm networks**". This theme capitalises and builds upon the papers presented during the previous ISL events. It also represents an emerging and highly challenging area of research and practice for both academics and practitioners alike, considering the current global economic uncertainties and downturn in the global manufacturing and services sector. Against this backdrop there is an emerging consensus that reliance on efficient and responsive supply chains which are underpinned by robust yet flexible inter-firm networks is the key to future survival and long-term prosperity of firms. The current industrial context is characterised by volatile global competitive environment, shortening product life cycles, flexible and distributed manufacturing, increased levels of global outsourcing, networked organisations, higher levels of economic 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 the 14th ISL in Istanbul represents a timely opportunity for academics and researchers to address pertinent issues surrounding logistics and supply chains within a global context. Turkey is a country that has a rich history and culture and is ideally positioned as a natural bridge between Europe and Asia. We are optimistic that this year's event provides an opportunity to address some of these issues and challenges.*

Potential authors were invited to submit an abstract to the Symposium Chairmen. All abstracts were reviewed by two experts from the International Advisory Committee and final papers were further reviewed by an International Panel of Reviewers. As a result papers are included in this volume with 214 contributing authors coming from 28 countries. This book of proceedings has been organised according 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 organisers especially Sinan Yener, Yigit Oztriryak, Tamer Ovutem 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.

Professors Kulwant S Pawar, Chandra S Lalwani, Moreno Muffatto and Bülent Çatay – July 2009

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ABSTRACT
This paper pins down the essence of logistics and SCM, taking a systemic-constructivist perspective. Whereas logistics is the difference of movement/not-movement, SCM is the difference of integration/disintegration. Therefore, logistics and SCM ought to be two distinct areas of study, even though they are structurally coupled to each other. Any hierarchical classification, question of 'ownership', or similar subordination appears from this perspective as unnecessary—if not as nonsense.

INTRODUCTION

Research on logistics and/or supply chain management (SCM) is currently confronted with two interrelated controversies which are rooted in the excessive broadening of the domain and scope of research in the field especially since the notion `supply chain management' gained popularity in research:

First, the very objects of research in the field became nebulous. With the notion of scm gaining popularity and its strong ties to (or inconsiderate blending) with logistics (cooper et al., 1997), the domain, scope, and theoretical underpinning of research in the field(s) increasingly blurred (new & payne, 1995; new, 1997; burgess et al., 2006), leading to a disintegration and fragmentation of its core findings (e.g., croom et al., 2000; chen & paulraj, 2004; cousins et al., 2006). As arlbjørn and halldorsson (2002) observe: "it seems as if everything can be discussed within the discipline" (p. 26). Second, researchers in the field question the various approaches to creating logistics/supply chain management knowledge, because with the broadening of the domain and scope of the field valid research questions and investigative strategies became less clear (new & payne, 1995). hereas mentzer and kahn (1995, p. 231) called for "a rigorous orientation toward theory development, testing, and application" by adhering to the positivistic tradition of logistics research, mears-young and jackson (1997) criticised that logistics' realist ontological assumptions are fundamentally flawed, because "the definition of the logistics' system is continually being re-defined or, as subjectivists would say, since individuals perceive a 'system' in different ways then there is no one definable system" (p. 612; cf. Also new, 1997). Therefore, they propose the adoption of 'softer' methodologies and a shift to the interpretative paradigm. Similarly, näslund (2002) and kovács and spens (2007) demand that the methodological choice should depend upon the research object. As recent literature reviews (e.g., craighead et al., 2007) implicitly affirm, many researchers have followed these calls, employing different research approaches.

Nevertheless, researchers in the field still face a number of problems, which are:

The lack of a common definition or understanding of the major terms and concepts (e.g., cooper et al., 1997; croom et al., 2000; mentzer, et al., 2001; gibson et al., 2005; burgess et al., 2006; frankel et al., 2008; mentzer et al., 2008).

The lack of a clear delineation of research or subject areas, especially between scm and logistics (e.g., cooper et al., 1997; larson & halldorsson, 2004) and marketing (e.g., min & mentzer, 2000; svensson, 2002).

The unclear state of the concepts as new paradigms or independent discipline (e.g., harland et al., 2006; cousins et al., 2006).

- The diverse bodies of literature (e.g., Croom et al., 2000; Chen & Paulraj, 2004).
- The lack of clear valid research questions and investigative strategies (e.g., New & Payne, 1995; Halldorsson & Aastrup, 2003) and theories (e.g., Stock, 1997; Svensson, 2003), which again depend upon the research object investigated in (Näslund, 2002; Kovács & Spens, 2007).

Although recently a number of attempts have been made to clarify the domain and scope of research in supply chain management and 'related' research areas—especially operations management, marketing, and logistics—a consensus concerning the respective research content does not seem to exist (cf. Mentzer et al., 2001; Svensson, 2002; Larson & Halldorsson, 2004; Gibson et al., 2005; Ballou, 2007; Frankel et al., 2008; Mentzer et al., 2008). Similarly, a solution to the 'who owns whom' question does not seem to emerge (cf. Larson & Halldorsson, 2004; Mentzer et al., 2008).

However, former attempts to clarify the domain and scope of research in the field focused primarily on 'supply chain management' and were based on pre-defined definitions of SCM, its domain, or related areas—logistics and other fields, if at all, were touched only briefly from a unionist's perspective (cf. Larson & Halldorsson, 2004). For example, Frankel et al. (2008) based their investigation into the nature of SCM research and its foundational disciplines on CSCMP's definition of SCM. Therefore, purchasing, operations management, logistics, and marketing channels were considered as 'related fields'. Similarly, Mentzer et al. (2008) refer to two alternative definitions of SCM by the CSCMP, the definition by Mentzer et al. (2001), and the "Ohio State model" of SCM (Cooper et al., 1997). Thus, they look at the "marketing, logistics, production, operations management, and supply chain management phenomena" for developing their framework on "the scope of SCM decision making relative to the aforementioned disciplines" (Mentzer et al., 2008, p. 33). Besides, the former contributions used mostly narrative literature reviews to define and delineate the domain, scope, or foundational disciplines in supply chain management in "drawing upon selected literatures" (Frankel et al., 2008, p. 2) only. Yet, this methodology tends to be biased towards the researcher's views or opinions on the area of study and often lack rigour (Denyer & Tranfield, 2006).

This paper intends to contribute towards a solution of the first—most fundamental and essential—controversy: a definition and delimitation of research objects in the field.[1] Although we thereby intend to advance and refine the most recent studies by Mentzer et al. (2008) and Frankel et al. (2008), we take a very different approach by defining and delineating the research field(s) from a systemic-constructivist perspective (cf. Georgi, 2008, on a similar discussion concerning logistics only). In comparison to the outlined former *explicit* approaches to solve the controversy, we therefore take an *implicit* approach. That is, we do not review literature or interview experts in order to *review* or *describe* the debate and potential solutions, but to *define* and *delimit* the different research areas by their respective least common denominator implicitly agreed on in past literature. By taking a systemic-constructivist perspective, we are able to abstain from the current epistemological discussion and existing attitudes towards the role or definition of supply chain management and its related functions in businesses. Moreover, utilising the rich theoretical base of systems theory, autopoiesis theory, and social systems theory, the different research areas can be related as autonomous, yet interdependent systems. Hierarchical classifications (i.e., the 'who owns whom' question) thus become unnecessary—if not nonsense—without dismissing their interrelationships.

LOGISTICS: A SYSTEMIC-CONSTRUCTIVIST PERSPECTIVE

During the conceptual transition of military logistics to the business context at the end of the Second World War, "a functional rather than a systems orientation to management prevailed as organizations developed" (DeHayes & Taylor, 1974, p. 38): Whereas in military organisations logistical operations were carried out "*within* centrally directed social organizations" (Morgenstern, 1955, p. 129), logistical activities in the business context were carried out *between* a composite organisation of many independent firms, or even between single functions within a firm. In 1954, Paul Converse pointed to the high costs caused by the physical distribution side of marketing, demanding that more attention is to be given to this function. As a consequence, systems thinking

[1] Due to space limitations, we will primarily focus on the areas logistics and SCM only.

was re-introduced to logistics in the early 1960s, foremost by applying the total cost concept (cf. Bowersox et al., 1969). Drawing on the systemic property of 'wholeness' (von Bertalanffy, 1950), the total cost approach intends to minimise "the *sum* of the costs of performing those activities responsible for having materials at the right place at the right time" (Williamson et al., 1990, p. 65). Especially the cost trade-offs between transportation and storage within a given logistical system were investigated. Consequently, logistics underwent a metamorphosis from being part of functional independent areas to being an integrated function (Bowersox, 1969; Ballou, 2007).

However, although systemic thinking has developed from a theory of closed systems to a theory of open and complex systems; and then to a theory of observing and self-referential/autopoietic systems (Luhmann, 1984, 2006), systems in logistics (or SCM) are still considered as `close' (cf. Mears-Young & Jackson, 1997) in the tradition of the total cost concept: The system is constituted by the difference 'in parts' and 'as a whole' (Luhmann, 1984). The more parts (or elements) are put in relation, the better the logistical network can be coordinated. Ballou (2007), for example, points to the fact that "although the idea [of SCM] is potent and the benefits obvious, the notion of lowering costs by including more of a system in decision making is not new" (p. 340). Similarly, systemic thinking is still equated with a 'holisitic view', which shall be taken upon value or supply chains (e.g., Arlbjorn & Halldorsson, 2002). However, as the elements of a supply chain are indefinite, holism depends on the respective researcher. As Chen and Paulraj (2004) stated: "Each focal organization has its own unique network that comprises a unique set of actors, resources, and activities" (p. 123).

In systems theory, this problem was realised in the early 1970s by cyberneticists as they began to recognise "that all our knowledge of systems is mediated by our simplified representations—or *models*—of them" (Heylighen & Joslyn, 2001, p. 3): The researcher (or observer) has to make a decision as to the boundary of the system he investigates. Thereby, he limits the 'outcome space' of his investigation: His boundary judgement prevents him from obtaining all the results which are in principle possible, but are outside the domain of the system investigated (Ulrich, 2000).

Once we acknowledge boundary judgements, though, we have to think differently of systems: A system is no longer constituted by the difference 'in parts' and 'as a whole', but by the difference of 'system' and 'environment': "A system *is* the difference between system and environment" (Luhmann, 2006, p. 38). Consequently, systems are not understood as a complex set of interrelated elements isolated from their environment, but as a complex of interrelated elements which, in composite, can be differentiated from their environment (system/environment paradigm). In order to 'exist', any system requires an observer, who has the ability to ascribe certain properties to a system, such as to separate it from what it is not (cf. Spencer-Brown, 1969; Maturana & Varela, 1980; Luhmann, 2006). Therefore, to 're-think' logistical systems, we do not have to ask how many elements ought to be considered systemic (part vs. whole), but how we can distinguish the logistical system from its environment (system vs. environment).

Although the scope of logistics in literature has apparently broadened since the 1950s (cf. Frankel et al., 2008), it was concerned with transportation (and storage) of materials, information, and services from source to consumption ever since its military role in the first century. Therefore, the comprehension of logistics as a function that transforms objects in space and time is, in our opinion, most fundamental to (and most agreeable for) logistics (e.g., Converse, 1954; Heskett et al., 1964; Halldorsson & Aastrup, 2003; Frankel et al., 2008; Mentzer et al., 2008). By providing time and space utilities of objects, logistics adds customer value (e.g., Williamson et al., 1990; Novack et al., 1992); is a distinct and important part of any value chain (e.g., Porter, 1985); and can be clearly delimited from other functions and research areas, as we will demonstrate later.

Logistics as the transformation of objects in space and time is primarily concerned with transportation and storage. Transportation essentially is the movement of objects in an environment of non-movement; similarly, storage essentially is the non-movement of objects in an environment of movement. A logistical system can therefore be observed as a system of movement in contrast to non-movement and non-movement in contrast to movement: "Logistics is the difference of movement and non-movement" (Bruns-Vietor, 2004, p. 272). Similarly, the notion of 'flows' or 'flow thinking', considered a central element to defining logistics (e.g., Arlbjorn & Halldorsson, 2002; CSCMP's definition of SCM), points to nothing but to a system of movement (flow) and non-movement (non-flow).

Moreover, with time and space being viable—if not neccessary—assumptions concerning reality (von Glasersfeld, 1984), logistics can be established as a self-referential, autopoietic system (cf. Maturana & Varela, 1980; Luhmann, 1984; Mingers, 1989). The logistical system maintains its autopoietic organisation as it alternates movement (transportation) and non-movement (storage), linking the alteration with the impulse of changing direction (handling) (Bruns-Vietor, 2004).

Although such a logistical system is omnipresent, it is generally only heeded as logistics in an organisational context. Therefore, the logistical system needs to be realised as an organisational system. Logistical organisations emerge with communications and decisions being restricted to those concerned with movement and non-movement (cf. Luhmann, 1986, 2006). The autopoiesis of the logistical organisation is not only maintained by active decision making, but by the expectation of those decisions, too (Bruns-Vietor, 2004). Hence, the logistical organisation does not need to produce the movement/non-movement difference without rest, but remains alive in the expectation of future production of its difference (cf. Blaschke, 2008).

In the context of organisations, the logistical system appears as a functional differentiated subsystem that fulfils a certain function of the entire system (cf. Luhmann, 1984; Bailey, 1997), more specifically, the organisation. Logistics produces movement and non-movement, in order to make the organisation's products or services available in time and space (e.g., Converse, 1954; Heskett et al., 1964; Novack et al., 1992). Yet, if logistics would also be responsible for form and possession utilities (as suggested e.g. by Novack et al., 1992), it would not any more differentiate itself as a system by the production of movement/non-movement but by the production of availability/non-availability, thus being the organisation entirely (cf. Baecker, 1999).

The logistical system also needs to be substantiated as a system of 'material facts': warehouses and trucks, sources and activities, rates of consumption and supply, etc. that cause "certain effects of logistics practices such as efficiency, bottlenecks or resource usage" (Halldorsson & Aastrup, 2003, p. 330). This we term the logistical infrastructure. The logistical infrastructure reflects the structure of the logistical system inasmuch as it comprises the machines with which the logistical system can operate. It is an allopoietic system because it is not autonomous and its boundaries, inputs, and outputs are defined by observers (cf. Maturana & Varela, 1980). The infrastructure does not produce itself (the infrastructure), but movement and non-movement if the observer intends for it to do so. Therefore, the logistical infrastructure can be determined, such as to solve the logistical problem. Still, the logistical infrastructure is necessarily an open system (cf. von Bertalanffy, 1950), which is only maintained in a steady state and may be subject to changes if the logistical system/organisation is faced with a prevailing change in its environment. However, in the short term, the structure of the logistical system may also change by only changing the utilisation of its infrastructure.

Accordingly, logistics presents itself as a three-layered system: (i) an autopoietic organisational system that decides about movement and non-movement of objects between source and activity; (ii) an autopoietic system that operates by the differentiation of movement and non-movement of objects (transportation, storage, and handling) between source and activity; and (iii) as an allopoietic deterministic system in which the logistical system operates. All three layers are embedded as a functionally differentiated subsystem in organisations. The organisation determines the environment (i.e., conditions) within which the logistical system—as a unity—has to operate.

SUPPLY CHAIN MANAGEMENT: A SYSTEMIC-CONSTRUCTIVIST PERSPECTIVE

The term "Supply-Chain Management" was notably first used in literature by Oliver and Webber in 1982 to depict intra-firm supply chains as a single entity and to consolidate the fragmented responsibilities for various supply chain segments within the firm (such as purchasing, manufacturing, distribution, and sales) to a single function. This was necessary because "what were hitherto considered 'mere' logistics problems have now emerged as much more significant issues of strategic management" (Oliver & Webber, 1982, p. 64). Three years later, Houlihan (1985, 1988) included inter-firm inventory trade-offs in Supply-Chain Management, reviving the seminal work by Forrester (1958) on industrial dynamics. Similarly, Jones and Riley (1985) and Stevens (1989) emphasised that inventory levels ought to be considered throughout entire (inter-firm) supply chains in order to balance between costs and service levels. As such, Supply-Chain Management raised logistics to become an issue of strategic management and extended the scope of inventory management from intra- to inter-firm trade-offs—as proposed by Heskett et al. in 1964.

However, what became to be the central issue in supply chain management—the coordination and collaboration among channel partners, integrating supply and demand management within and across companies (CSCMP, 2008)—was considered by Heskett in 1973 as the logical progression of logistics: "While technological and organizational change will, of course, continue, major challenges will be met primarily by institutional change [...] within an organization and among cooperating organizations" (p. 124).

This becomes apparent when studying the first academic papers that used the term 'Supply Chain Management': Ellram and Cooper (1990), Ellram (1991), and Ellram and Cooper (1993) basically used LaLonde and Masters' (1990) fifth proposition about the future development of logistics—"the primary relationship in the logistics channel will shift from a transaction based relationship to a contractual based relationship" (p. 5)— to form the foundation of academic supply chain management research: They realised that supply chain management can hardly be just a new inventory management approach as proposed by the consultants. Rather, they characterised it as an "integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user" (Ellram & Cooper, 1990, p. 2). Ellram and Cooper (1990) identify the driving force behind supply chain management to be the trade-off between inventory and information sharing (cf. LaLonde & Masters, 1990, fourth proposition), the latter requiring partnerships rather than adversarial relationships between supplier and buyer. As such, Ellram and Cooper initiate a shift from transactional to a relational view on trade partners. One year later, Ellram (1991) proposes industrial organisation theory to be "the theoretical roots of modern day supply chain management" (p. 13). She elaborates on the advantages and disadvantages of vertical integration and obligational contracts and finds that supply chain management is a hybrid of both, with the recognition of mutual dependence and mutual credible commitment forming a sound base for strong inter-firm relations. Likewise, Ellram and Cooper (1993) discuss the similarities and differences between supply chain management and 'keiretsu', a Japanese relationship philosophy based on "cooperation, coordination, and joint ownership and control to competitively position businesses and industries" (p. 2).

Today, all definitions of SCM rely "on terms such as coordination and integration, and emphasizes the harmonization of operations among supply chain members" (Frankel et al., 2008, p. 3; cf. also Mentzer et al., 2008). We propose that SCM's focal concept is *integration* (cf. Frankel et al., 2008), because integration is the most general and encompassing term characterising the aim of supply chain management: The objective of coordination or collaboration among trade partners *is* to integrate processes, functions, and systems in order to share information and harmonise operations. However, common consensus has not yet been reached as to which functions, processes, or systems are to be included or excluded by SCM.

Whereas the latter intends to define SCM as a 'whole' as opposed to its 'parts' (which has been problematic for logistics in the past), a system/environment difference of SCM can be established when considering integration as the most fundamental concept of SCM: Since only processes, functions, or systems that are not integrated can be integrated, integration can only occur in an environment of disintegration; similarly, the disintegration of processes, functions, or systems can only occur if they are integrated, that is, in an environment of integration.[2]

[2] Obviously, the same holds true for concepts such as coordination, collaboration, and harmonisation. E.g., coordination is only necessary if there's no coordination.

In comparison to the autopoietic logistical system, it is doubtful whether or not there are viable assumptions about reality that enable us to establish the SCM system—defined by the system/environment difference of integration/disintegration—as an existing system, whether heeded in an organisational context or not. However, SCM can clearly be realised as an (autopoietic) organisational system, as well as substantiated as a system of material facts. Analogous to the respective logistical systems, the former emerges with communications and decisions being restricted to issues concerned with integration in an environment of disintegration, and *vice versa*. As organisational system, SCM appears as a functional differentiated subsystem, too, that fulfils a certain function (i.e., deciding on integration/disintegration) of an entire organisation or even of a meta-organisation, which encompasses the organisations forming a supply chain. The (allopoietic) materialised SCM system comprises those elements that enable integration, for example, IT systems. As the logistical infrastructure, these are open systems that are only maintained in a steady state; they may be subject to changes if the SCM organisation decides on changes if faced with a prevailing changes in its environment.

Therefore, SCM presents itself—at least—as a two-layered system: (i) an autopoietic organisational system that decides about integration and disintegration; and (ii) an allopoietic deterministic system that enables or is required for integration to happen. Both layers are embedded as a functionally differentiated subsystem in organisations or meta-organisations. The (meta-)organisation determines the environment (i.e., conditions) within which the SCM system has to operate.

CONCLUDING THOUGHTS: LOGISTICS VS. SUPPLY CHAIN MANAGEMENT

From the systemic-constructivist perspective taken in this paper, there is strong evidence to suggest that logistics and supply chain management emerge as two autonomous and functionally differentiated subsystems in organisations. Defining SCM as the difference of integration/disintegration and not as the difference of movement/non-movement, clearly delimits SCM from logistics: Whereas decisions taken in logistics are concerned with movement, decisions in SCM are concerned with integration. Therefore, logistics and SCM are (or ought to be) two distinct areas of study.

Yet, both systems are interrelated, that is, structurally coupled: The operational closeness of systems (autopoiesis) is overcome by the system's ability to observe, that is, by referencing its environment (what it is not) (Luhmann, 1986; Bailey, 1997; Blaschke, 2008). Although their autonomous operations cannot be changed by environmental systems, "they can be perturbated by independent events and undergo internal structural changes which compensate these perturbations" (Maturana & Varela, 1980, p. 81). For example, the integration of IT systems among supply chain partners to share production plans or stock availability may enable (or even force) the logistical organisation to change its structure in terms of changing the utilisation of its warehouses or frequencies of transportations. Similarly, an inefficient utilisation of the logistical infrastructure may give rise to the need of integrating IT systems among channel partners. Clearly though, such changes are only induced if there is, for example, a need to lower costs. Yet, this is decided neither by the logistical, nor by the SCM subsystem, but by those organisational subsystem that deal with demand or sales (e.g., marketing) or the overall profitability of the firm (e.g., top-management).

All in all, by taking a systemic-constructivist perspective on the domain and scope of research in 'the field', we can clearly define and delimit what research in logistics and SCM—as well as in any 'related research areas' or 'foundational disciplines'—ought to focus on: Those operations that do maintain the systems' respective system/environment difference. Each area addresses distinct issues and research should thus be clearly separated. Still, the mutual dependencies need to be kept in mind: Although these research areas are concerned with autonomous, functionally differentiated subsystems, the mutual dependencies between the systems remain, since the systems are structurally coupled to each other. However, any hierarchical classification, question of 'ownership', or similar subordination appears from this perspective as unnecessary—if not nonsense—because the systems cannot be determined by other systems, but may change due to perturbations caused by the other systems in their environment (or organisation). Therefore, SCM should only to considered as an interdisciplinary research area that may (and usually does) affect and may be affected by other (research) areas, but that cannot determine those in the sense of being superior.

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SIX PATHWAYS TO ACHIEVING A SEAMLESS SUPPLY CHAIN

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ABSTRACT
Many academics report that supply chain excellence is still rare, and that guidance is missing on how supply chain integration is achieved in practise. A conceptual model has been developed presenting six distinct pathways to supply chain integration. This exploratory research utilised four longitudinal case studies to test the developed conceptual model. The findings highlight that the pathway to supply chain integration is indeed not a single. Companies are taking various, organizational specific, roots to achieve the seamless supply chain.

INTRODUCTION
The ultimate goal in supply chain management is to create value for the end customers as well as the organisations in the supply chain network (Christopher, 1998). To accomplish this, organisations in the supply chain must integrate process activities internally and with customers and suppliers externally (Lambert et al., 1998). Yet in most organisations the situation is chaotic. Lack of supply chain integration is expensive for companies. For example, in the USA the National Institute of Standards has estimated that inadequacies in managing inventory, scheduling and accounting information costs the automotive and electronics industries a combined total of almost $9 billion annually (NIST, 2004).

Academia is continuously enhances the body of knowledge, linking supply chain integration to performance improvement (e.g. Frohlich & Westbrook, 2001); but knowledge is lacking in terms of pathway(s) available to achieve the integrated supply chain across operations internally, and with suppliers and customers externally. What routes do companies follow when integrating their supply chains? The conceptual model developed by the authors is introduced in the literature review section that is judged capable of capturing the different pathways to supply chain integration using uncertainty measures. Following a review of the relevant literature a rigorous multi-method approach termed the 'Quick Scan Audit Methodology' (QSAM) is introduced. Application of the conceptual model to four comparative longutidunal case studies, provide insight and a framework for operational practice. Findings are discussed and future research avenues highlighted.

LITERATURE REVIEW
Possibly the most influential work regarding pathway(s) to supply chain integration is by Stevens (1989). He suggests that companies follow an integration process that goes through different stages by first integrating internally and then extending the integration process externally to other supply chain members. Empirical evidence (Towill et al., 2000; Koufteros et al., 2005) and case study research (Gimenez, 2004) support the conceptual model developed by Stevens. Bowersox & Daugherty (1995), and Gimenez (2004) also emphasize that the improvement of each internal function should precede the external connection with suppliers and customers in the external integration stage. However, Gimenez's (2004) qualitative study identified one exemplar that did not follow Stevens (1989) integration model. Also, Halldorsson et al. (2008) report that managers seem to achieve more successful integration with external business partners than they do with managers and departments within their own company. From this discussion it seems that there is more than one path to supply chain integration.

Numerous authors have identified the need to manage, minimise, and remove uncertainties from their business so as to increase control and co-ordination and improve the effectiveness of their decision making processes (Chopra & Meindl, 2007). This also holds true in a supply chain context as Christopher (2005) explains, "One of the main reasons why any company carries safety stock is because of uncertainty" (p. 51). This point is further emphasised by Bowersox et al., (2002) when they state, "… a basic objective of overall logistical performance is to minimise variance" (p.164). Further, Sabri and Beamon (2000) state, "uncertainty is one of the most challenging but important problems in supply chain management" (p. 582). Finally, according to Lee (2002) "it is necessary to understand the sources of the underlying uncertainties and explore ways to reduce these uncertainties" (p. 107). Here, the concept of supply chain uncertainty, and more specific uncertainty reduction, is used to identify pathway(s) to supply chain integration.

Both Davis (1993) and Mason-Jones and Towill (1998) have segmented supply chain uncertainties into four areas termed the 'uncertainty circle', so that root causes and methods for minimisation can be developed (Childerhouse et al., 2007). The supply chain uncertainty circle has been applied and validated successfully (Towill et al., 2002; Childerhouse et al., 2007). Figure 1 illustrates an adapted version of the original supply chain uncertainty circle by clustering the circle into internal-, supply-, and demand uncertainty.

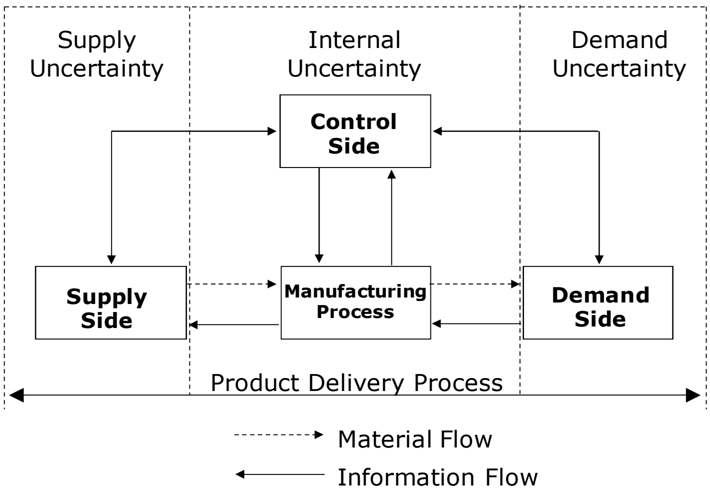

Figure 1: The Supply Chain Uncertainty Circle

Figure 1 presents three distinct areas a focal company can remove uncertainty and hence further integrate its supply chain. Control and manufacturing process uncertainties can be addressed predominantly internally; whereas demand uncertainty requires customer involvement and supply uncertainty requires the involvement of the supplying entities. The four areas of uncertainty are explained in detail in Naim et al. (2002).

The conceptual model developed in Figure 2 is deviated from the adapted version of the uncertainty circle in Figure 1 and additionally on the note that integration has been predicated in the past on the assumption that integration occurs in distinct stages (Stevens, 1989).

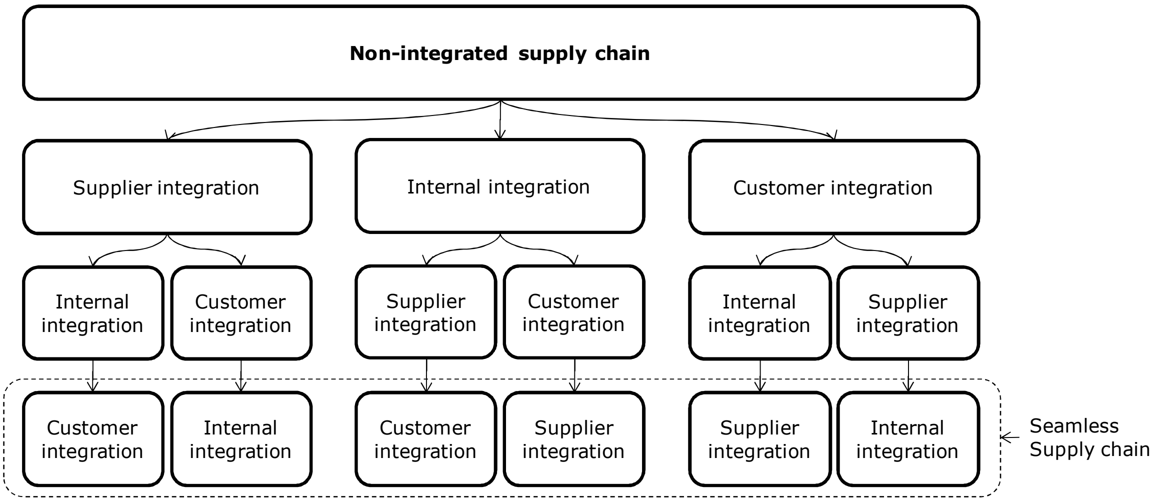

Figure 2: Proposed supply chain integration model

At the top of Figure 2 is the non-integrated supply chain stage. Companies that are at this non-integrated stage may choose to reduce uncertainty and hence integrate internally or externally (with customers or suppliers) first. Once the first integration stage is achieved, the remaining uncertainty areas are tackled until the seamless supply chain is achieved.

Methodology for assessing uncertainty

Four New Zealand based longitudinal case studies were undertaken. Table 1 presents the dates of the data collection points for each of the four cases, and person days spent within each focal company.

Company	Data point 1	Data point 2	Timeframe (months)	Person days
Manufacturer	Dec, 2006	Mar, 2008	16	41
Pulp/Paper	Mar, 2006	April, 2008	25	32
Dairy	Jan, 2004	Dec, 2006	35	34
Food	May, 2006	May, 2008	24	27

Table 2: Time overview of case studies for longitudinal data

The longest timeframe between the two data points was almost three years, with Dairy. Pulp/Paper and Food cover a timeframe of approximately two years, whereas Manufacturer covers only 16 months. The average time between the two data points is some 25 months. In total, some 135 person days were spent on-site auditing and reassessing the four supply chains.

The unit of analysis used was a 'value stream'. This has been popularised by Womack and Jones (2005) 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.

The longitudinal studies followed a structured approach; first, the supply chain status was evaluated using the Quick Scan Audit Methodology. The Quick Scan is a site-based audit methodology and was applied to the four companies and resultant nine value streams. These covered a Varity of sectors and organisation types. During a QS audit, material and information flows are process mapped and 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 comprehensively documented. The QS process is explained in considerable detail in Naim et al. (2002); 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. A follow up case study was then conducted after the organisation had advanced its supply chain practices. During the follow up study quantitative and archival data was reassessed. By predominantly interviewing staff members, the researcher gained an overview of the change process before evaluating the resultant performance ramifications. In a final step, the findings were presented to management and staff to gain consent.

During a Quick Scan and follow up study, supply chain uncertainty is quantified using the supply chain uncertainty circle presented in Figure 1. The uncertainty data was used to evaluate the conceptual model in Figure 2, which highlights three distinct areas for uncertainty reduction. In essence, a focal company can concentrate its efforts internally, thereby focusing on control and process uncertainty, or externally by focusing on supply or demand uncertainty reduction. Each of the three uncertainty areas were evaluated during the initial Quick Scan and a second time during the follow up case study. Table 2 presents these three distinct areas of uncertainty and the resultant eight possible integration states.

Internal	High				Low			
Demand	High		Low		High		Low	
Supply	High	Low	High	Low	High	Low	High	Low
Integration Status	Non-integrated	Supplier	Customer	External	Internal	Internal & supplier	Internal & customer	Seamless

Table 2: Assessing the path to supply chain integration

The research applied a 4-point Likert scale to each uncertainty area, which anchors 1=lowest uncertainty and 4=highest uncertainty. For simplicity, values of 1 and 2 were taken to represent low uncertainty; and 3 and 4 were taken to represent high uncertainty. Hence, Table 1 highlights that a focal company can be placed into one of eight possible outcomes. If a company faces high uncertainty in all of internal, demand and supply uncertainty no integration is present. Conversely, if a company faces low uncertainty in all these areas, the supply chain is seamless. The intervening six stages present uncertainty reduction for one or two uncertainty areas, and are named accordingly.

FINDINGS

Table 4 summarizes the change processes of each case company in chronological order.

Pulp/Paper	Dairy	Manufacturer	Food
• Implementing new scm related employees • Combine the management of four closely related plants • Hiring of new procurement manager • Implementation of a track and trace system • Introduction of non-compulsory staff training • Launching of intra-net web site to enhance cross-functional visibility • Consolidation of supplier base • Standardisation of S&OP for four plants.	• Appointment of new CEO • Flattening of organizational structure • Staff training through job rotation • Appointment of purchasing manager • Fortnightly S&OP meetings • Increase supply chain measures (efficiency and effectiveness) • Supply chain strategy aligned to product type • Implementation of outbound information system to set desired stock levels.	• Daily cross-functional production meeting • Hiring of three supply chain professionals • Empowerment of current staff • Staff training on shop floor • Implementation of communication platform (no blaming culture) • Increase supply chain measures (efficiency and effectiveness) • Implementation of cross-functional KPIs • Implementation of 2-Bin System leading towards Kanban • Update of current ERP system including MRPII.	• New S&OP software package integrated into current ERP system • Hiring of new logistics manager • Improved relationship with 3PL • Updated warehouse management system • Upskilling and empowerment of warehouse staff • Restructuring of order information flow.

Table 3: Overview of change implementation within case companies

The change management process highlighted in Table 3 resulted in uncertainty reduction. The case companies implemented many good practises resulting in internal and/or external value stream integration. Applying the uncertainty data to Table 2 allows the researcher to map the current stage of each value stream on the developed conceptual model in Figure 1. Figure 3 has been slightly amended from the original conceptual model shown in Figure 1. The reason lies with the measurement process. Consider value stream 7, for example, which experienced considerably reduced supplier and customer uncertainty. Also, while the process uncertainty was reduced to a minimum, medium to high control uncertainty remains. However, value stream 7 still needs to implement many improvements on the control side in order to become truly seamless. Thus for any value stream that only reduces uncertainty to low-medium levels uncertainty remains, and the value stream is not truly seamless. Thus a new, seamless supply chain stage has been added at the bottom of Figure 3.

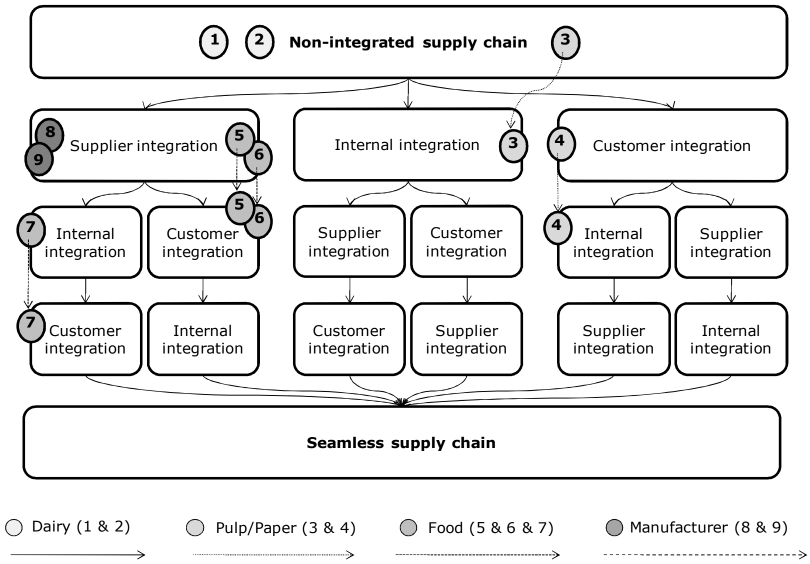

Figure 3: Populated integration model

The value streams of the four case companies are at various stages on their individual pathway to supply chain integration and have chosen various routes to achieve the seamless supply chain. Dairy has reduced uncertainty but still faces high uncertainty in all three areas. Hence, both value streams (1 & 2) remain in the non-integrated supply chain stage. Manufacturer has reduced supplier uncertainty in the past and therefore is placed in the supplier integration stage. Currently, Manufacturer is reducing internal uncertainty; however, internal uncertainty remains high. Further, all of Food's value streams integrated with their suppliers in the past. However, from the supplier integration stage, value stream seven took a different route than the remaining two value streams five and six. Value stream seven is one of Food's high volume products and the company place high emphasis on reducing process uncertainty to a minimum. Hence, internal integration was achieved before recently reducing demand uncertainty. However, control uncertainty remains medium-high. Therefore, Food still needs to put a lot of effort to achieve the seamless supply chain stage for value stream seven. Internal uncertainty (process and control) remains medium-high for value stream five and six. Hence, Food managed to achieve external integration with customers and suppliers before integrating internally.

Finally, Pulp/Paper's value streams predominantly reduced internal uncertainty. Value stream 3 moved from the non-integrated supply chain stage to the internal integration stage. Therefore, value stream five is currently the only value stream that follows Stevens' (1989) integration model. Value stream 4 instead managed to reduce uncertainty on the customer side in the past and likewise benefits from better supply chain control mechanisms. The key reason for Pulp/Paper and Food to manage to move into the internal integration stage is a highly automated process, which impacts positively on internal uncertainty. However, control uncertainty for those two companies remains high.

DISCUSSION

This research makes an early attempt at investigating how companies achieve supply chain integration in practice using longitudinal studies. This paper provides some evidence that the pathway to supply chain integration is not a single one as proposed by Stevens (1989). The four cases reveal that currently only one value stream followed the Stevens' integration model. Hence, the research contradicts Stevens conceptual supply chain integration model and Romano's (2003) findings that intra-company integration is a precondition for inter-company integration.

Six distinct pathways to supply chain integration have been identified. It should be noted that, in this early stage of the research, it is impossible to compare or rank the pathways to supply chain integration. Arguably, companies in the non-integrated stage face high uncertainties in all four areas of control, process, supply, and demand. Reducing process and control uncertainty first will take waste out of their own operations and will have a direct impact on a focal company's bottom line. The drive to further enhance efficiency will result in targeting the purchasing price on the supply side next. Lastly, customer integration will be addressed to increase the effectiveness of the supply chain. Frohlich's (2002) findings also suggest that an 'inside-out' strategy of first removing internal barriers and then bringing upstream suppliers and downstream customers onboard is the best way to change the supply chain. Hence, it might be argued that Stevens' (1989) conceptual integration model represents the ideal theoretical path to supply chain integration; however, as shown by the findings, in many cases this is not the most feasible pathway to supply chain integration in the real world. Notwithstanding the fact that Fine (1998) introduced clock speed as a concept to characterise different rates of evolution in various industries, the present research has clearly demonstrated that there is no single route to supply chain integration; that the pathway to supply chain integration is essentially contextually specific.

This exploratory investigation into the pathways to supply chain integration is not without limitations. The most obvious is that the small sample of four organisations does not allow for generalisation. The question remains if other companies follow different or similar pathways to supply chain integration shown in Figure 2. Also, part of the Quick Scan Audit Methodology is the development of improvement opportunities. Hence, the Quick Scan is already pointing companies in the direction of where to put most emphasis to further integrate the focal company's supply chain (Naim et al., 2002).

CONCLUSION

The present paper aimed to answer the research question "What routes do companies follow when integrating their value streams?" Here, the initial Quick Scan Audit Methodology has been extended to enable longitudinal case study data collection. Four longitudinal case studies into achieving supply chain integration in practice were conducted. The average timeframe between Quick Scan and follow up study was 25 months.

The conceptual model developed in Figure 2 containing six pathways to supply chain integration has been populated. The conceptual model contains three different areas to supply chain integration: internal integration, supplier integration and customer integration. The present research has demonstrated that there is no single route to supply chain integration. Arguably the pathway to supply chain integration is essentially organisation specific.

There are a multitude of further research avenues to extend this exploratory research. Firstly, the identified six pathways to supply chain integration need further validation. Also, the question remains which of the six pathways is the ideal path to achieve the seamless supply chain. And, unless being concerned with speed of change, what is considered ideal for one company is unlikely to be ideal for another. Is the achievement of the seamless supply chain always feasible or even desirable? Also of interest, is the question of which changes have the greatest impact on supply chain integration and performance?

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IMPLEMENTING LEAN-FLOW IN AN AEROSPACE SUPPLY CHAIN

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ABSTRACT
This empirical paper discusses the application of the Flow Accounting methodology for the design and implementation of a pull-system in an aerospace supply chain that is based upon the Drum-Buffer-Rope approach derived from the Theory of Constraints. This applied research project was derived from the PreMade programme of work and was designated 'Workpacket 3' (WP3). The focal case involves a fabrication facility responsible for producing aircraft fuselage and nacelle panels and which is characterised by many shared and natural batch resources. The resultant pull-system design is explained, as are the initial results from the implementation of this design.

INTRODUCTION
A review of the management literature reveals that Lean thinking (Womack and Jones, 1996) continues to be the dominant contemporary management paradigm and holds a pervasive influence within the fields of logistics, operations and supply chain management. However, ongoing discussions with practitioners underlines the fact that Lean initiatives regularly disappoint the operational process improvement expectations placed upon them, and their claimed financial impact continues to be virtually impossible to reconcile with the bottom line. The implementation of 'Lean Accounting' to support Lean supply chain improvement initiatives therefore continues to be an extremely topical subject amongst practitioners and academics.

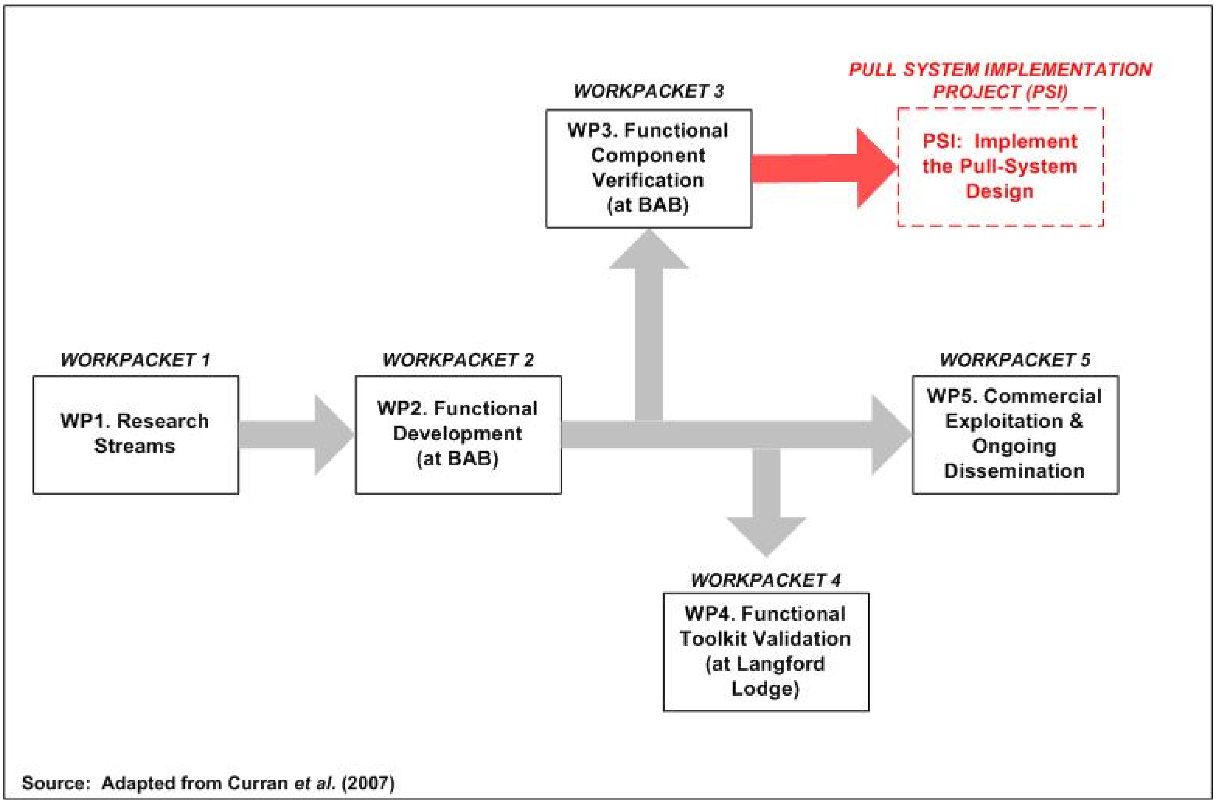
This empirical paper builds upon two papers that were submitted to ISL in 2008 (Darlington *et al*., 2008a; 2008b) that discussed the new *Flow Accounting* (FA) methodology advanced by the authors as the most effective approach to the Lean Accounting issue. The purpose of this paper is to elaborate upon the theoretical FA framework and initial empirical findings that were advanced in these previous papers by providing a longitudinal analysis of the case study supply chain at Bombardier Aerospace Belfast (BAB) that was designated the 'Workpacket 3' (WP3) study. 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 applied research project that started in 2006 and ended in April 2009. Its £2.5m of funding is provided by the UK Department of Trade and Industry, now called the Department of Business, Enterprise & Regulatory Reform (BERR). PreMade 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 (QUB). The project aim 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 and supply chain process design principles; hence becoming a Digital Lean Manufacturing (DLM) tool. The concept 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.

RESEARCH METHODOLOGY

The high level PreMade research design and project management framework 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 involved the functional development of the DLM tool components and supporting methodology. This was conducted at Bombardier Aerospace Belfast (BAB), who are a manufacturer of aircraft fuselages and nacelles and are the lead industrial partner in the PreMade project. WP3 entailed the [internal] verification of this functionality by means of an alternative test application within BAB, whilst WP4 formed the [external] validation of the generalised functionality in a new industrial setting. This was conducted at the aerospace component and sub-assembly firm called Langford Lodge Engineering Company Ltd in Crumlin, Northern Ireland. The last workpacket is the ongoing dissemination and commercial exploitation of the project deliverables by the academic partners, of which this conference paper forms a part.

Figure 1. The PreMade High Level Research Design and Project Management Framework



The two previous ISL papers derived from this project detailed the theoretical underpinning of the Flow Accounting methodology and its application and initial findings at BAB under the Workpacket 2 (WP2) part of the programme of work (Darlington *et al*., 2008a; 2008b). The output of WP2 was a diagnosis of the configuration and financial consequences of the current-state of the whole of BAB's Northern Ireland (NI) supply chain (Darlington *et al*., 2008b); embodied in a high level schematic representation called a Big Picture Financial Map (BPFM). This FA diagnosis enabled BAB's senior management team to objectively target the focal area within their NI supply chain that would most benefit from improved product flow characteristics. They decided that this would be in an area that they call 'Centre 4' (C04) because the BPFM had identified this as an area of particularly high inventory and operating expense (after the terminology of Goldratt and Cox, 1984). Coincidentally, C04 was also a high profile 'problem child' area at that point in time because it was struggling to service its Final Assembly customer; with [typically large and expensive] panels not being available when required. C04 was not synchronised with Final Assembly and also suffered from significant rework and scrap rates. The response to this had been to work upon more panels; producing more WIP and consequently more damages (but no more throughput). BAB were running out of space to store these panels and the problem was poised to become critical within six months due to a large increase in demand on their order book. A project designed to reduce WIP whilst increasing responsiveness to this demand was therefore both urgent and important.

It was subsequently decided that C04 would form the focal participant organisation for the WP3 study conducted by the LERC research team working in conjunction with Queens University Belfast, and this forms the subject of this paper. The purpose of WP3 was to identify the optimum point of intervention into this supply chain and **design** the characteristics, buffering regime and operating procedure of an appropriate pull system to significantly improve the flow of material through C04 by minimising lead time and hence maximising *throughput* to the downstream final assembly area.

The academic rationale behind this undertaking was to further test the FA methodology in a complex fabrication environment that was characterised by material flows through many shared and natural batch resources. This is a very limited body of Lean knowledge in this area, and many of the conventional Lean assumptions and 'solutions' are inappropriate for it. For example the conventional Lean position for maximising product flow is to demand that resources are dedicated to value stream and 'rightsized' so that they can respond to a customer-derived takt time signal (see for example Womack and Jones, 1996 and Maskell and Baggaley, 2004). C04 houses the largest autoclave oven in Europe, which services between 10-20 contracts and is of this scale because of the size of the panels that it needs to process. It is consequently neither economically nor physically viable to dedicate such a resource per contract. It is likewise not viable to apply the concept of takt time to an autoclave oven; the door closes, it takes [x] hours to process a batch of panels and then the door can be opened. The batch processing lead time is the same regardless of whether there is one on fifty panels in the oven; and a change in the customer demand rate will have no influence whatsoever on this reality!

WP3 consequently represents a purposively selected (Silverman, 2000) multiple unit of analysis case study; a research strategy 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 and various observational techniques. Document and archival analysis were used for the secondary research, with the resultant data being ordered into a number of software deliverables (capacity planner, WIP monitors and a software simulation of material flows) that were used to support the resultant pull-system design. Data is disguised in this paper in the interest of commercial confidentiality.

THE CASE IN CONTEXT

Bombardier Aerospace Belfast (BAB) is an integral part of Bombardier Aerospace; the world's third largest civil aircraft manufacturer. Bombardier Aerospace is headquartered in Montréal, Canada and employ more than 28,000 people worldwide. For the year ended January 31 2009 Bombardier Aerospace's revenues amounted to $10 billion. BAB by contrast employ over 5,000 people and at six plants in Northern Ireland. They design, manufacture and support fuselage, engine nacelle and flight control surface structures for the parent firm's small and medium sized regional aircraft series such as the Learjet, Challenger and Global Express ranges. These structures are assembled on a number of dedicated assembly lines in the Main Factory (final assembly hall) in Belfast before the resultant 'pods' (complete fuselages or nacelles) are shipped on; with final aircraft assembly being conducted at the parent firm's North American plant.

C04 that forms the focal case organisation within the WP3 project is one of these six plants and is located approximately one mile from the Main Factory. C04 is an upstream fabrication facility that receives raw material such as sheet metal from external suppliers and produces a variety of aircraft panels. The facility produces both bonded (parts glued together using adhesive) and non-bonded panels. Panel production starts with the rolling of sheet metal into the panel shape/ curvature at large machines called the Farnham Rolls; the *gateway* work centre. These, and most of the other main manufacturing resources used in panel production are shared *shared resources;* not being dedicated to any contract or value stream. Many of these resources such as Chemical Milling, Clean Line and Autoclaving are also natural batch processes. Once produced the panels might either be transported to a panel cell in the Main Factory, or alternatively to a local BAB pre-assembly buffer area called the Flight Shed before being called off by the downstream Main Factory where they are then assembled into fuselage or nacelles 'rings' (concentric sections) as part of the final assembly process.

THEORETICAL UNDERPINNING

The conventional framework for implementing a Lean project is to follow Womack and Jones' (1996) *Five Lean Principles* of specifying value by product, identifying the value stream, making the product flow in response to a customer demand signal, while constantly seeking perfection in the guise of a programme of continuous improvement. This is usually translated by practitioners and many academics to mean undertaking a *Learning to See Mapping* (Rother and Shook, 1998) exercise that is then used as a catalyst for the broad deployment of one or more tools from the *Lean toolbox* such as [typically] 5S. The aim of this is reducing 'waste', with the assumption that this will equate to a concomitant cost reduction (Darlington, 2006). Many Lean initiatives consequently fail to progress to the third Lean principles of instigating flow; and if they do the resultant pull system is usually based upon a 'Lean supermarket'. This is a tightly controlled buffer area that is used to store a number of *each SKU* used by the downstream resource; the replenishment of which is controlled by means of kanban system into a set physical space allocation (Bicheno, 2004). It is to the analogy of on-shelf availability of the portfolio of available products at a typical grocery store that this system owes its name.

Such a framework as the above was not viable for the WP3 project given its academic and practical imperatives for increasing the *throughput* rather than reducing the costs of the C04 operation. The variety, cost and physical size of the panels produced by C04 meant that a Lean supermarket/ kanban system was similarly not viable. The research team consequently affirmed the *Synchronous Principles* of the Theory of Constraints (Goldratt and Cox, 1984) as a more appropriate framework for guiding the research in this area. In summary these principles are:

1. Balance flow, not capacity.
2. The utilization of a non-bottleneck is determined not by its own capacity but by some other constraint in the system.
3. Utilisation and activation are not synonymous.
4. An hour lost at a bottleneck is an hour lost for the whole system.
5. An hour saved at a non-bottleneck is merely a mirage.
6. Bottlenecks govern both throughput and inventory in the system.
7. The transfer batch may not, and many times should not, equal the process batch.
8. The process batch should be variable, not fixed.
9. Lead times are the result of a schedule and cannot be predetermined.
10. Schedules should be assembled by looking at all the constraints simultaneously.

DISCUSSION
Drawing upon these guiding principles and utilising the associated Flow Accounting methodology detailed in Darlington *et al*. (2008a; 2008b) the following programme was undertaken at C04 by the LERC research team:

- Construct a Big Picture Financial Map (BPFM) that illustrates the physical & information flows and the financial consequences of operating the current-state of the C04 operation.
- Building upon the data collected as part of the BPFM exercise such as the Bill of Material, routing and resource files from the firm's MRP system and collect the supplementary data required to build a new capacity planning tool using Microsoft Access/ Excel (such as demand, shift patterns, scrap/ rework rates and batching rules for resources such as the Autoclave ovens and Clean Line). This software tool calculated demand in hours for [any] given period and compared this to the available hours for that period. Its output was a visual display of the resultant load percentage on each of the resources in C04.
- Use this information to identify the *constraint* or *pacemaker* process (the resource with the highest loading) that was to form the focal point for the pull-system design.
- In conjunction with a researcher from QUB, to create a simulation model of the C04 panel production process using the DELMIA software set in order to triangulate the findings of the capacity planning exercise.
- Again using Excel, to design a work in progress (WIP) monitoring tool and undertake a longitudinal analysis of the C04 WIP profile to establish how long the system takes to serve the customer today, and to also further triangulate the findings of the above prior to pull-system design (hoping to identify a WIP build up in front of the resource identified as the constraint/ pacemaker and little WIP after it). This tool was also intended to be used as a monitoring device for post implementation performance. The pre-design phase involved the analysis of 17 separate WIP 'snapshots' over a 16 week period.
- Drawing upon the above data collection and analysis to identify the most appropriate type of pull-system to implement then designing the mechanics required to operate this.

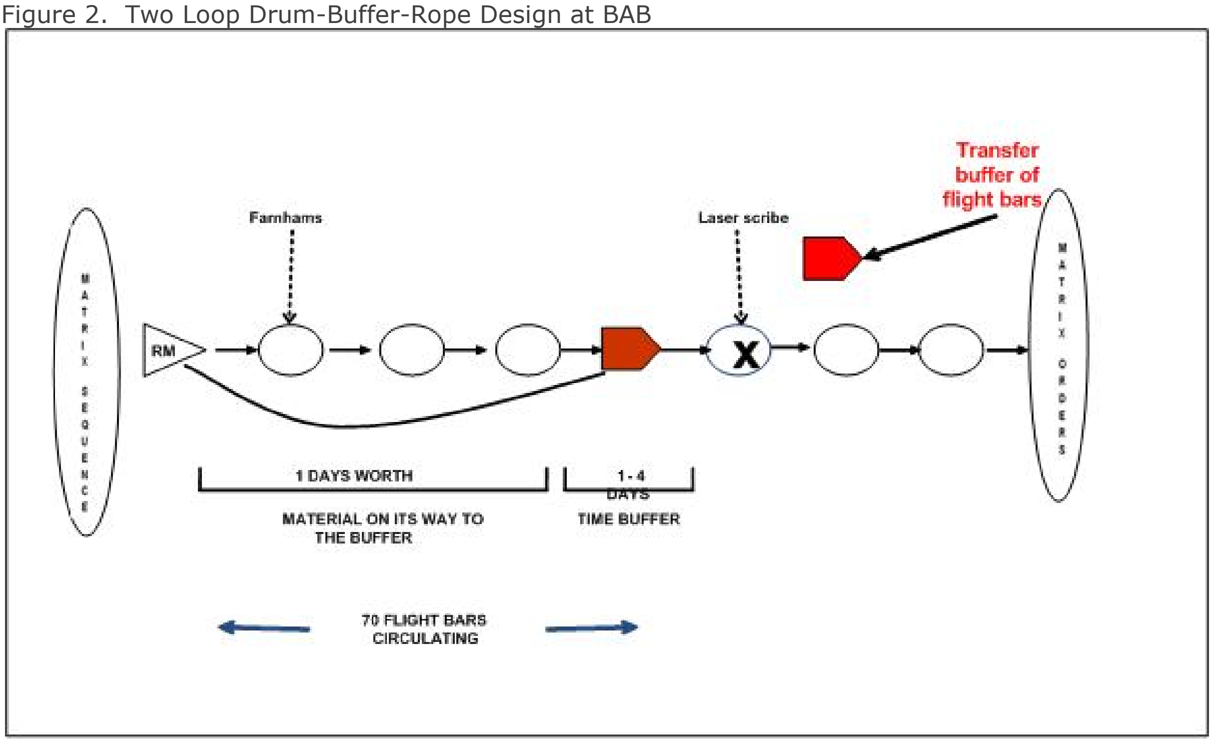
A number pull-system types exist including the kanban/ supermarket summarised earlier and the CONWIP approach advanced by Hopp and Spearman (2000). However, after due consideration of the C04 operating environment and the variation in physical size and work content of the panels produced by it, the team decided to implement a pull-system based on *time based buffering*. They consequently selected the Drum-Buffer-Rope (DBR) approach illustrated in Goldratt and Cox (1984). In DBR, the 'Drum' is the constraint/ pacemaker whose 'beat' determines the throughput of the whole system (Bicheno, 2004, pp.125-126). According to the Synchronous Rules a minute lost at the [Drum] is a minute lost for the whole system. A 'Buffer' is therefore required to protect the Drum by ensuring that it is never starved of work.

This is a time based buffer representing a pre-determined amount of processing time of the next items to be processed, rather than a discrete number of or specific type of item. The actual size of this Buffer is determined by the probability of failure upstream of the Drum. The 'Rope' is a signalling device that links the Drum to the gateway work centre(s) which is synchronised to the Drum processing rate. When the Drum processes an item the Rope is used to send a signal to the gateway to release the next item into the first workstation for processing. Similarly, if the Drum stops for any reason; no signal is sent and therefore no more work is released into the system as this would merely build WIP/ queue size (*op cit*.).

The resultant pull-system design is illustrated in Figure 2. Triangulation of the findings of the capacity planner, simulation model and WIP monitoring tools confirmed that the pacemaker/ constraint (ie 'Drum') resource was the *Laser Scribe* machine. This was a machine that etched the pattern of details such as fuselage strengthening 'rib' locations into the maskant material coating the inside of the panel prior to the Chemical Milling process.

Based on the analysis of C04's breakdown records and downtime reports it was decided that an appropriate initial Buffer would be two daysworth of work. However, to service increased C04 demand Darlington produced a business case for adding a Laser Scribe shift at the weekend. This necessitated an increase in the Buffer size to 3-4 daysworth (to cover the weekend shift and ensure buffer inventory in place at the start of the Monday morning shift). After calculating what 3-4 daysworth of panels represented in a physical sense it was then validated that this buffer could be physically accommodated in the designated WIP area in front of the Laser Scribe machine.

Figure 2. Two Loop Drum-Buffer-Rope Design at BAB



A ready-made Rope signalling system was already in existence in C04 the form of the 'flight bars'; a manual overhead conveyance system on which the panels were hooked for material handling purposes. The 'first loop' of this Rope was between the Laser Scribe Drum and Farnham Rolls gateway resources. The signal to the Farnhams to release/ process the next panel on the schedule was therefore the availability of a flight bar upon which to hang it. This proved to be a very useful physical WIP limiting device as the number of flight bars in circulation determined the 'daysworth' of inventory in the system as a whole. As illustrated in Figure 2, this first loop up to and including the Buffer amounted up to five daysworth of inventory (four daysworth in the Buffer and one daysworth upstream of this). This equated to 70 flightbars. However, another consideration was the 'second loop' of flight bars necessary to transport the panels processed by the Drum downstream to the exit (Despatch) area. After making due calculations it was established that the process variability and scrap/ rework rates of these downstream resources such as Chemi Milling and the Clean Line necessitated the creation of a transfer buffer of flight bars to ensure there were always enough flight bars available for which the Drum to offload its processed panels - else risk stopping (and hence reducing throughput). An important point to stress is that the schedule of which panel to process next at the Farnham was still derived from BAB's MATRIX MRP system sequence/ prioritisation; this new system just ignored the MRP derived operational start dates and instead finite forward scheduled from now.

CONCLUSIONS, EXPLOITATION AND FUTURE RESEARCH

The WP3 project was undertaken to further test the FA methodology in a complex fabrication environment characterised by material flows through many shared and natural batch processes, and hence contribute to the very limited body of Lean knowledge on this topic. It was found that the FA methodology did indeed prove useful, and in conjunction with the Synchronous Principles and DBR pull-system derived from the Theory of Constraints yielded a viable theoretical means of reducing the throughput at C04.

On completion of WP3 a proposal was made to the BAB senior management team to undertake a £70K action research project to **implement** the designed pull-system at C04 with one of the authors (Darlington) acting as the main change agent. Based on the WP3 analysis it was estimated that this would result in a 20% lead time reduction as measured by WIP from a starting position of 40 daysworth of inventory. Working in conjunction with BAB's accountants this level of inventory reduction was equated to a $450K material and utility cost reduction, or $850K in fully absorbed standard costing terms. BAB subsequently commissioned this project, which was entitled *Pull System Implementation (PSI)*. At the time of writing PSI is nearing completion. Initial results are very promising and have already exceeded expectations. While the new pull-system has not yet been 'fine tuned', the latest results show a reduction in the total number of panels in C04 from 432 to 174 (59.7%). When converted into 'daysworth' of inventory this reduction equated to 39.61 to 17.01 days (57.1%); which translated into an increase in inventory turns from 9.09 to 21.16.

PSI has been nominated by BAB for a worldwide Bombardier Aerospace process improvement prize and plans are in progress to rollout the FA/ PSI methodology to all six of BAB's Northern Ireland facilities. It is hoped that this will form the subject for a paper at ISL 2010.

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NEED FOR SPEED: THE ANTECEDENTS OF SPEED-TO-MARKET IN SUPPLY CHAINS

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ABSTRACT
The concept of speed-to-market has received much attention from industry and academia for the past two decades. It has been recognized that time-to-market plays an important role in determining the ultimate success or failure of a new product launch. Despite its importance, past research largely focus on speed-to-market in the new product development process, while the role of supply chain management in improving speed-to-market for existing products has largely been ignored. In this paper, we attempt to shed some light on the behaviour of speed-to-market from a supply chain perspective. Specifically, we focus on speed-to-market in a dyadic buyer-supplier relationship. Traditionally, companies persistently aim at greater speed and cost-effectiveness, which are popular grails of supply chain management. Very often, companies have to trade-off between cost and speed. While recognizing the traditional research on speed and cost trade-offs, we address the behaviour of speed-to-market in supply chains from a relational perspective. We posit that trust and frequency of communications are two key antecedents of speed-to-market, and frequency of communications is affected by trust and power. We used a questionnaire to survey the professional opinions of our respondents. The questionnaire was developed based on existing measures in the literature. A large-scale mail survey was conducted and 198 complete and usable responses from more than ten industries were collected. The results in structural equation modelling generally support our hypotheses. Theoretical and practical contributions are shared and documented in this paper.

Keywords: Supply chain, speed-to-market, trust, frequency of communications.

INTRODUCTION

The concept of speed-to-market has received much attention from industry and academia for the past two decades. It has been recognized that time-to-market plays an important role in determining the ultimate success or failure of a new product launch (Bayus, 1997; Smith, 1999). Despite its importance, past research has largely focused on speed-to-market in the new product development process, while the role of supply chain management in improving speed-to-market for existing products has largely been ignored.

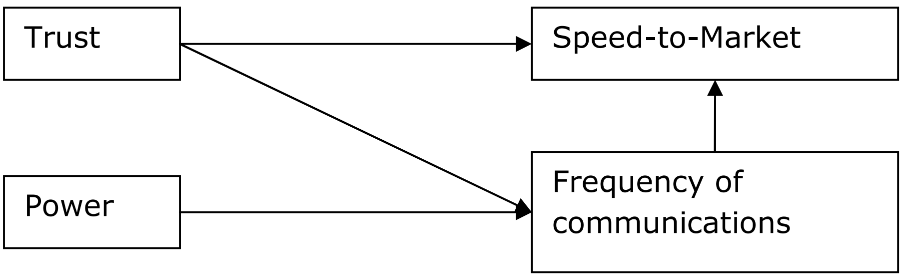
Speed-to-market can be equally important in supply chain practice, wherein increasingly impatient customers favor providers that offer speedy delivery of a quality product or service (Hult, Ketchen, & Slater, 2004). Recent research has suggested that fast speed-to-market could increase market share, lower overhead and inventory cost, and link to profits directly (Handfield & Nichols, 2002; Hult et al., 2004). Traditionally, companies persistently aim at greater speed and cost-effectiveness, which are popular grails of supply chain management. Very often, companies have to trade-off between cost and speed. While recognizing the traditional research on speed and cost trade-offs, we address speed-to-market in supply chains from a relational perspective.

In this paper, we attempt to shed some light on the mechanisms to faster speed-to-market in supply chains from a relational perspective. There is growing consensus among scholars that effective exchange relationship management is central to a more efficient supply chain. We posit that trust and communications between buyer and supplier are key determinants of speed-to-market. A mail survey was conducted in Singapore and 198 valid questionnaires were returned. Structural equation modeling (SEM) was employed to test our theory. The results generally support our hypotheses. We conclude with some suggestions for further research.

Theoretical Model and Hypotheses

In today's dynamic environments, as increasingly impatient customers favour providers that offer speedy delivery of a quality product or services, time-based competition is regarded as latest mantra being touted as the way to achieve a competitive advantage (Bayus, 1997; Hult et al., 2004). Speed-to-market, which refers to the time interval between a user's request for a product or service and its delivery (Hult et al., 2004; Hult, Ketchen, & Nichols, 2000), is recognized as a key to customer satisfaction and competitive advantage. Figure 1 presents a research model of speed-to-market in supply chains. The model includes two key antecedents of speed-to-market: frequency of communications and trust. Further, frequency of communications is conjectured to be affected by trust and power. We shall elaborate the proposed research model and hypotheses development in the following section.

Figure 1: Proposed research Model



Communication is essential in setting priorities and coordinating activities to accomplish each party's objectives (Mohr, Fischer, & Nevin, 1996). The communications between buyer and supplier can happen in several ways, including face-to-face communications, telephone communications, and written communications. Although different communications modes differ in their richness, in general, more frequent communications can help streamline the supply chain process and improve speed to market. In our model, the frequency of communications refers to the frequency of information sharing between buyer and supplier. According to the theory of communication (Attewell, 1992), communication is an act of signalling where a source transmits a fully codified message that is absorbed and then acted on by a recipient. The transfer is seen to be effective to the extent that it changes the behaviour of the recipient in productive ways (Szulanski, Cappetta, & Jensen, 2004). The frequency of communications is conjectured to affect speed-to-market in supply chains for two reasons. First, frequent communications between buyer and supplier help buyer and supplier to build a more effective and efficiency system for handling ordering and delivery (Cannon & Homburg, 2001; Song & Zipkin, 1996). More frequent communication enables the supplier to gain a deeper understanding of how its products are used by the customer. On the other hand, more frequent communications helps buyers to familiarize with the products or services provided by the supplier, as well as gain more knowledge on the manufacturing capacity and the inventory level of the supplier. As noted by Song and Zipkin (1996), good information is the key to effective just-in-time inventory management and delivery. Second, when exceptions or undesired problems take place during the ordering and delivery process, frequent communications would help both supplier and buyer to design solutions and fix the problem. Accordingly, we hypothesize that:

H1: the frequency of communications is positively associated with speed-to-market between supplier and buyer.

There is extensive support in prior research for the overall beneficial effect of trust to business transactions (Yang, Wang, Wong, & Lai, 2008), operational effectiveness and product quality (Shin, Collier, & Wilson, 2000) and inter-organizational relationships (Szulanski et al., 2004). Empirical studies have shown that trust, by bringing about good faith in the intent, reliability, and fairness of partner behaviour (Krishnan, Martin, & Noorderhaven, 2006; Zaheer, McEvily, & Perrone, 1998), reduces the potential for conflict (Zaheer et al., 1998), and promote smooth information flow between partners (Sako, 1991). The commitment–trust perspective argues that a buyer's trust in and/or commitment to a seller is the prime determinant of exchange performance (Morgan & Hunt, 1994). "Trust is confidence in an exchange partner's reliability and integrity (p. 23)" that directly and indirectly through commitment affects exchange outcomes (Morgan & Hunt, 1994).

Trust could be equally important in promoting communications between buyer and supplier. Trust reduces the potential risk of sharing information with partners. Very often, information sharing needs to release some guarded information, e.g., financial, strategic and operating information, to partners who might have been or will be competitors. Information sharing entails some level of risk because the partners cannot fully control how the other partner may use the shared information (Becerra, Lunnan, & Huemer, 2008). The risk of benefiting competition prevents a buyer from any information disclosure unless it has confidence in the goodwill of the receivers. Thus, in the absence of trust, a buyer will take defensive measures which block communications of important information. In contrary, trust would increase the willingness to communicate with supply chain partners. Accordingly, we hypothesize that:

H2: trust is positively associated with the frequency of communications between supplier and buyer.

Trust is also conjectured to affect speed-to-market directly for two reasons. First, with the presence of trust, it would be more efficient and effective for supplier and buyer to work together in designing a smooth supply routine. Supply chain activities between supplier and buyer would also be easier to coordinate. Second, trust would help supplier and buyer to settle down disputes and fix the unexpected problems in ordering and delivery. Therefore, we hypothesize that:

H3: trust is positively associated with the speed-to-market between supplier and buyer.

No organization is self-sufficient. Firms always depend, albeit to varying degrees, on their trading partners. An examination of the supply chain partners indicates that they are often asymmetrical pairs in terms of power. The larger enterprise appears to be throwing its weight into "coercing" the smaller one. the resource dependency theory asserts that inter-organizational dependence is created when one business partner "does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action (p. 40)" (Pfeffer & Salancik, 1978). The communications between the buyer and the supplier requires that business practices and information be shared. These requirements can substantially affect the allocation of key resources that can determine the interdependent relationship. When a supplier is powerful, for the firm's own good, it would be likely to throw its weight into "coercing" its buyers to communicate and share information. The more bargaining power a firm has over its business partners, the greater the likelihood the organization can obtain resources from its business partners. Therefore, we hypothesize that:

H4: The power of the supplier is positively associated with the frequency of communications between supplier and buyer.

Research Method

We used a questionnaire to survey the professional opinions of our respondents. The questionnaire was developed through a three-stage process. We first extensively reviewed the literature to list the candidate constructs and measures that were used in previous research. A draft questionnaire was developed. Each item was measured in a five-point Likert scale. We then conducted structured face-to-face interviews with fourteen managers from logistics firms or firms with logistics functions in Singapore, using an interview protocol based on the draft questionnaire. In the third stage, following some revisions, four researchers reviewed the draft questionnaire, ranked each item according to their content validity, and suggested improvements in wording and the layout of the items. The instrument for the constructs in our research model is presented in Table 1.

Table 1: Construct Measures

Construct	Item	Description	References
Speed-to-market	STM1	The length of the supply chain process is getting shorter every time.	(Hult et al., 2004)
	STM2	We are satisfied with the speediness of the supply chain processes.	
	STM3	The length of the supply chain process could not be much shorter than it is today.	
Frequency of communications	COM1	In the development process, direction of communication is bilateral rather than unilateral.	(Kotabe, Martin, & Domoto, 2003)
	COM2	Frequent contact between our partner and our engineers is important.	
	COM3	Communication with our partner often begins to occur earlier in the development process.	
Trust	TRUST1	This supplier would always look out for our	(Levin &

		interests.	Cross, 2004)
	TRUST2	This supplier would go out of his/her way to make sure we will not be damaged or harmed.	
	TRUST3	We believe that this supplier approach the assigned jobs with professionalism and dedication.	
	TRUST4	Given this supplier's track record, we see no reason to doubt his/her competence and preparation.	
Power	POWER1	The bargaining power of your principal suppliers, that is, their capacity to impose their pricing conditions, is__________.	(Cool & Henderson, 1998)
	POWER2	The impact of the products purchased from your suppliers on your product differentiation is______.	
	POWER3	The impact of the products purchased from your suppliers on your cost structure is_____.	

A large-scale mail survey was conducted from a random list of 800 companies drawn from the membership list of the Singapore Logistics Association (SLA) and Supply Chain Exchange '08. Each surveyed respondents was asked to identify one of their key suppliers and answered questions on their relationships with the specific supplier. After two rounds of follow-up reminders, we had 198 complete and usable responses (24.8% response rate). Table 2 reports the demographic description of those respondents.

Table 2: Demographic Descriptions

	Max.	*Min.*	*Mean*
Number of years in the industry	34	2	7.02
Number of years with the current organization	34	1	5.92
Position in the organization		Number of cases	%
Top Management (President, Vice President, Director, CEO, CFO, MD)		29	14.6
Senior Management (AVP, Senior Manager, etc)		17	8.6
Manager		55	27.8
Administrative Executive		47	23.7
Unreported		50	25.3

Industry		
Chemical	21	10.6
Petroleum/mining	11	5.6
Utilities	1	0.5
Military	7	3.5
Aerospace	11	5.6
Automotive	9	4.5
Transportation/Logistics	21	10.6
Manufacturing	38	19.2
Consumer Goods	12	6.1
Medical	5	2.5
Others	47	23.7
Unreported	15	7.6

Data Analysis and Results

We then conducted data analysis in accordance with a two-stage methodology (Anderson & Gerbing, 1988). The first step in the data analysis is to establish the convergent and discriminant validity of the constructs. We test the measurement model using Principal Components Analysis (PCA) using SPSS. In the second step, the structural models are examined using Structural Equation Modeling (SEM). We examine the data using PCA with Varimax rotation. We identify four factors with eigenvalues greater than 1.0. All the items are loaded on the intended constructs (Table 3). We then proceed to hypotheses testing.

Table 3: Factor Analysis

	Component			
	1	2	3	4
TRUST1	**.768**	.184	.165	.123
TRUST2	**.826**	.088	.098	.126
TRUST3	**.626**	.075	.345	.031
TRUST4	**.782**	.098	.157	.230

Power1	.093	**.785**	.043	.157
Power2	.203	**.798**	.088	.111
Power3	.059	**.838**	.174	-.026
STM1	-.014	.172	.180	**.750**
STM2	.192	.035	.250	**.778**
STM3	.276	.038	-.110	**.725**
COM1	.171	.093	**.779**	.148
COM2	.121	.156	**.820**	.056
COM3	.372	.070	**.664**	.114

Next, we examine the structural models. The normed Chi-Square (Chi-Square to degrees of freedom) is 1.34, which is below the desired cut-off value of 3.0 (Gefen, 2000). The RMSEA is 0.042, indicating a good fit, while the Root Mean-square Residual (RMR) is 0.031, which is lower than the desired cut-off value of 0.05. All the fit indices are satisfactory (GFI = 0.94, AGFI = 0.91, NNFI = 0.97, CFI = 0.98, NFI = 0.92). These results suggest that the structural model adequately fits the data.

Table 4 shows the hypotheses testing results and R^2 for the dependent variables. Frequency of communications and trust are found to be significantly affect to speed-to-market (H1 and H3), explaining 30 percent of the speed-to-market variance. Further, our analysis also reveals significant relationships between trust and frequency of communications, and between power and frequency of communications. Trust and power collectively explains 38 percent of the variance frequency of communications. Hence, all the hypotheses in this study are supported.

Table 4: Hypotheses testing results

	Beta	T value	P value
Paths (Hypotheses)			
Communications → Speed-to-Market (H1)	0.24	1.99	0.047
Trust → Communications (H2)	0.51	5.19	0.000
Trust → Speed-to-Market (H3)	0.38	3.13	0.002
Power → Communications (H4)	0.20	2.12	0.035
R-square			
Communications	0.38		
Speed-to-Market	0.30		

CONCLUSIONS AND IMPLICATIONS

Our findings offer a number of insights into speed-to-market in supply chains. Of particular importance in this study is that these findings are derived from a broad range of logistics players, representing firms from more than ten industrial sectors. This study highlights the importance of relational perspective in predicting and explaining speed-to-market in supply chains. Beyond the traditional cost and speed trade-offs, this study proposed and confirmed new antecedents of speed-to-market. By identifying frequency of communications and trust as key factors to speed-to-market, this study complement the current literature on speed-to-market by offering the relational variables on how to improve speed-to-market. In addition, our research also highlights the importance of trust building between supply chain partners. By investing in trust, supply chain players are able to work together for a more efficient supply chain, which will ultimately benefit all parties in the supply chain. Finally, this study is conducted in Asia. Traditionally, relationship and trust are important components of the Asian culture. To our knowledge, the extant literature is not particularly insightful on the role of trust on speed-to-market across different cultures. Investigating the impacts of trust in connection with cultural differences could be interesting for future research.

We too note the limitations of this research. First, the speed-to-market of a supply chain could be closely related to its size, revenue, profit, and so on. As many firms surveyed are unwilling to disclose their sensitive financial status, we were not able to measure the relative power of supply chain partners through objective financial data. Finally, the cost side of speed-to-market plays a minor role in this study. The engagement in a supply relationship most certainly commands significant investments and raises the cost of switching away from the current relationship. It would be fruitful to integrate the traditional economic view of speed and cost trade-offs into the analysis in future research.

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SUPPLY CHAIN VOIDS (SCVs) WITHIN THE FINANCIAL INTERMEDIATION AND INSURANCE SECTOR IN WALES. FACT OR FICTION ?

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ABSTRACT
The research into supply chain voids (SCVs) in capability within Wales was described by Whitehead and Found (2007) where SCVs were defined in relation to the study region and initial research findings were reported; identifying three sectors within which to carry out case studies into specific SCVs. This paper furthers this work and reports on the results from one sector, specifically, financial intermediation and insurance.

INTRODUCTION
The study, part of a PhD thesis, investigates SCVs within the supply chains (SCs) of regionally based customers. Ultimately, the research develops a framework for use by the Welsh Assembly Government (WAG) to address SCVs in the future. This paper covers the case study stage for the financial intermediation and insurance sector whilst addressing the research question: *'What supply chain voids in capability exist in three of the priority sectors in Wales and why?'*

RELATIONSHIP TO EXISTING WORK
The literature review for the overall study is shown in Figure 1.

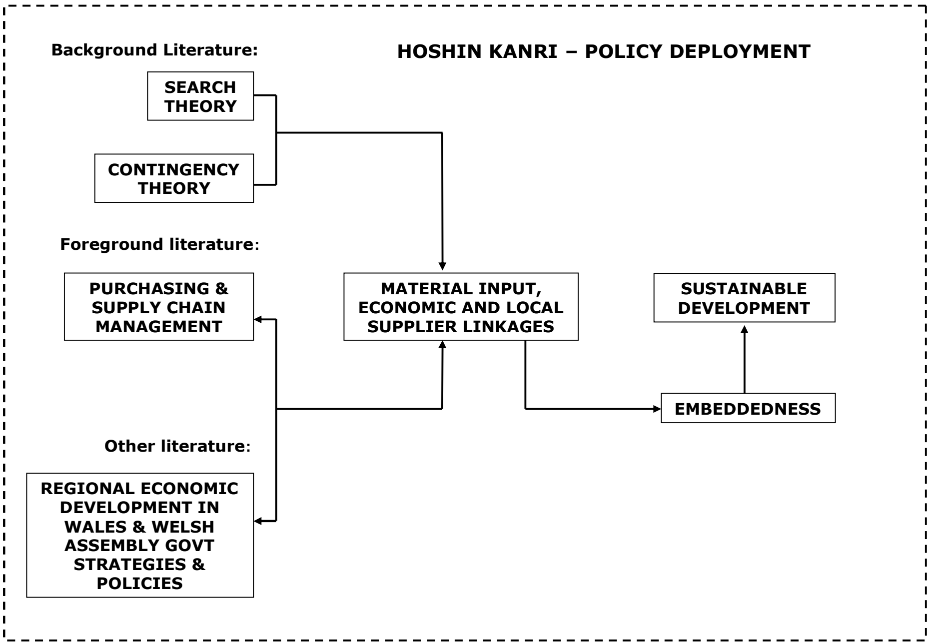

Figure 1 – Literature Review for the Supply Chain Voids Study

The literature emphasises a multi-disciplinary study involving for example purchasing and supply chain management (P & SCM), economics and economic geography. Limited evidence exists in relation to reporting the mechanisms or models employed to identify and respond to SCVs that may exist, although Crone (2002) identifies potential policy interventions for regional development agencies (RDAs) to consider in addressing weak supply linkages.

Local sourcing by foreign multinational enterprises (MNEs) in the United Kingdom (UK) and the Republic of Ireland has received considerable interest (Collis and Roberts, 1992; Turok, 1993; Gorg and Ruane, 2001; Phelps, 1993a, 1993b and 1997). However, much of the empirical evidence suggests that foreign investors rarely develop significant input linkages with their host economy. On the contrary, considerable evidence shows that the sourcing patterns of MNEs have become increasingly internationalised (Phelps, 1993a and 1997; Hudson, 1997, Rees, 2005).

Scott-Kennel (2007) reviews the material linkage literature and identifies that the majority of studies in developed countries have focussed on manufacturing (Hewitt-Dundas *et al*., 2005; Crone 1999). A large amount focuses on the macro or meso level, identifying percentage levels of local linkages, not the micro or firm level detail whereas empirical research into firm level linkages has often been limited to the use of econometric studies, panel data and input-output tables (Girma *et al.*, 2004, cited by Scott-Kennel, 2007).

METHODOLOGY

A multi-method case study strategy has been adopted utilising semi-structured interviews, structured telephone interviews and standard business strategic analysis techniques such as PESTEL, SWOT and TOWS (Yin, 2003; Bryman and Bell, 2003; Denzin and Lincoln, 2000; Saunders *et al*., 2003; Johnson *et al*., 2006). The results of the interviews are reported here, with reference to the SWOT analysis.

FINDINGS

Companies engaged within the study were allocated pseudonyms in order to preserve confidentiality. The first phase of the research involved 6 semi-structured interviews with 5 companies whose details are summarised in Table 1 below. Note that 2 SC operations were investigated for Company 'A'.

Companies reported that they and their suppliers must comply with the Financial Services Authority (FSA) regulations. Suppliers may also have to comply with ISO accreditations or become approved suppliers by, for example, Company 'A'. Levels of P & SCM professionalism varied with only companies 'A' and 'D' reporting specially trained personnel within their purchasing departments as highlighted in the literature by Handfield, 2006; Quale, 2006; Lysons and Gillingham, 2003).

Purchasing operations at companies 'A' and 'D' are a mixed economy of both centralised and de-centralised decision making as discussed in the literature (e.g. Quale, 2006; Cavinato, 1992), whereby some goods and services are authorised on site but others are bought as part of group or head quarter (HQ) decisions. Companies 'B' and 'E' operate what they term as a de-centralised system, albeit they are HQs. Company 'C' is centralised with all purchasing decisions made at their HQ site. Regarding decision-making units (DMUs) as defined by Webster and Wind (1972), companies 'A', 'C' and 'E' all use a multi-disciplinary team approach, whereas companies 'B' and 'D' operate structures that are contingent upon what is being bought.

Companies were asked to prioritise their P & SC requirements (e.g. Simpson *et al.*, 2002; Varmazis, 2006; Day, 2002, Heriot, 1996) and reported that *cost, quality* and *delivery* were the top 3 priorities, although not necessarily in the same order for all companies.

Company/ Type	**HQ/ Branch**	**Product/ Service**	**Market**	**No of Employ-ees**	**No of Years in Wales**
Company 'A' - Insurance	Branch/UK	General Insurance underwritten by other companies.	Consumer	Over 250	Up to 15 years
Company 'B' - On-line aggregators and product comparison site	HQ/Wales	General Insurance, banking plus other non-financial services e.g. travel.	Consumer	Over 250	Up to 5 years
Company 'C' - Bank	HQ/Wales	Life insurance, banking and building society activities.	Business and Consumer	50 - 250	Over 15 years
Company 'D' - Building Society	HQ/Wales	Banking and building society activities, contact centre.	Consumer	Over 250	Over 15 years
Company 'E' - Insurance	HQ/Wales	General insurance direct to consumers.	Consumer	Over 250	Up to 15 years

Table 1 – Summary of Companies Involved in Semi-Structured Interviews

A combined total of 41 specific, high-value SCVs were identified in the study with the top 5 accounting for over £400m being leaked from the Welsh economy and these are summarised in Table 2. In addition, a trend emerged for Disaster Recovery (DR), Data Centre (DC) or Business Continuity (BC) services, which are relatively low-value but increasingly, affect more sectors. The majority of SCVs are perceived to exist because of a lack of local supplier availability, technical competence, quality and the required service levels or SC priorities (e.g. Hewitt-Dundas *et al*., 2005).

These SCVs were validated with sector experts through alignment to WAG strategies and policies (i.e. policy deployment), which was challenging as no specific sector strategies exist. Therefore, this needs to be rectified for each of the priority sectors identified by the WAG. The outcome of this process was to further investigate SCVs for advertising and DR/DC/BC services.

Company 'B' did not know how many suppliers are on its supplier database and stated that the list is still growing as the business develops. Company 'A' has a total of 58 suppliers across 2 SCs whilst Company 'C' has less than 50. Company 'D' has 900 suppliers: of which 500 are 'live' in the current year and this is being actively reduced. Company 'E' has 2 key suppliers for advertising, their biggest expenditure line. In relation to sourcing activities, the rest of the UK is the major source of supply, followed by Wales. Nothing is bought from outside of the UK.

Product/Service Description	**Supplier Country/Location**	**Total Value in £ p.a.**
Insurance services including general consumer insurance, card protection, loan protection and small business insurance	Rest of UK	Over £100m
Loan Protection services	Rest of UK	Over £100m
Card Protection services	Rest of UK	Over £100m
Loss Adjusting (General Adjusting i.e. basic household claims - fire, theft, escape of water, floods, etc.)	Rest of UK	£75.2m (£5.2m fees plus £70m spend on repairs)
Advertising Space (Various Media) On-Line & Off-Line	Rest of UK - Manchester & London	Over £25m

Table 2 – Top 5 Supply Chain Voids by Value (£)

In order to scope broader sector demand, a total of 49 companies were contacted via tele-interviews, to identify if purchasing decisions are being made in Wales and where DR/DC/BC and advertising are being sourced from. Where purchasing decisions are not made in Wales, such information was not pursued with HQs located elsewhere. This activity identified that only 5 (10%) companies have HQs in Wales, 39 (80%) are in the rest of the UK, 4 (8%) are in the wider EU and 1 (2%) is elsewhere in the world. Therefore 90% of purchasing decision making is not in Wales.

For those companies operating centralised purchasing outside Wales, it is understood that for many, DR/DC/BC services are an in-house solution and no Welsh suppliers were identified. For advertising, again, no Welsh suppliers were identified. Up to 5 companies who make sourcing decisions in Wales provided information relating to the SCVs. The advertising requirements identified by 4 companies totalled £750k for on-line advertising and £170k for off-line advertising. The DR/DC/BC requirements identified by 5 companies identified that 3 carry out the services in-house and 2 spend a total of £102k.

The requirements identified during the tele-interviews were added to those from the semi-structured interviews. The results for advertising are summarised in Table 3 and for DR/DC/BC services in Table 4 where a bioscience company from another case study has been included. (On-line advertising is via the internet e.g. google whereas off-line is traditional media advertising e.g. radio, television and press).

Companies	**Size**	**HQ**	**Ad Agency used**	**Ad Agency Location**	**Type of Advertising**	**Value (£) p.a.**
'B'	L	Wales	N/K	Manchester & England	On-Line & Off-Line	> £2m
'D'	L	Wales	Yes	UK	Off-Line	> £1.3m
'E'	L	Wales	Yes	London & Manchester	On-Line & Off-Line	£22m
'M'	M	Wales	No	Wales	Off-Line	£120k
'S'	M	EU	Yes	London	Off-Line	£40k
'T'	M	Wales	Yes	Cardiff	Off-Line	£10k
'Y'	L	Wales	No	UK	On-Line	£750k

Table 3 - The Total Requirements Identified for Advertising and Sources of Supply

Demand for advertising exists in Wales (£26.2m), based on 7 companies but it is skewed by the company 'E' requirement. The SWOT for advertising identified 29 companies in Wales, the majority of which are small with limited capabilities, but 1 (Granada) could possibly deliver the capability and capacity required. A local supplier could be found, if sought (e.g. Rothschild, 1974; Manning and Morgan, 1982) and suitable in terms of meeting customer priorities (e.g. Simpson *et al.*, 2002; Varmazis, 2006; Day, 2002, Heriot, 1996). However, competition may mean that prices are too expensive or that service levels demanded by customers are not met locally (Crone, 2002; Turok, 1993). Also, Granada may have insufficient capacity as their usual demand is up to £2.5m per client, per annum and company 'E' has an annual demand of £22m. However, Granada is the HQ of a company with 9 other branches across the UK and other Welsh companies could create capacity. For all 7 companies, the purchasing decision is made on site.

Companies	Size	Main Activity	HQ	Supplier Location	Services Required	Value (£) p.a.
Bioscience Company	M	Biopharm manufacture	Rest of UK	England	Restore, hardware, mobile server	£6.5k
'A'	L	General Insurance & contact centre	Rest of UK	In-House	DR services	N/K
'B'	L	On-line aggregator	Wales	North West England	Main servers and systems	N/K
'C'	M	Financial intermediation and insurance	Wales	Bristol	Office facilities, IT, telephones	£30k
'D'	L	Building society	Wales	Bristol & Milton Keynes	DR services	£95k
'E'	L	General Insurance & contact centre	Wales	In-House	DR services	N/K
'M'	M	Building society	Wales	In-House	Data back-up services	N/K
'P'	L	Loans	Rest of the World	Cardiff (sub-contracted to Bristol & Hounslow	DR for all core systems and a standby site/offices	£35 - 45k
'S'	M	Credit information services	EU	Cardiff	All web site and critical IT systems	£60k
'T'	M	Insurance broker	Wales	In-House	Data back-up services	N/K
'Y'	L	Loans	Wales	In-House	Data back-up services	N/K

Table 4 - The Total Requirements Identified for Disaster Recovery/Data Centre/Business Continuity Services and Sources of Supply

Table 4 shows that demand and a source of supply exists within Wales for DR/DC/BC services, albeit most companies seek suppliers outside Wales. However, the SWOT shows that demand is increasing and capacity is limited within Wales. A new DC providing a suite of services has since opened in Newport, early 2008, following this study. This is understood to be the largest DC in Europe, creating up to 100 jobs over time. The total requirement within Wales per annum is approximately £236.5k, based on eleven sample companies from two sectors. Five companies use in-house solutions for DR. It would appear whilst DR/DC/BC may have been a SCV, this is no longer the case. Therefore, a local supplier could be found, if sought (e.g. Rothschild, 1974) and suitable in terms of the priorities demanded by customers (e.g. Simpson *et al.*, 2002; Varmazis, 2006; Day, 2002, Heriot, 1996). However, competition may mean that prices are too expensive or that service levels demanded by customers are not met locally (Crone, 2002; Turok, 1993). Of the 11 companies identifying a requirement for DR/DC/BC, 9 make the purchasing decisions on site in Wales.

RESEARCH LIMITATIONS

Limitations include the centricity of the study region, the focus on priority sectors thereby ignoring others, the lack of available data on all sectors, reliance on WAG data which was incomplete or out of date. These were countered by consulting other RDAs regarding SCV problems, using the literature where possible to source data to triangulate that from WAG and the Office for National Statistics (ONS) and updating company data using their web sites.

PRACTICAL IMPLICATIONS OF THE STUDY

The WAG now has detailed information regarding SCVs in this sector, why they exist and how they may be addressed plus the PhD research has aided the development of a framework for potential use by WAG.

CONCLUSIONS, CONTIBUTIONS AND FUTURE RESEARCH

In addressing the research question, the study concludes that although there are perceived SCVs in this sector in Wales, capabilities exist within the region. However, such suppliers are not being selected by Welsh customers owing to the nature of the search carried out or by contingent requirements such as SC priorities, for example. Contributions include the addition of a study into the service sector at the firm, micro level, regarding specific material linkages and the resulting development of a framework for potential use by the WAG. Future research into SCVs could investigate other sectors in other regions whilst applying the proposed framework.

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SUPPLY CHAIN MANAGEMENT: HOW TO STEP FROM LEAN TO BEYOND-LEAN APPROACH

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ABSTRACT
In this paper we analyse the Beyond-Lean paradigm as a way for companies to face turbulent environment. The most important strategic drivers are depicted as a starting research point to support companies in the implementation of a dynamic model to improve their performance working in networks for the production of high-value-added products to face current market competition.

INTRODUCTION
The Lean approach has been applied in many different sectors as a methodology to improve company performance. In this paper, the Lean Approach is further discussed integrating the principles of the "Beyond lean" where agility and adaptability of the systems are gaining importance, where product and services have to be designed together, where value originated by the supply chain is more important than the single company (Zajac et al., 2000), (Gunasekaran, 1999), (Sharifi, 2001).

In this work we have used these principles for the consumable products and in particular the footwear sector was analysed to understand how the performance of shoe companies can be improved with a new approach to production. The footwear sector is characterized by volatile product demand with a short time-to-market and time-in-market of product (Fornasiero et al, 2008). Shoe producers need to quickly plan production since completely new models are to be put in the market every 4-6 months. Moreover the sector is characterized by a long supply chain where for each tier level many actors have to collaborate together all along product implementation (from design to production to delivery).

The most important actors in the supply chain have been investigated in order to have the view not only of the shoe producer as the main tier of the supply chain but also its suppliers to extrapolate the synergic points on which to work to improve the performance of the whole system.

After analysing the company structure with the Value Stream Mapping methodology the most important logistic inefficiencies have been identified and the organizational drivers for improving the whole system have been proposed (Fornasiero et al., 2008). The result of the research is based on a Future State Mapping where many different opportunities can bring the supply chain to a new scenario where performance indicators on time reduction, service and quality level both from suppliers and to customers are considered.

MOST IMPORTANT FINDINGS
Innovative Lean principles have to be defined to attain high flexibility and efficiency, addressing radically new ways to organize production according to process orientation and streamlining. New organizational methods supported with technological innovation are needed to produce very differentiated products to allow a low level of WIP, short response time and low cost. Also in footwear sector, companies do not control only cost categories but also quality and service level. Most of the time supplier selection is based on the service he provides more than on the cost of the components. The analysed

companies are part of an industrial cluster producing high quality shoes mainly for the luxury market.

In this scenario, besides new processes and tools for product design, a new framework for process re-engineering is necessary to:

- specify the reference processes to be addressed;
- define new production concepts encompassing new and flexible production systems without taking over productivity;
- define requirements for methods and tools to support the efficient design of these production systems and processes.

The final objective is to achieve a practical and affordable process engineering framework to allow a large number of shoe companies to adopt new, flexible and beyond Lean production systems.

In the table below a short summary of the most important means to pass from Lean to Beyond Lean is depicted. This is the results of important findings reported in (Westkamper, 2007), (Jovane et al.,2008), (Carpanzano et al., 2008), (Ashall et al., 2002).

Lean	**Beyond lean**	**Tools and methods to be implemented**
Single company	Network and supply chain	Real time transparency of the supply chain
Focus on production (Gemba)	Focus on all company processes	Flexible and adaptive production Integration between the different processes from design to production to sales to disposal
Flexibility of the production flows	Production independent on the production volumes and complexity of the models	Efficiency and agilty in the management of small production lots. New logitistics paradigms Advanced systems for the order management
Process driven	Product /process life cycle	Flexible network configuration Integrated product design with customer
Focus on products and on value flow	Focus on Integrated product-service systems	Integration of services to physical products for customer care
Reduction of costs to increase profits	Focus on added value as tool to improbe cash flow	Innovative Strategies to manage mature products, innovative strategies for high value products
Continous improvement	Continuous improvement supported by technological innovation	Advanced production system High tech Products

TOWARDS A REFERENCE MODEL FOR SUPPLY CHAIN MANAGEMENT IN THE TURBULENT ENVIRONMENT

In this context, companies need to use dynamic networks as a means to be flexible. Dynamic networks are based on temporary partnership between different actors of the value chain according to the principles of Virtual enterprise to maximize the value to be added to the final product.

The dynamism of the market and the fast changes in the customers requirements make fundamental for companies to be flexible with a strong capability of partnership creation and management.

Sometimes establishment of collaborative schemes is yield difficult due to problems of trust, system integration and organizational management of the partnership.

Setting-up such an infrastructure has to be based on the reduction of engineering effort for creating it, which represents a major obstacle for the implementation of this organizational paradigm expecially in SMEs context.

The approach to dynamic networks is based on a roadmap that should guide companies through the process of implementing periodically new partnerships, designing co-operation process with the support of a web platform. When companies need to establish supplier relationship the first step to consider is Trust Building: the concerns to the dynamic networks has to be mutual for all companies but it can be more difficult than in other contexts due the temporary kind of relationships.

Companies need effective methods and tools to create, manage and dissolve networks all along their lifecycle. In the footwear sector, most of the times the network is based on non-hierarchical relationship because matrix of reciprocity shows that, in most of the cases, producers and suppliers are at the same level of capability to influence /be influenced by the behaviour of the partners. Assimetry of information is reduced and collaborative game is more fruitful for both the partners.

Methodologies and tools should promote and enhance collaboration supporting partner identification and selection, network set-up and configuration, product design and manufacturing, supporting innovative forms of distributed decision making in aspects such as capacity management, optimisation of production resources and logistics management.

For most of SMEs in the footwear sector the implementation of a decision support tool as a stand alone system which internally control and plan production can be too much time and resource consuming, and since most of SMEs are working in large Supply Chain, a web service available all along the tiers of the chain can help the system to go beyond lean production integrating concepts of real time monitoring and co-planning. The system should be based on:

- Definition of performance indicators for supplier selection to assess subcontractors in terms of quality, service and costs. Definition of suppliers means definition of the "nodes" of the graph to be created (manufacturing, assembly, distributors).

- Definition of criteria to assign orders to subcontractors. Criteria need to be defined not only in terms of capabilities but also in terms of compliance to past goals.

- Once defined the nodes it is necessary to define the "relations" (logistics) between actors defining how and with which frequency they have to collaborate.

- Definition of a planning production system to manage outsourcing activities and definition of routing and distribution rules.

- The system needs to be completed with real time monitoring where suppliers and producers coordinate their work in a synchronized way.

Both increasing the speed in information exchange and introducing automatic tools for evaluation procedures can support companies in decreasing time to deal with assembling decisions and improving accuracy of data and information. The idea is to establish an automated determination of the logistic processes and candidates.

The implementation of such a system needs to be managed by an external enabler like a service provider, which does not take or support decisions at local level but guarantee performance and update of the system periodically at global level. In a sector like footwear such a role can be played by cluster manager. Industrial clusters are mostly managed by associations or entities with the role to promote innovation among the companies. In some cases they also provide advanced services for the implementation of advanced ICT systems so that SMEs can share costs of implementation avoiding waste of internal resources.

CONCLUSION

The increasing of global market turbulence and the high demand volatility are two of the main characteristics of the footwear industry, but are increasingly becoming the defining characteristics of labour intensive fast moving consumer goods industries. The lean strategy, with its focus on waste elimination, is mainly used for functional products, with a predictable demand pattern and a long life-cycle. In the case of innovative items with very short lifecycle it is necessary to go beyond lean paradigm with agile strategies to react speedily to a volatile demand. The use of a system of sourcing based on product assembly postponement and fast reconfiguration of the entire supply network are some of the practices that allow producers to achieve the required speed to market. Agile supply chain management needs to be based on the fact that the more turbulent the environment and the more uncertain the decision making, the greater the need for strong strategic relationships which need to configure time by time the supply chain according to specific and temporary needs. When there is no dominant partner, supply chain optimisation decisions is based on symmetrical distribution of information, inventory and, ultimately, bargaining power between the parts. This can be guaranteed only with the implementation of a platform where all the partners have access to shared information on the system.

The conceptual model is based on the fact that relations between participating companies are non-hierarchical and that the decision making processes are totally decentralized. Individual companies must be able to find and receive the commitment of the required partner companies (in terms of competencies and available capacity) to respond to all potentially interesting market opportunities they are aware of in real time. Next steps will be mostly focused on the design of the communication mechanisms among the actors and definition of the criteria for prioritisation of suppliers to be implemented in a supplier management platform.

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SUPPLY CHAIN AND LOGISTICS APPROACHES TO SERVITIZATION IN THE AEROSPACE MANUFACTURING INDUSTRY: A CASE STUDY APPROACH

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ABSTRACT
In industries such as aerospace manufacturing, some companies have pushed SC integration to the highest level, operating their SCs in a highly collaborative fashion. By forming Extended Enterprises, aerospace companies aim to differentiate themselves, reap the benefits of reduced lead times and costs and enhance collaborative development of new products and associated aftermarket services. As a result, leading Original Equipment Manufacturers (OEMs) have offered a hybrid leasing option, where instead of purchasing, the customer pays for use of the product per hour of use. This servitization-based approach creates an integrated product/service mix that has to be supported by the SC network, imposing a novel set of challenges on both the upstream and downstream aspects of the Logistics function: indeed, lead times for maintenance processes and associated aftermarket component supply become key issues for success of the business model. With the help of a case study, this paper explores these issues and develops understanding of the SCM and Logistics challenges in delivering such integrated offerings.

The case company is a leading manufacturing OEM in the civil aerospace industry and a market leader in the hybrid leasing offering within its sector. Interviews with key SC and Logistics managers in the company provided primary data. The purpose of the paper is to explore and evaluate the logistics approaches currently followed within the case company, and to indicate the challenges and opportunities faced in terms of Logistics when a company operating within a highly integrated global SC develops new service offerings.

Keywords
Servitization, Logistics, Supply Chain Management, Aerospace Industry

INTRODUCTION
Traditionally, a strong divide in management theory and research has been that between product and service industries. The first was associated with the manufacturing of tangible offerings, and the latter with the provision of intangible offerings. Accordingly, a great number of the published management literature has focused on developing of understanding relevant to either manufacturing or service organisations. That view was to some extent empowered by economic research focusing on the debate around the fundamental principles of the stage-theory of development for national economies (see, for example, Katouzian, 1970). Nowadays, that perspective has been further expanded, and the rapid shift of developed and developing economies from manufacturing-based to predominantly service-based economies is being attributed to the globalisation of the markets and the development of the Information Technology (Barrett and Davidson, 2008).

THE EMERGENCE OF SERVITIZATION

The terms Supply Chain Management (SCM) and Logistics have often been confused and perceived as overlapping (Lummus *et al*., 2001) or even synonymous (Lysons and Farrington, 2006), while early attempts to define SCM focused on the flow of material and information. Logistics coordinates the flow of material and information across the Supply Chain (SC) making it an essential trigger for SCM (Harrison and Van Hoek, 2008), but today it is usually considered as a subset of SCM. For example, the Council of Supply Chain Management Professionals (CSCMP) states that the scope of SCM "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities" (CSCMP, 2009).

Consequently, SCM has been defined as "the systemic, strategic coordination of the traditional business functions within a particular company and across businesses within the SC, for the purposes of improving the long-term performance of the individual companies and the SC as a whole" (Mentzer, 2000). Nevertheless, there have been recent debates and various propositions have been advanced, as to whether SCM and Logistics constitute sub-sets of one another, co-exist or whether SCM simply constitutes a re-labelling of Logistics (Larson *et al*., 2007).

In industry sectors such as the aerospace manufacturing, some companies have pushed SC integration to the highest level, operating their SCs in a highly collaborative fashion. By forming Extended Enterprises, aerospace companies aim to differentiate themselves, reap the benefits of reduced lead times and costs, and enhance collaborative development of new products and associated aftermarket services. The EE extends beyond the traditional company boundaries. By integrating customers and suppliers, and sometimes even former competitors, it networks their activities and, by focusing on the product value chain, it takes responsibility for the entire product life cycle (Browne *et al*., 1996; Browne and Zhang, 1999; Browne *et al*., 1995).

In fact, the EE views the entire manufacturing system (from end suppliers to end customers) not as a sequence of interlinked value chains, but as an element of one 'EE-wide' value chain (Browne *et al*., 1996). Therefore, the EE is an advanced form of SC, or a development of the SC concept, which extends the notion of SC integration (see also Davis and Spekman, 2004) based on a philosophy in which member organisations strategically combine their strengths, i.e. core competencies and capabilities, to create new unique competencies.

The EE has recently been defined as "the entire set of collaborating companies, both upstream and downstream, from raw material to end-use consumption, that work together to bring value to the marketplace" (Davis and Spekman, 2004).

In our view, Logistics is primarily associated with the coordination of the flow of material and information across the SC, and is a subset of SCM. Nevertheless, the growing importance of servitization and enhanced product maintenance requirements have brought new Logistics challenges and enlarged the scope of the Logistics field, making it an essential competitive factor. Servitization, a term introduced in the late 1980s, can be defined as the process of creating value by adding services to products (Baines et al., 2009). As Oliva and Kallemberg (2003) suggested, there are three main arguments in favour of integrating services into the product offerings:

- Economic arguments, deriving from the significant and fairly stable revenue that can be generated based on products with long life cycles, considering that services have higher margins compared to products and are resistant to economic cycles.

- Customer arguments, deriving from the demand from the customer side for more and specialised services.

- Competitive arguments, deriving from the nature of the service offerings, being less visible and difficult to imitate, constituting therefore sustainable sources of competitive advantage.

The growing importance of servitization and enhanced product maintenance requirements have brought new challenges for aerospace manufactures, making service offerings a vital competitive factor for growth or profitability protectionism (Slack, 2005). As a result, leading Original Equipment Manufacturers (OEMs) within the aerospace industry offer a hybrid leasing option, where instead of purchasing, the customer pays for use of the product per hour of use (Slack *et al*., 2004; Slack, 2005).

This servitization-based approach in the aerospace industry creates an integrated product/service mix that has to be supported by an integrated SC network, imposing a novel set of challenges on both the upstream and downstream of the SC and the Logistics function: indeed, lead times for maintenance processes and associated aftermarket component supply become key issues for success of the aerospace EE. According to Slack (2005), through the enhancement of service aspects associated to their offerings, product manufacturers are seeking either to grow or safeguard their profitability. Indeed, to appreciate the reason behind the servitization of manufacturing industries such as the aerospace industry, many aspects have to be put into perspective.

With a small customer base of approximately 500 customers worldwide (Smith, 1997), the aerospace industry's products have long life cycles (15 to 40 years) that require intensive technical support throughout. Due to the high costs involved in new product development and the associated risks, the industry has been traditionally dominated by collaborations – vertical and horizontal partnerships – and joint ventures (Smith, 2003). To cope with all these dynamic parameters, the need to establish strong collaborative SCs has been a central focus in aerospace manufacturing.

Effective use of supplier knowledge and capability is seen as a differentiation factor between product development projects in this particular industry, and it is anticipated that as the result of the shifting of SCM responsibility down the SC, there will be a greater need for supplier integration (MacDonnell and Clegg, 2007). Jordan and Lowe (2004) argued that high Research and Development (R&D) and product development costs encourage companies in the aerospace sector "to share risks and revenues in order to avoid 'betting the company' situations in which the failure of a new product can cause the company to fail". Within this framework, aerospace companies utilise the form of the EE, sharing risks and rewards, and, in addition, aim to servitize their offering in order to cope effectively with the dynamic market situations on their SC downstream side.

RESEARCH METHODOLOGY

A case study approach was employed to perform an in-depth study of the behaviour and approaches of a single large company, and a "study of singularity into particular events" (Bassey, 1999). The case study research strategy was considered appropriate as it focuses on understanding the dynamics present within a single setting and generates theory (Eisenhardt, 1989), within real-life contexts and settings, and tests views directly in relation to phenomena as they disclose in practice (Flyvbjerk, 2007). Participants in the research were senior, middle and operational managers in the participant organisation.

Semi-structured interviews provided the main source of primary data, and in order to avoid conducting the case study at an abstract level, a clearly defined and structured Case Study Protocol guided the researchers through the inquiry. Analysis of the interviews was then undertaken to identify the Logistics challenges imposed on the participant organisation from its transition to a predominantly service-based business model.

THE CASE COMPANY

The case study company is a leading global Original Equipment Manufacturer (OEM), which is pursuing a differentiation strategy, aiming at offering both innovative products (in terms of performance and environmental issues) and innovative aftermarket services. Due to the long lead time and the high cost involved in product development, the company has partnered with suppliers, adopting the EE paradigm for its upstream manufacturing operations, which is now extending to its service offerings to customers. In an attempt to simplify its SC, on the upstream side the company has reduced its supplier base and offers long-term contracts to partnered suppliers in the form of Risk and Revenue Sharing (RRS) partnerships. RRS constitutes a form of partnering in which the company and its suppliers contract to share both risks and rewards throughout the production and marketing phase of the product developed, allowing for high transparency among the RRS partners. On the downstream side of its SC, the company is a market leader in servitizing its business model, offering to its customer a hybrid leasing option for its products per hour of use.

FINDINGS AND DISCUSSION

Fan *et al*. (2000) argued that the aerospace OEMs are not the vertically integrated companies they used to be, as their suppliers fulfil diverse roles and have diverse levels of responsibility, providing around 70 per cent of an OEM's product. This is a view that is confirmed by this research: the subject OEM makes physically in its factories only 30 per cent of the products delivered, with the remaining 70 per cent coming through external sources. Therefore, the tasks involved in meeting essential commercial objectives such as meeting customer needs, cost reduction and product improvement, etc. extend beyond the OEM's company boundaries. As one of the participant managers stated, the collaboration within this context goes beyond the "this is what we want, deliver it".

Apart from the dynamic and cyclical nature of the aerospace industry (IATA, 2008), the high competition with other OEMs and the very high developmental costs associated with the products manufactured by the company, the OEM has to deal with the very long SC lead times. Because of the nature of the materials required, there are cases where the OEM has to give 2 years notice to its suppliers about required materials, parts and sub-assemblies. Although the company's manufacturing SC is long in terms of lead time, its options for suppliers are complicated, and in occasions restricted, by regulation, certification and capability barriers, which guide the company's options for sourcing and outsourcing. In addition to that, the company has to deal with a constantly changing issue of cost, which is affected by environmental forces (e.g. fluctuations in material prices and pressures for reduced product prices).

Maintenance, repair and overhaul (MRO) of airframes and products is a major and growing business worldwide. Indeed, aftermarket support now accounts for a significant portion of revenues in the aerospace industry: about 50% in the case of our OEM. As discussed earlier, on the downstream side, the OEM offers an innovative differentiated service to its airline customers, in which customers do not purchase products from the range offered by the company, but lease the products and pay for their use by flight time. Offering the service at a fixed leasing cost makes it attractive to the customers, as they can avoid the initial cost of purchasing the OEM's products. This approach offers further customer advantages, as by outsourcing MRO activities, airlines can dispense with costly in-house maintenance facilities. In addition, the product can be more readily monitored and maintained by the OEM itself, thus ensuring ongoing performance and safety. Here too, innovative EE partnerships are being developed to facilitate aftermarket MRO and Logistics for the OEM's products. For example, to enhance their service offerings, the OEM moved into establishing a network of Joint Ventures (JV) to enhance the network of MROs around the world.

As one of the respondents stated, the introduction of the leasing service was a competitive move based on the company's collaboration capability: "Here is something we can do, we have the skills to do it, then we do it as a new service" as he stated. Because of the OEM model, and the limited profit made, the company had to capture the aftermarket in order to increase its profits. Another participant added that that, "this justifies the company's appetite to undertake so much risk". Essentially, the product leasing service that the OEM offers transforms it from a predominately 'product company' to a 'service company'. It was acknowledged by all the interviewees that the OEM was able to achieve this transformation based on the collective capabilities of its collaborations within the EE.

One of the main advantages of this transformation indicated by the interviewed managers was that this way, the company's management shifts its focus from estimating to planning, which is a big advantage for the OEM in terms of inventory and thus costs. Planning the business means that 'speed' is not the key issue anymore, and that allows a reduction of structural costs. In addition, apart from helping put a stop to the spares 'black market', this form of service was considered by the interviewees as a protection mechanism, which 'locks' the customer into the OEM. As one of the respondents stated, the leasing service "can offer stability in terms of what you need", offers advantage in terms of competitive position and strengthens operational effectiveness aspects through this stability.

The service mix enhancement means undertaking the whole maintenance of the product. As a business model, this offering has been based on the assumption of the products being extremely reliable: this suggests a high degree of predictability in when the product will require servicing, as well as the associated cost of servicing. For the OEM, although the company is approximately aware of a schedule of work (hence can predict the service attributes that will be required to be planned), the company also performs constant monitoring (much of it remote and automated) of individual performance product. Essentially, this means that the company can schedule parts and hold the appropriate inventory, which results in reduced costs and downtime. The customer finds this offer appealing and he is willing to pay a premium for what is, essentially, a 'predictability' offering, due to the guaranteed cost stream for the product/service mix, allowing for accurate planning. In other words, this enhancement offers significant operational and financial advantages to both parties, and it was suggested that it impacts positively on both parties' profitability.

All participants to the research agreed that the concept of moving from a product-based to a service-based organisation is seen as a necessity, as the company generates over 50% of its turnover from services. In fact, as an indication of their strategic importance to the OEM for success in the aerospace industry, the service offerings are treated as a separate business, and not a simple aspect of the manufacturing business, with its own member of the board and strategists. Nevertheless, the servitized business model imposes great challenges for the company, and it is customised depending on the customer. Issues to be considered in the customisation process are the MRO level that will be required, which depends on several factors, such as company specific characteristics (e.g. duty cycle of the aircraft) or geographical characteristics (e.g. in the Middle East the desert sand may impose more frequent maintenance compared to the Scandinavian region). In addition, although the OEM tries to push all of its business towards the leasing service offering, for a customer that wishes to retain MRO capability, therefore not demanding the full servitized offering, the OEM can customise the product/service mix accordingly.

Nevertheless, in relation to the Logistics function, it was suggested by the participants that Logistics was not successfully assessed in this transition to the servitized business model. For example, in one of the hybrid leasing offerings with an airline based in the same country as the OEM, one of the contract clauses required the OEM to deliver a replacement product within 12 hours. On initial study, this clause was thought to be readily achieved: the OEM holds a stock of replacement products, it can arrange for the transportation, dispatch the product, and the distance is not great in order for the 12-hour clause to be easily met. Unfortunately, there were practical logistics issues that made this clause unfeasible: for example, the police escort required when transporting products by road needed 48-hours notice, and did not allow the OEM to transport its products during rush hours. In addition, the OEM needs to make arrangements to have the appropriate transportation fleet and drivers available at all times (considering that every driver was required by local regulations to have regular driving breaks).

Hence, although the OEM had reserved products to cover for eventualities, had stocked sufficient spare parts to support its maintenance plans and had located well-scheduled MRO facilities around the world, transportation considerations imposed challenges to the company's response and despatch capabilities. Eventually, as suggested by the participants, the important questions in relation to being able to provide the product/service mix are whether the company has an adequate transportation capability and how long it is going to take to deliver and fit the product or spare parts for the customer. Nevertheless, due to these unforeseen factors, in many cases the OEM could not achieve the contractually delivery agreements, paying agreed financial penalties for late delivery. Similar practical considerations occur in the air transport of products and spares to more remote MRO facilities. For new contracts these logistical factors have now been taken into consideration to establish realistic delivery times.

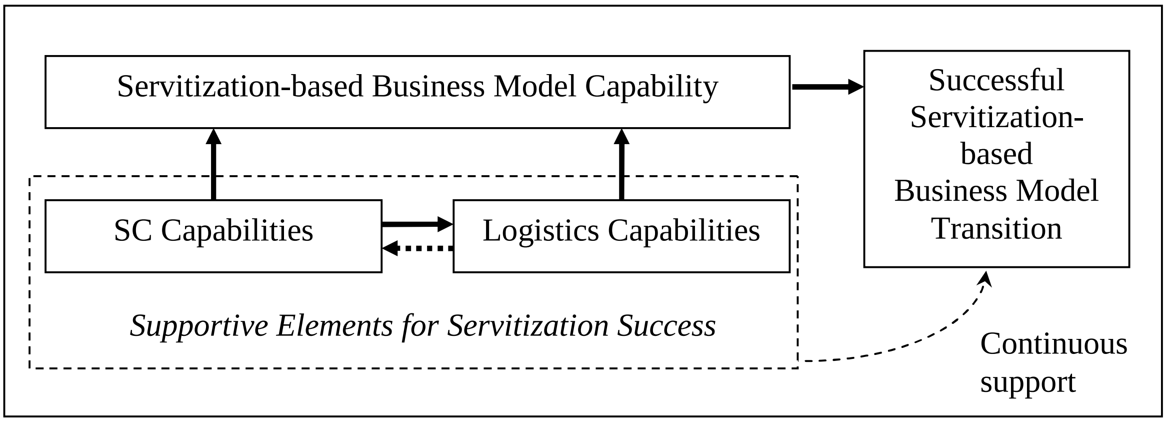
A further area of interest is in the move to closed-loop reverse SCs that have accompanied the increased servitization. The OEM has set up dedicated repair, refurbishment and overhaul facilities for its own products, which it continues to own and lease to customers. At the time of writing, 17 sites (some joint ventures) around the globe employed approximately 8,000 people in this area. For current products, the demand for new components from these facilities can impact on new-build orders to upstream SC partners, who may have capacity limitations. In addition, as some components are refurbished by SC partners, the OEM engages in further upstream reverse SC activity. This reverse SC activity adds considerable complexity to company SCM, compared with earlier periods when the OEM simply stocked spares for customers to purchase and use in their own MRO facilities. Much of the logistics effort for the global distribution of components, etc., has been outsourced to third-party logistics (3PL) partners with integrated IT systems who employ staff co-located with OEM staff in their SCM offices.

The servitization approach has had a positive impact in terms of warehousing and inventory levels for the OEM, and in particular the safety stock of products that the OEM maintains. In the traditional product-based model, an airline would purchase 'spare safety stock' from the OEM to allow for exchange before maintenance of the already installed products in the aircraft. With the new business model, the OEM keeps that stock and leases items interchangeably to most of its customers. As a result, on an aggregate basis considering all customers engaged in the hybrid leasing offering, the OEM has to maintain a lower safety stock for all customers sharing the same product compared to the sum of those products if they were purchased and reserved by each individual customer. It was suggested by interviewees that this results in a win-win situation for the OEM and its customers: the OEM generates more profit per safety stock product by leasing them interchangeably to the airlines, and each customer will be able to avoid both initial payment and stockholding costs for spare products.

In the case of spare parts stock, planning with some degree of predictability is essential as well. With more companies participating in the hybrid leasing offering, the safety stock of spare parts for supporting the OEM's products is predictable as well, and the company can now maintain stock levels on a consolidated basis for its customers in strategic airport hubs for them to be available (i.e. for all airline customers using that airport). Therefore, the servitization-based model planning has resulted in enhanced anticipations of the total inventory in the SC, making operations and the Logistics functions more effective along the entire SC.

Consequently, as illustrated in Figure 1, based on our research findings, there is evidence to suggest that in the aerospace industry, SCM and Logistics are being treated as different and complementing domains, and have both significant, but different effects on the servitization-based business model. In particular, the SC capabilities were considered the absolute prerequisite for the OEM to decide the transition toward the servitized-based model. Nevertheless, the success of the servitization-based model was largely depended, and in fact was hindered in cases regarding our OEM, by the Logistical aspects of the SC, and more specifically the practical and realistic planning considerations and contractual arrangements for the Logistics function. The practical Logistics issues to cope with would affect, in return, the SC capabilities, as they would demand to consider SC capabilities issues, such as the upstream reverse SC activities and their possible outsourcing.

Figure 1: The Interaction between SCM and Logistics for Successful Servitization



CONCLUSIONS

This paper has aimed to explore and evaluate aspects of the Logistics approaches currently used by a civil aerospace OEM, and to indicate some of the challenges and opportunities faced when operating within a highly integrated global SC as it develops new service offerings. In that perspective, the paper has indicated Logistics practices and challenges that an OEM faces and attempted to explore their impact on the company's performance. In that respect, the paper aims to assist our understanding of important Logistics aspects to be considered in a servitized manufacturing company, and their impact on cost and business performance. Further research will focus on incorporating other members of the OEM's SC partners and explore the Logistics challenges imposed on the upstream side of the SC to support the servitization business model.

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SECTION 2 – Supply Chain Inter-Firm Networks and Collaboration

AN OPERATIONAL PERSPECTIVE TO BORDER MANAGEMENT REFORM

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ABSTRACT
Purpose: Border management reform and trade facilitation are topics of growing interest in international trade policy, development aid, trade and customs moderations, and supply chain security. Much of the international debate is focused on the implementation of international trade facilitation recommendations and instruments. This paper introduces the operational perspective as an alternative source for border reform stimulus.

Design / approach / methodology: The paper builds on the author's first hand practitioner experience as Deputy Director at SITPRO (the UK trade facilitation agency) and Secretary at EUROPRO (the umbrella body for European trade facilitation bodies). It also integrates various pieces of commissioned work and academic research by the author into one concept paper.

Findings: The author argues that despite the current policy momentum, the interests of actors, institutional limitations, and lack of knowledge constitute formidable obstacles to border management reform.

Research limitation / implications: Although border management reform and trade facilitation are now established agenda items in trade and customs policy circles, the topic remains under-researched. The paper hopes to raise awareness about the topic and stimulate academic enquiry.
Practical implications: Active academic enquiry can help overcome the lack of knowledge, one of the main obstacles to border management reform and trade facilitation.

What is original / value of paper: The paper proposes an operational perspective to border management reform, which currently is predominantly described in terms of international trade facilitation recommendations.

Keywords: Border management reform, trade facilitation, operational perspective

CONTEXT
Over the last few decades the nature of international trade operations has changed by leaps and bounds. Innovations in transport, information and communications technologies as well as the liberalisation of trade tariffs and finance have brought to life a global production structure (e.g. Dicken 2003) that is highly dependent on international trade operations. This trend firmly places cross-border operations at the centre of supply chain management (Grainger 2007). A frequent complaint amongst businesses – when interfacing with regulatory authorities at the national border – are excessive documentation requirements, lack of use of information technology and automation, lack of transparency in requirements and objectives, inadequate procedures and operating practices as well as lack of modernisation. Trade compliance costs, when compared to falling tariff levels, increasingly appear to be disproportionate (Grainger 2007). Costs may be directly attributable to collecting information and submitting declarations, or an indirect consequence in the form of delays and associated time penalties, forgone business opportunities, and reduced competitiveness (OECD 2003).

The topic of trade facilitation is about improving the trade environment through border management reform and to achieve a reduced operational burden on businesses as well as increase the control efficiency of regulatory agencies. Topical issues include the World Trade Organisation's Doha Trade Round where, irrespective of failed negotiations, prospects for agreement on trade facilitation remain strong. Linked to GATT Articles V, VIII, and X – covering the freedom of transit, fees, and formalities as well as publication and administration of trade regulations – trade facilitation is usually viewed as a relatively uncontentious issue. The economic prize for agreement on trade facilitation is held to be high; for example, the OECD calculates that each 1% saving in trade-related transaction costs yields a worldwide benefit of US$43 billion (OECD 2003). Between 2002 and 2005, donors committed an average of US$21 billion per year on more narrowly defined aid-for-trade projects. Grants and loans to trade facilitation specific projects have increased from US$101 million in 2000, to US$391 million in 2006 (OECD and WTO 2007). Individual national and regional trade and customs modernisation initiatives – such as the EU's eCustoms initiative (TAXUD/477/2004) or ASEAN's commitment to interoperable trade systems (ASEAN 2005) – have budgets with equally high sums.

Trade facilitation has also come to prominence within the area of supply chain security, where it is generally seen as a means to soften the additional regulatory burden associated with the avalanche of new security and safety-focused regimes. In most countries a long list of security and safety-related procedures (often overlapping) can be identified. For example, in the United Kingdom, SITPRO and Grainger (2008) count a total of 37 safety and security procedures that impact on the efficient movement of goods. The more recent initiatives, such as the Authorized Economic Operator (AEO), the ISO 28000 system, the USA's Customs and Trade Partnership Against Terrorism (CTPAT), and the USA's Container Security Initiative (CSI) focus on the entire supply chain and seek to identify security risks before goods are moved. Underlying these new security initiatives is the desire by government agencies (such as customs administrations) to make efficient use of finite enforcement resources, to enhance controls at the border, and ensure that wealth-generating trade continues while extending controls up and down the supply chain (Grainger 2007).

Today, about 18 themes that define the content of trade facilitation debate can be observed [Figure 1] (Grainger 2008). Organisations such as UN/CEFACT and the World Customs Organisation, amongst others, have been particularly active in defining trade facilitation instruments and recommendations. The subsequent list of prescriptive international trade facilitation recommendations and instruments is long [Figure 2]. Bodies with a development or capacity building orientation – such as the World Bank, UNCTAD, APEC, UN ESCAP as well as numerous donors – have also actively contributed to the debate by developing or commissioning a small number of survey tools (e.g. UN ESCAP 2004; Raven 2005; Widdowson and World Bank 2007).

Figure 1. Trade Facilitation Concepts: a practitioner's observation (Grainger 2008)	
Better regulation: 1. Simple rules and procedures 2. Avoidance of duplication 3. Memoranda of Understanding (MoUs) 4. Alignment of procedures and adherence to international conventions 5. Trade consultation 6. Transparent and operable rules and procedures 7. Accommodation of business practices 8. Operational flexibility 9. Customer-service provisions for government administrations 10. Mechanisms for corrections and appeals	11. Fair and consistent enforcement 12. Proportionality of legislation and control to risk 13. Time-release measures 14. Risk management and trader authorisations **Information and communication technology:** 15. Standardisation of documents and electronic data requirements 16. Automation 17. International electronic exchange of trade data 18. Single Window

Figure 2. International Trade Facilitation Recommendations and Instruments (adapted from: UN/CEFACT and UNCTAD 2002; Grainger 2007)

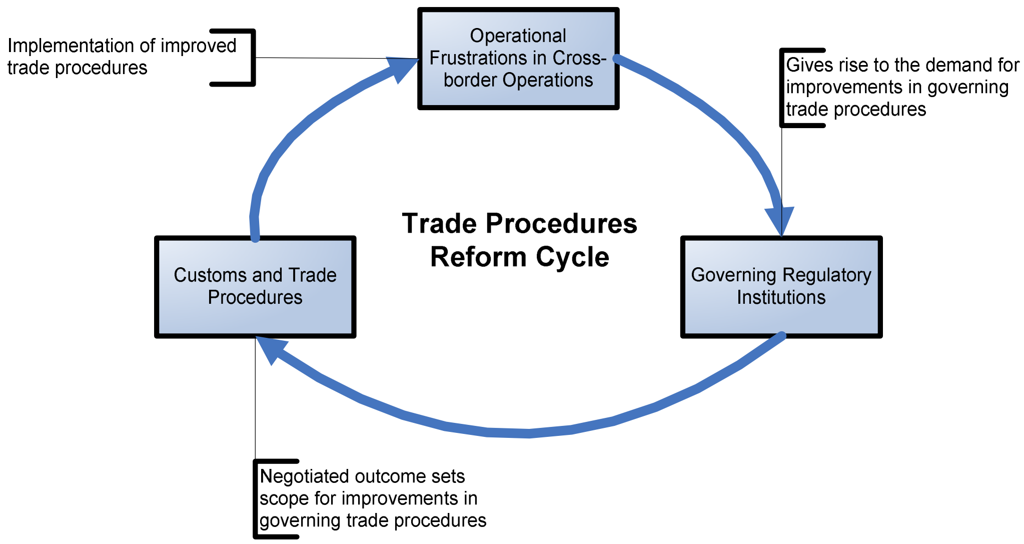
International Trade Facilitation Recommendations and Instruments
World Trade Organisation (WTO) Trade Facilitation Specific Articles: **GATT Article V** (freedom of transit), **GATT Article VIII** (fees and formalities) and **GATT Article X** (publication and administration of trade regulations) Customs Valuation: **GATT Article VII** (technical interpretation covered by the WCO) **WTO Agreement on Rules of Origin** (technical interpretation of 'non-preferential rules of origin' covered by the WCO)
World Customs Organisation (WCO) **Kyoto Convention** for Harmonising Customs Procedures; WCO Harmonised Commodity Code Descriptions and Coding System (**HS System**); Framework of Standards to Secure and Facilitate Global Trade (**SAFE**);
United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) **Rec. N°**1: United Nations Layout Key for Trade Documents; **Rec. N°. 2**: Locations of Codes in Trade Documents; **Rec. N°. 3**: Code for the Representation of Names of Countries; **Rec. N°. 4**: National Trade Facilitation Bodies; **Rec. N°. 5**: Abbreviations of INCOTERMS; **Rec. N°. 6**: Aligned Invoice Layout Key for International Trade; **Rec. N°. 7**: Numerical Representation of Dates, Time and Periods of Time; **Rec. N°. 8**: Unique Identification Code Methodology – UNIC; **Rec. N°. 9**: Alphabetic Code for the Representation of Currencies; **Rec. N°. 10**: Codes for the identification of Ships; **Rec. N°. 11**: Documentary Aspects of the Transport of Dangerous Goods; **Rec. N°. 12**: Measures to Facilitate Maritime Transport Documents Procedures; **Rec. N°. 13**: Facilitation of Identified Legal Problems in Import Clearance Procedures; **Rec. N°. 14**: Authentication of Trade Documents by Means Other than Signature; **Rec. N°. 15**: Simpler Shipping Marks; **Rec. N°. 16**: LOCODE - Code for Trade and Transport Locations; **Rec. N°. 17**: PAYTERMS - Abbreviations for Terms of Payment; **Rec. N°. 18**: Facilitation Measures Related to International Trade Procedures; **Rec. N°. 19**: Code for Modes of Transport; **Rec. N°. 20**: Codes for Units of Measure Used in International Trade; **Rec. N°. 21**: Codes for Passengers, Types of Cargo, Packages and Packaging Materials; **Rec. N°. 22**: Layout Key for Standard Consignment Instructions; **Rec. N°. 23**: Freight Cost Code – FCC; **Rec. N°. 24**: Trade and Transport Status Codes; **Rec. N°. 25**: Use of the UN Electronic Data Interchange for Administration, Commerce and Transport Standard (UN/EDIFACT); **Rec. N°. 26**: The Commercial Use of Interchange Agreements for Electronic Data Interchange**; Rec. N°. 27**: Preshipment Inspection; **Rec. N°. 28**: Codes for Types of Means of Transport; **Rec. N°. 31**: Electronic Commerce Agreement; **Rec. N°. 32**: E-Commerce Self-Regulatory Instruments (Codes of Conduct); **Rec. N°. 33**: Single Window Recommendation
ICAO and IATA (Air) IATA **e-freight initiative**; ICAO Convention on International Civil Aviation (**Annex 9**: Trade Facilitation); "**know shipper/known consignor**" concept
International Maritime Organisation (IMO) Convention on Facilitation of International Maritime Traffic (**FAL**); Safety of Life at Sea Convention (**SOLAS**); International Ship and Port Facility Security Code (**ISPS-Code**)
Other International Organisations UNECE: Working Party 7 looking after **agriculture quality standards**; UNECE and IRU: **TIR** (Road Transit) Convention; **ISO**: countless product and quality standards; ICC: **Incoterms** (standardised trading terms used in international trade); ICC: Uniform Customs and Practices for Letters of Credit (**UCP**); ICS: **Standard [shipping] Manifest** Report and Recommendation; ICS: Standard **Format of Bills of Lading**

AN OPERATIONAL PERSPECTIVE TO BORDER MANAGEMENT REFORM

The majority of international recommendations and instruments reflect international consensus on what is best practice. Much of the focus is on harmonisation and modernisation in the trade environment. However, significant elements of operational frustrations are likely to have local and national origins. These are unlikely to be adequately addressed by international recommendations. For example, operational frustrations might relate to how a particular inspection facility manages its queuing system or the manner in which a particular customs office handles paper and electronic documents. Border management reform thus extends significantly beyond implementing international recommendations and instruments. To this effect, Andrew Grainger proposes the Trade Procedures Reform Cycle (Grainger 2007), where operational frustrations give rise to demand for reform as opposed to "top-down" dictates from central government policy makers.

To enable such operational-driven improvements to take hold in policy consideration, suitable institutional arrangements between business and government stakeholders are an essential reform ingredient. The UK example, which has an active public consultation culture, shows some of the vehicles that are available in fostering the exchange of views between business and government stakeholders. These include: dedicated trade facilitation consultation vehicles (these bring together all stakeholders to explore scope for reform), departmental consultation vehicles (e.g. monthly meetings between customs executives and business stakeholders), arms-length consultation approaches (e.g. in the form of published invitations to respond to a regulatory initiative), assessment and research-driven consultation approaches (e.g. a sustainability or regulatory impact assessment), and informal consultation approaches (e.g. in the form of workshops, breakfast meetings and information collated from executive officers operating helplines and similar front-end services). Each one of these vehicles has its own qualities. Unfortunately, a full discussion goes beyond the parameters of this paper but is provided by Andrew Grainger (2009) in the World Bank's forthcoming Border Management Reform Handbook.

Figure 3: Trade procedure reform cycle (Grainger 2007)



In addition to the institutional arrangements that are in place (or might be put in place) to drive reform of the wider regulatory environment, it is also worth making reference to the vehicles employed to govern the interface between business and government stakeholders in day-to-day operations, and how they can be improved. To give an example, the traditional approach to border control can be described as one where the regulator sets mandatory requirements – for instance the legal obligation to present and declare goods. Should a trader be found in breach of set requirements, fines and criminal proceedings apply. However, the blanket enforcement of such rules and procedures is resource intensive and difficult to reconcile with growing volumes in international trade, economic dependencies on international trade to safeguard wealth, and rapidly increasing political concerns to safeguard security. International recommendations, such as the World Customs Organisation's (WCO) SAFE Framework of Standards (2007) or some of those listed in Figure 1, will therefore often stress more collaborative enforcement approaches.

Such collaborative enforcement approaches seek to encourage traders to internalise controls and free-up executive resources to target high risk areas of concern. Practitioners often make reference to the 20/80 principle whereby, for argument sake, 20% of the trade population are responsible for 80% of declarations. In many trade intensive economies this ratio can actually be significantly higher. Unfortunately, there is little published research but anecdotal evidence suggests that ratios of 5/95 or even 3/97 are not unusual. Thus, a smart enforcement strategy for government executives is to encourage traders with high volumes – the 20% that are responsible for 80% of trade-related activity – to internalise regulatory-set control objectives and free up inspection resources to focus on more risky movements.

Of course, businesses need to be suitably coerced or incentivised if they are to internalise the control burden. Depending on the countries and government executive agencies concerned, a wide range of coercive vehicles can be observed. These range from pre-specified conditions set out in official authorisations (e.g. the authorisation to operate a port facility or a customs warehouse facility) to detailed licensing requirements (e.g. set conditions stipulated when handling licensable goods such as drugs or goods with military applications). Incentive based collaborative vehicles can include the preferential treatment of a specific operator (e.g. less inspection or access to advantageous fiscal treatment) and simplified procedures (e.g. allowing goods to be cleared at the trader's premises instead of at the port, or by allowing the payment of import duties on a monthly basis).

OBSTACLES TO BORDER MANAGEMENT REFORM

There are many obstacles to reform, which can be difficult to overcome. These can be attributed to overall complexity of cross-border operations and include conflicting interests, institutional limitations, and the lack of knowledge (Grainger 2007; Grainger 2008).

The cross-border environment is a complex construct involving many different types of actors. While comprehensive research is still in its infancy, Andrew Grainger (2007) counts over 60 UK trade and customs procedures which target goods, the vehicles that move them (for example, ships, planes, and trucks), or their operators (for example, drivers, seafarers, and flight crew). These are enforced by a range of different government agencies including: customs, immigration, police, quarantine services, trading standards, port authorities, and many more. Practitioners outside of the UK will be familiar with an equal diversity of regulatory requirements. The commercial side of cross-border operations is no less complex. Typically, importers and exporters will employ a wide range of intermediaries who in turn will often further subcontract. Intermediaries commonly employed include freight forwarders, shipping lines, airlines, haulage and trucking companies, packaging companies, insurance brokers, banks, express carriers, couriers, electronic services providers, sales agents, and distributors.

Although there is a collective interest to bring down the cost of trade, improve efficiency, and increase overall competitiveness, the interests of individual actors are unlikely to be aligned. Frequently, as can be observed in the exchanges (published and unpublished) between business and government stakeholders, interests are also conflicting. Unaligned or conflicting interests tend to be found between: businesses with different types of operational requirements and capabilities (e.g. small vs. large ports, or airports vs. seaports); business interests and the interests of individual executive agencies (e.g. between control and compliance); competing government departments (e.g. Department for Transport vs. Customs vs. Immigration); competing policy priorities when bidding for budgets (e.g. transport, customs, health, or education); and between preferences for protectionists and liberal trade policies. Moreover, it is not uncommon to observe rent-seeking behaviour and vested interests. One person's simplification can easily become another person's redundancy.

Institutional limitations also form significant obstacles to the implementation of trade facilitation. At their core lies a conflict between day-to-day business operations and the institutional mechanisms that govern the trade environment. While the former is very fluid and can change from one transaction to the next, the latter is embedded within the wider regulatory regime and takes time to amend. Legacy arrangements can be equally difficult. Changes – for example through the introduction of new control procedures, amendments to declaration documents, or changes to electronic systems – can be costly to implement and stakeholders need to be convinced that the costs for migration from the existing *status quo* are justified. Another example of institutional limitations may be found in the way governments procure their IT services. Trade facilitation projects like the single window (UN/CEFACT 2004), which seek to reduce trade transaction by integrating public IT infrastructure, can potentially stand at odds with preferential supplier agreements but in place by each of the affected government agencies. For example, customs may have one IT supplier with its preferred technology and business architecture while the port authority or quarantine service might contract with other suppliers who build their electronic solutions on different technologies and business architectures. Institutional difficulties might also be found in the geographical distance between head office and the borders or ports. As argued in this paper, much of trade facilitation is about fixing operational problems. Those executive officers with direct operational experience at the borders may not necessarily be the same individuals who help shape policy at headquarters and in the capitals. Much of the details required to understand trade facilitation problems can easily go missing.

The lack of knowledge and awareness can be a further significant obstacle to regulatory improvements. International supply chains tend to be complex arrangements and vary from one company to the next. Few individuals in business and policy circles are able to take an umbrella view and expand analysis beyond the confines of their own organisations. Few research bodies have yet attempted to take an umbrella view of the cross-border environment and develop a body of knowledge that looks at the wider operational aspects of international trade or help find and implement improvements. Subsequently, policy makers have few places to turn to for substantiated research. While dedicated trade facilitation committees can be of significant help, their resources are usually very limited. For example, SITPRO – the UK trade facilitation agency which is probably one of the largest national trade facilitation bodies – has an annual budget of no more than one million pounds (SITPRO 2008).

CONCLUSION

Good supply chain management is about increasing value and reducing cost. These objectives apply equally to trade facilitation; though they may be described in terms of “effectiveness” and “efficiency” when applying regulatory control objectives. International recommendations and instruments, as outlined in Figure 2, can be powerful tools in driving forward the trade facilitation agenda and border management reform. They can also be useful vehicles for harmonising and standardising trade procedures at an international level. However, their operational roots should not be forgotten as these are likely to feed a reform agenda that is independent of any international effort. The vehicles that define relationships between public and private sector actors – be it by defining scope for reform to the wider regulatory environment or in the context of day-to-day interactions at the operational level – deserve an active consideration within supply chain management and logistics research. Moreover, in the absence of substantiated academic research, the initiation of an operations led trade facilitation research programme could significantly help build the knowledge required to overcome current obstacles in border management reform and transaction cost problems between business and government stakeholders.

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MOBILISING KNOWLEDGE ACROSS ORGANISATIONAL BOUNDARIES: ADDRESSING HUMAN ISSUES IN THE TELECOMMUNICATIONS INDUSTRY

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ABSTRACT
This paper explores how knowledge sharing and transfer occur when developing new products within the extended enterprise. The benefits of implementing Knowledge Management (KM) strategies have been proven but research to date has largely focussed on technology as a solution to KM issues. This study focuses instead on exploring the softer, human issues within KM. Working together with European-based companies and research institutions, we sought to address the gaps in KM research with respect to these human-centred issues. The results are based on interviews and workshops conducted with European managers that specifically address KM within the Telecommunications industry (TLC). The main human barriers identified were language, international differences, accuracy and reliability of knowledge, protection of proprietary knowledge, maintenance of communication channels, lack of time, fear of penalties, fear of losing profile and market position. A framework is proposed that seeks to assist in addressing such barriers in an inter-organisational knowledge management context.

INTRODUCTION
In the age of globalisation and the extended enterprise, managing knowledge effectively is becoming both increasingly complex and important. Organisations today operate in a turbulent global business environment, underpinned by variability in work practices, technology and organisational structures. This takes on more importance and meaning when one considers the challenges involved in managing the extended enterprise, with all of its associated stakeholders (Jagdev and Browne, 1998; Post, et al, 2002).
The stereotype of the concept of the all-encompassing 'quick fix' technology-focussed solution to the organisation's problems still persists. However if technology delivered all of its ambitious promises, the corporate world would be a very different place. In reality, KM initiatives have failed time and again, with both managers and employees becoming disenchanted with adopting fashionable technologies (McDermott, 1999; Weber, 2007). Although technology provides the infrastructure for change, we maintain that it is the softer human issues that are pivotal to the successful adoption and effective implementation of any KM initiative. Now that we have had time to reflect on previous successes and failures, here we investigate the issue of how to manage knowledge in the extended enterprise.
According to Nonaka and Takeuchi (1995), KM in an organisational context can be simply defined as a relational and action-oriented network of information that firms develop in order to effectively interact with their environment. Gupta and Govindarajan (2000) argue that, in addition to capital and product flows, knowledge flows across subsidiaries become particularly significant for ongoing success. The main reason for this is that compared to products, technologies and other 'hard' resources, knowledge is difficult to communicate, duplicate and hence use. Thus, those firms who succeed are able to build a reliable and sustainable source of long term competitive advantage (Adams and Lamont, 2003; McDermott, 1999). The interpretation and significance of KM has taken on such a varied platform of understanding that it is difficult (and perhaps non-sensical) to apply a generic universally-applicable definition (Jakubik, 2007; Wiig, 1997). However for the purposes of this paper, we concur with the view that the role of the human dimension is crucial to carrying out KM effectively. Technology is, in most cases, essential but the impetus in successfully implementing KM should be provided by focussing on the human-centred aspects. The extended enterprise view of the organisation that includes all contributing stakeholders (such as suppliers,

employees, distributors, governments, etc.) is increasingly being seen as the best basis for a successful KM environment (Jagdev and Browne, 1998; Post, et al, 2002). Broadly speaking the following gaps regarding research into KM in the extended enterprise remain:

- Inadequate research about the type of knowledge that trading partners are able to transfer and share in the supply chain (Jagdev and Browne, 1998; Post, et al, 2002)
- Limited information about how to train and motivate people to share and transfer knowledge and achieve a knowledge-rich culture (Alavi and Leidner, 2001; McDermott, 1999)
- Lack of an implementation framework and accompanying tools; the focus has been on *what to do* rather than how to do it (Gupta and Govindarajan, 2001; Weber, 2007)
- Lack of focus on acquiring and sharing tacit knowledge (Alavi and Leidner, 2001)
- Limited information about KM performance metrics (Bose, 2004; Liebowitz and Suen, 2000).

The researchers participated in a number of projects that provided the case data for this paper. Of particular relevance was CORMA[1], an EU project that addressed the issue of inter-organisational KM. CORMA's aim was to develop a KM environment consisting of integrated methods, tools, knowledge representation models and training materials to support the new product development process in 'Concurrent Enterprises' (Wunram, et al 2002). The key innovation in CORMA was to enhance the quality of interactions at the customer-supplier interface by developing a holistic framework and supporting toolbox to facilitate the transfer, share and use of knowledge. The industrial partners were all in the telecommunications sector, placed along different points of the supply chain. This allowed them to provide practical insights into the main barriers hindering KM in the extended enterprise in this industry.

Telecommunications (TLC) has been one of the major growth industries for over a decade, which until recently experienced exponential growth in demand for its products and services (Economist Telecoms Survey, 2007; Trebing and Estabrooks, 1995). As such it is characterised by the following features (Gupta, et al, 2007; Li and Whalley, 2002):

- TLC operates in a highly dynamic market. It has a worldwide customer base and exhibits a mass-customisation appeal.
- Time to market and product life cycles are short, with knowledge aging rapidly. We see technological innovation continually driving down costs, with quality standards being simultaneously raised.
- Products are heavily regulated with all 'active' devices requiring type approval by the relevant governmental standards offices. Manufacturing aspects are hybrid in that some features are dependent on highly skilled people and some are totally automated. Overall production is flexible for high volumes and predominantly capital intensive.

In an industry defined by information and characterised by competition, in order to survive and prosper, TLC companies must find ways to utilise their knowledge assets to maximum effect. In other words, knowledge from many different domains is needed, knowledge ages rapidly and a high degree of knowledge protection is required. It is these characteristics that make this industry particularly suitable for a study on knowledge management.

OBJECTIVES

Acknowledging that KM is a vast area that covers many aspects of business operations, it is important to drill down further. Thus the authors have made a clear split down the middle of KM differentiating between inter- and intra-KM. As implied, intra-organisational KM represents the management of a company's knowledge within that company and inter-organisational KM is the process of managing knowledge between companies. As we had interview access to four

[1] CORMA: Practical Methods and Tools for the Corporate Knowledge Management: Sharing and Capitalising engineering know-how in the Concurrent Enterprise.

companies, we have focussed on the inter-organisational KM aspects and are particularly interested in the extended enterprise. So conceptualising an extended supply chain, we have an interface whereby an OEM recognises the need to collaborate with its suppliers and customers. However this interface is often a source of conflict, caused by trust and cultural issues and confusion over intellectual property rights (House, et al, 2004; Dyer and Chu, 2000; Zaheer, et al, 1998). For example, as it can be impossible to establish ownership of one's knowledge or ideas that have been exchanged, partners fear that their original work may be divulged to competitors. This induces complacency and the prevalent attitude becomes 'do not bother to share knowledge with other companies - only share what you have to'. The goal is that project information, decisions and resources should flow freely between the trading partners of an extended supply chain. All of the companies in this study are 'KM aware' but are keen to improve their usage of KM-related activities and hence better manage knowledge flow between their stakeholders. Therefore, given that the broad aim of this study is to better understand how we manage and mobilise knowledge in the extended enterprise, the specific objectives are to:

- understand and contextualise the barriers to KM in the extended enterprise
- understand how KM transfer is measured
- incentivise stakeholders to share knowledge.

RESEARCH METHODOLOGY

Four multinational companies participated in this study, two of which were based in the UK, one in Austria and the other in Finland. All four work within the extended supply chain in the TLC sector and focus on improving new product development processes. Two have over 35,000 employees, with the other two having in excess of 5,000 employees. Owing to the collaborative relationship, a face-to-face data collection strategy was selected. A good understanding of the company's employee structure existed, making it easy to identify the best employees to target for data collection. Individual semi-structured interviews (in a private environment) and group workshops were selected as the most appropriate methods, as these provide a good opportunity to break down cultural and language barriers (Yin, 1994). Using both methods enhanced the richness of the information received and offered an opportunity to verify responses. Individuals were selected from differing backgrounds in each partner company to extend the depth and reach of the information collected.

To ensure consistency of information during the interview process, assessment areas were agreed upon (culture, structure, strategy, people and technology) and guidelines were developed. The companies provided input to ensure maximum buy-in and clarity. A total of 40 interviews were conducted (10 at each company) involving a cross section of employees including engineers, project managers, directors and product development personnel. The companies themselves assisted with the selection of relevant participants. The information was summarised and returned to the companies to enable them to evaluate it. Following feedback, the data was analysed and conclusions were drawn. A focused group workshop was then carried out to enrich the results and to provide a further opportunity for the interview results to be evaluated. A member of each company was invited to discuss the themes that had been identified from the interviews, with the researchers acting as facilitators. The evaluated results from both the interviews and workshops were then analysed together.

The data collected were analysed using the Theme Based Content Analysis (TBCA) technique (Neale and Nichols, 2001). TBCA can be broadly defined as 'a research method that uses a set of procedures to make valid inferences from text.' TBCA was applicable to this study, as the information collected was high volume and very rich in content. TBCA uses five stages to focus in on the information to highlight the main trends present in the data, without destroying the richness. These stages are: data collection, data collation, theme definition and classification, higher order theme selection and classification matrix. In content analysis, text is summarised by counting elements of text and applying a classification scheme. This allowed us to make sense of the large volume of qualitative data.

RESULTS AND DISCUSSION

The large volume of data collected entailed a complex analysis task. For ease of presentation a summarised version of the interview data collected is presented in Table 1. This example shows how the results were collated and TBCA was carried out to highlight the dominant themes.

Person (coded)	Answer to question **"how do you evaluate the knowledge and/or information that you get?**	**Raw data theme**	**Higher order theme**
P6	If it is something from a colleague it should be OK.	Believe internal company information (2)	Trust or mistrust built up through experience (15)
P11	If it is internally generated, then believe it. Question it if it is unexpected or "off the wall".		
P15	Depends on the source and type of information.	Dependent on source (1)	
P3	Based on personal experience of the people.	Experience of people (8)	
P12	Do I trust the person who sent it?		
P5	If you respect the person who gave you the information then you would think it is OK.		
P15	If market figures and other business-related information, treat suspiciously.	Wary of business information (1)	
P4	You cannot always sure with customers because they can be play you off against another supplier.	Wary of customer (1)	
P17	Externally it is hard to judge. Take it at face value, and investigate. Don't ignore something just because you don't think it is reliable.	Wary of external information (1)	

TABLE 1 – EXAMPLE OF RAW DATA FROM INTERVIEWS AND TBCA OF THE DATA

From these tables, an indicative list of human barriers and suggested solutions was drawn up. Some dominant themes act as barriers to KM activities; fear, culture, trust and time. Fear (in all of its forms) was particularly dominant as it works on both a personal and organisational level and stems from individuals and organisations being aware of the worst-case scenarios that can stem from ineffective sharing of knowledge.

For the individual, this is losing employment and for the organisation it is going out of business. Empson (2001) outlines the major barriers to knowledge sharing and transfer. In particular, she maintains that fear of exploitation starts with the premise that 'I will only share my knowledge with you if I think you can give me something in return.'

The main barrier to sharing proprietary information with collaborators is that it leaves an organisation open to the risk that this information will be revealed, (intentionally or otherwise) to competitors. Ragatz et al. (1997) identifies the consequence of this risk as being a resistance within the organisation to sharing proprietary information with suppliers. There is the desire to protect the interests of the company, by restricting the knowledge being transferred to outside sources. However, the appropriate use of enabling technologies such as Radio Frequency Identification (RFID) can mitigate this risk.

For example, most leading supermarkets now employ this tagging technology with suppliers that enables automatic updates via a satellite link, every time stock is moved into and out of warehouses. This technological solution is particularly effective when dealing with large numbers of suppliers on a high volume transactional rather than trust-based relationship basis. Trust concerns both the receipt and the dissemination of knowledge. If an individual does not trust the information or knowledge they are receiving, they are obviously unlikely to make full use of it. Trust provides the environment for collaboration and for the sharing of knowledge (Zaheer, et al, 1998; Dyer and Chu, 2000). It is thus indispensable to the successful usage of KM systems.

The discussions during the follow up group workshops also revealed similar issues. They ended with comments for improvement potential that highlighted themes such as improvement in communication, institutional arrogance, the need for active project management and relationship management.

6.1 Overcoming Barriers – THE framework

In line with previous studies, we found the existence of human barriers in inter-organisation knowledge management to be a key barrier to effective KM. Hence, we propose a framework – shown in Figure 1 - to help to reduce the complexity of addressing and overcoming these barriers.

Barriers are categorised according to their hierarchical level and at the same time assign broad corresponding methods and tools to overcome these barriers are suggested. If the assumption is made that KM begins at the smallest hierarchical level (i.e the individual employee), the complex problem of tackling barriers can be split into manageable 'chunks' across a spectrum that starts with the employee and ends with the whole extended enterprise.

The framework is built up around this hierarchy by identifying the main activity within each level and then attaching the barriers specific to that activity. One can see that the main activity to be performed on the individual level is the *training* and *education* of each individual to enable him/her to practice KM.

The main barriers, as identified by previous research are the lack of skills and abilities (Gupta and Govindarajan, 2000; Malhotra, 2005; Zack, 1999), knowledge transfer processes (Alavi and Leidner, 2001; Weber, 2007) and, in some cases, willingness (Davenport, et al, 1996; Empson, 2001).

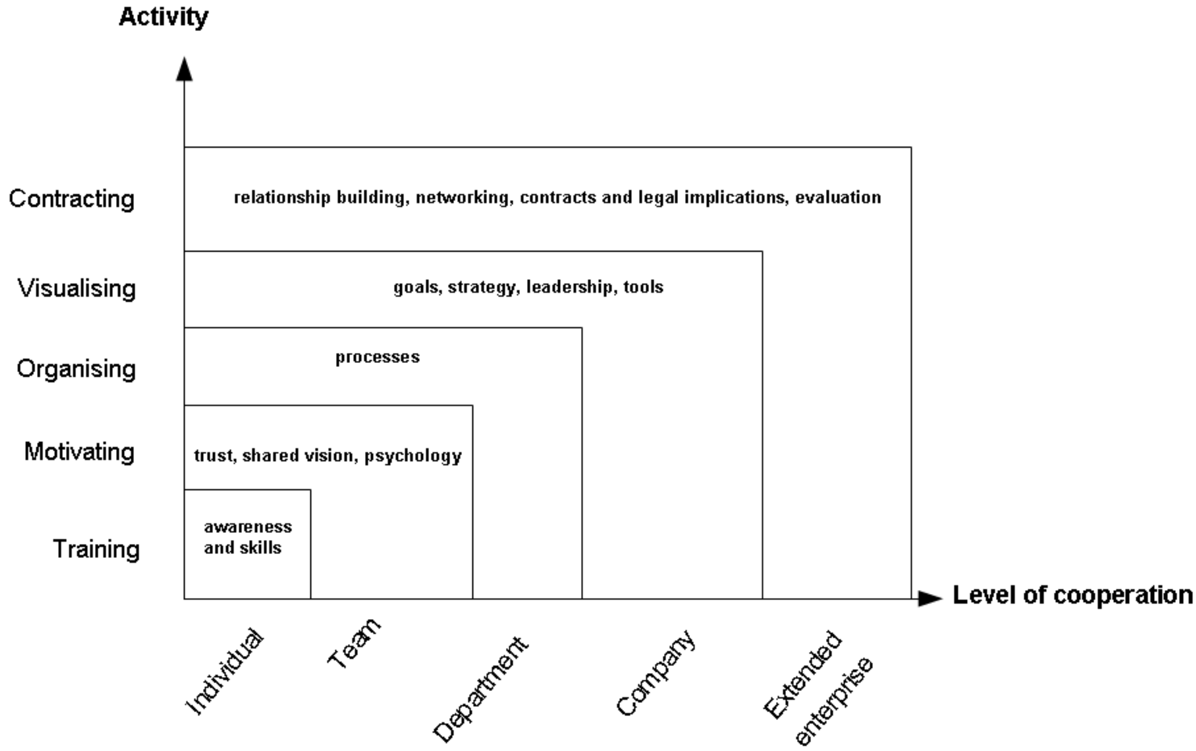

FIGURE 1 – FRAMEWORK FOR A HIERARCHY OF KNOWLEDGE MANAGEMENT ACTIVITIES

At the team level, the key activity to be performed is *motivating* the individuals to practice KM within this team by addressing *psychological* issues. The main barriers on this level are mistrust of others, along with the fear that can arise when sharing knowledge. These need to be clearly mapped, so that they can be understood and overcome. At the *department* level, the provision of defined *processes* that enable the practice of KM in teams (and for individuals) is key. Specific barriers to be overcome by the provision of *organisational processes* are those aspects related to space and time, such as the consideration of differences in culture, working hours, and business practices. This level should include steps on how to develop common procedures. The main activity at the *company* level is to fully support KM by ensuring that KM overtly lies at the heart of the company *strategy*. Without this, no KM initiative will be successful. Barriers to be addressed here are the lack of awareness of KM strategies, tools and capabilities. This leads to the last and highest hierarchical level - the *extended enterprise* itself. As well as considering all other lower levels and their related issues, this level must focus on *legal implications* and administrative issues. Thus, the main activity to be performed is developing appropriate *contracting* procedures with strategic partner companies in order to ensure that the company interests are best represented.

6.2 incentivising people – mobilising the KM framework

In order for a framework such as this to be operationalised, our results and existing research has shown that structured incentives need to be in place across the organisation (Bose 2004, Kaplan and Norton 1996, McInerney 2002, Ward, 2005). These often take the form of performance measurement systems such as the balanced scorecard, economic value added and the Skandia Navigator (Bose, 2004). Applying this to our framework, performance metrics can be implemented at each hierarchical level e.g. participation in team activities, rewards for information sharing ideas, application of shared - goals, processes, reporting systems, training events, etc.

Over time, all measurement systems ultimately suffer from the same fate that 'initiative fatigue' sets in and enthusiasm is lost. In order to avoid this and ensure that the knowledge remains mobilised, additional incentives are required. By setting up Communities of Practice (COPs) - both within the organisation and out to the extended enterprise - teams can remain energised for longer (Lank, et al., 2008, Nicolini, et al. 2008, Wenger, et al. 2002). Informal COPs have been established in many large organisations (such as DaimlerChrysler, Oracle, Schlumberger and Shell) to great effect. They differ from cross functional project teams in several important ways. Members select themselves, without management intervention and without a specific agenda with the aim of developing member capabilities and exchanging knowledge. They are held together by mutual interest and commitment for as long as there is voluntary interest in maintaining the group.

This framework and suggested measures and implementation methods, paves the way to exploring and developing these themes further. The next step is to now understand the underlying factors to these barriers and further develop the proposed solutions.

CONCLUSIONS

The paper has highlighted that in order to ensure that in order to survive and prosper, firms in the telecommunication sector must treat their extended enterprise and, in particular, their suppliers as active knowledge partners. This dynamic relationship needs to be knowledge-based, to allow communication barriers to be overcome and allow each partner to contribute their own unique skills, expertise and preferences. Furthermore, this knowledge-sharing must also be effectively distributed and reused. Knowledge management has in the past been dominated by technical considerations. Our research indicates that KM efficiency is linked to appropriate use and development of a technological solution, blended together with provisions for human factors. The barriers that can result from often unforeseeable and sometimes illogical personal issues have to be addressed and managed at the highest level if KM is to become successfully integrated into the organisation's culture and processes. Failure to do this only paves the way for KM being viewed as another management fad. This human-centred view of the major KM issues across organisational boundaries was formalised into a hierarchical framework that aims to simplify the process of identifying which tools and methods should be applied in companies. The use of performance measurement systems and Communities of Practice were also discussed as ways to implement the framework. As this framework was developed with companies in the TLC sector, additional testing (in particular empirically-based comparative studies) in other sectors is desirable to enhance its validity.

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COLLABORATIVE SUPPLY NETWORK MANAGEMENT IN THE COMPETITIVE ENVIRONMENT OF THE MUSIC INDUSTRY - AUTONOMOUS CO-OPERATION AS AN ORGANISATIONAL PRINCIPLE IN NON-PHYSICAL PRODUCT LOGISTICS

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ABSTRACT
This paper intends to show possible contributions and associated limitations of modifying the licensing processes within the supply chain management of non-physical product logistics in the music industry in order to prevent them from being inefficient. The theoretical concept of coopetition is used to identify complementary inter-relations between involved actors and the organisational principle autonomous co-operation to realise the resulting potentials to increase the whole market volume for non-physical music products.

INTRODUCTION
Whereas the sales of physical music products (e.g. CD or Vinyl) have declined at nearly 40 per cent during the last decade in the German music market, the sector of non-physical music products (e.g. mp3 or streams) grew continuously with annually growth-rates up to approximately 40 per cent (Bundesverband Musikindustrie e.V. 2008). Therefore, non-physical supply chains gain in relevance for the logistics management of record companies (Graham et al. 2004). In order to be capable to compete with Internet piracy sources, an area of conflict emerges from necessities to on the one hand co-operate and on the other hand compete with each other at the same time. This lead in the recent past to inefficiencies in the licensing processes between record companies and online-retailers (e.g. Cordes 2008). Therefore, the question that will be addressed in this paper, is how these licensing processes within the supply chain management of music industry corporations can be modified in order to prevent the market from future inefficiencies and to exploit the full potentials resulting from the possibilities to distribute non-physical music products over the Internet.

The aims of this paper are threefold: On a descriptive level, non-physical product logistics in the music industry shall be presented and the concepts of coopetition (Nalebuff, Brandenburger 1996) as well as the organisational principle autonomous co-operation (Windt, Huelsmann 2007) shall be outlined in order to afford a praxeological as well as a theoretical basis for the further analysis. On an analytical level, on the one hand the cause and effect chains between current licensing processes and their inefficiencies shall be analysed. On the other hand, contributions and limitations for applying the organisational principle autonomous co-operation in the licensing processes of record companies shall be deduced. Finally, on a praxeological level, an organisational alternative and associated limitations for the design of licensing processes shall be derived.

Therefore, the paper proceeds as it follows: After giving a short introduction (Section 1), characteristics of non-physical product logistics will be described and associated inefficiencies that result from long-lasting licensing processes will be illustrated. This corroborates the need for alternative approaches in current licensing processes. Furthermore, the concept of coopetition will be introduced and transferred into the context of non-physical product logistics in the music industry. This outlines the potentials that can emanate from co-operative strategies of competitors (Section 2). Following that, the organisational principle autonomous co-operation will be presented in order to discuss its potential contributions as well as its limitations for applying it to the supply chain management of non-physical product logistics (Section 3). Finally, the results will be subsumed and implications for the non-physical supply chain management of record companies as well as for further research will be deduced.

COOPETITION IN SUPPLY CHAIN MANAGEMENT OF NON-PHYSICAL PRODUCT LOGISTICS

Non-physical Product Logistics

The management of supply chains includes not only the planning, steering and control of flows of material and services, but also of informational and monetary flows (Hahn 2000). It has to integrate all business activities that are involved in the single value-added-steps of the development, creation and exploitation of products or services (Cooper, Lambert & Pagh 1997). These processes are usually distributed among several different companies, institutions or other actors. From a system-theoretical perspective they can be regarded as sub-systems or elements within a larger network (Krieger 1998). In order to add value to a product or a service, they have to interact with each other (Cooper, Lambert & Pagh 1997). This includes the exchange of resources like information and monetary flows.

The supply chains in the music industry have changed significantly during the last decade (e.g. Graham et al. 2004; Kusek, Leonhard 2005; Gersch, Avaria 2007). A still ongoing trend in consumers�NULL preferences from the purchase of physical to non-physical media products can be observed (Bundesverband Musikindustrie e.V. 2008). Therefore, the physical supply chain in the media industry becomes less and less important (Graham et al. 2004). Instead, with an ongoing increasing market share of digital, non-physical media products that can be distributed over the Internet, informational and monetary exchanges gain in relevance in the supply networks of the media industries. Due to a diversity as well as a variety of formats (e.g. mp3, wma, stream with or without constraints[2]) and associated business models (e.g. pay per track, subscriptions, advertising financed streams or downloads) (Cordes 2008) the information exchange processes, which means the licensing processes[3] between involved actors (e.g. record companies and online-retailers), are much more complex than in the media industries‛ physical supply chains.

Inefficiencies in Non-physical Supply Networks of the Music Industry

However, the recent past has shown, that long-lasting negotiations in licensing processes can lead to inefficiencies in the market (e.g. Cordes 2008; Gersch, Avaria 2007; Renner 2004). In terms of a general understanding of efficiency measured by the relation between inputs and outputs (Wolf 2008), this means that shorter licensing processes might have led in the end to greater profits.

This can be illustrated by the development of distribution standards in the music industry over the last decade since the emerging of the Internet. It took the music industry nearly 5 years since the start of the first p2p-system[4], to provide consumers who demanded non-physical media products a legal alternative to illegal sources with a possibility of choice, which ranges over artists from all major labels[5] (Cordes 2008). Instead, they *„[...] tried for years to develop technical platforms for digital distribution themselves, but major companies hesitated to sell their music through a platform owned by a rival*" (Porter 2008), p. 90). Finally, with Apples iTunes Music Store a new actor from outside the industry entered the market and advanced to a powerful player (e.g. Porter 2008; Gersch, Avaria 2007). Since then, the download market increased constantly with high growth rates (Bundesverband Musikindustrie e.V. 2008). The big record companies‛ licensing strategies were characterised by restrictive and observant

2 e.g. digital rights management (DRM) (Buhse, Guennewig 2005)
3 Licensing describes the specific arrangements concerning the rights for retailers, to use, in terms of producing and selling, products that they do not own (Mordhorst 1994).
4 P2P describes so called peer-to-peer systems, which can be used to share and distribute files over the Internet (Becker, Clement & Schusser 2005).
5 The term major labels describes the current biggest record companies (Universal, Sony, Warner, EMI), which hold a worldwide market share of more than 80 % (Steinkrauss 2005).

behaviour (e.g. Altig, Clement 2005; Emes 2004), which significantly extended the length of licensing processes to new business models for retailing non-physical music products. Not until the year 2009 all four major record companies resigned the technical constraints, non-physical music products should be equipped with when being sold over the Internet (Wellinger 2009).

However, in order to develop their full potentials, non-physical music retailers need to be able to provide a preferably high possibility of choice with preferably little constraints (Kusek, Leonhard 2005). The main reasons are twofold: First, the range of artists consumers buy products of, does usually span artists from different record companies (Clement & Schusser 2006; Renner 2004; Kusek, Leonhard 2005; Cordes 2008). Secondly, with an increased convenience of piracy an unlimited choice of music for free without any constraints like DRM-systems emerged (e.g. Blackburn 2004; Becker, Clement & Schusser 2005; Raschka 2006; Emes 2004), which can be seen alongside a relatively low risk to be prosecuted (Becker, Clement & Schusser 2005). As these aspects decrease the attractiveness of legal music downloads compared with illegal alternatives, the market for non-physical music products did not grow as fast as it could have grown (Cordes 2008), while the physical sector was declining further drastically (Bundesverband Musikindustrie e.V. 2008).

In order to meet these requirements the supply chain management of non-physical music products need to extend its perspective from interactions between actors along the chain (e.g. record labels, distributors, retailers) to interactions between the competitors. According to Nalebuff and Brandenburger *„creating value, a bigger pie, is fundamentally a cooperative activity involving customers and suppliers that a company can't establish alone. On the other hand, the act of dividing up the pie is fundamentally competitive*" (Nalebuff, Brandenburger 1997; p. 28). As this is a combination of co-operation and competition, this is called in the literature coopetition (Nalebuff, Brandenburger 1996).

Concept of Coopetition

The concept of coopetition was introduced into the management literature by Nalebuff and Brandenburger (1996). It has been derived from a game-theoretical basis and refrains from the assumption, that in order to „win a game", somebody else has to „loose". Instead, the focus lies on the question how to create „a bigger pie". How the pie will be divided later on is determined by the concept of added value, which estimates the size of the pie when a player is in the game, subtracted by the size of the pie when the player is out of the game (Nalebuff, Brandenburger 1997).

First of all, the relevant players in the business environment, which are acting in the so-called value net, have to be identified. A distinction can be made between the business that is regarded, its customers, competitors, suppliers and complementors (Nalebuff, Brandenburger 1996). A complementor is a player whose product or service increases the value that customers perceive from a second player's product. A competitor, in contrast, is a player whose product decreases the value that customers perceive from a second player's product. Players can have more than one single role, which means, that a competitor of a player can also be his complementor, and the other way round (Nalebuff, Brandenburger 1997). Following this logic, it can be reasonable for companies to approach strategies that foster the sales of their competitors in order to increase the value that consumers perceive of buying their products. This can be achieved by co-operation between competitors with the aim to increase the market volume for non-physical music products. Hence, the following question arises: Which aspects hinder the music industry to exploit the full potentials that result from the use of the concept of coopetition?

Coopetition in Non-physical Supply Networks of the Music Industry

If record companies would ask, what they could do in order to increase the attractiveness of buying non-physical music products instead of downloading them from piracy sources, independent from which record companies' sales should be increased, they might come to different results than if they ask what they could do to increase just their own sales. The reason for this can be found in the above-explained necessity to enable online retailers, independent from their business models and the sold formats, to provide a preferably high possibility of choice. More specific, the attractiveness for consumers to buy non-physical music products from an online retailer increases with every single additional record company that provides their music products to the respective retailer. The same applies on a macro-level: The general attractiveness to buy non-physical music products instead of downloading them from illegal sources increases with every additional participating record company. This shall be illustrated by one example: Providers and consumers in China do not have to expect prosecutions for infringement of copyrights (Montgomery 2005). This is the main reason why on the one hand domestic search engines that provide links to illegal music download sources obtain much bigger market shares than search engines like Google, which do not provide illegal content (Barboza 2009). On the other hand, the by far biggest share of music downloads in China is not licensed by their owners, the record companies or artists (IFPI 2008)[6]. With the idea to launch a free of charge music download service at Google's search engine, which lets the record companies take share in Google's advertising revenues (Barboza 2009), Google and the record companies became complementors. The value that consumers perceive of using Google's search engine increases by the possibility to download music of the record companies at Google for free. And consumers that use Google for music searches instead of illegal sources of other search engines increase the revenues of the participating record companies. Furthermore, not only Google and the record companies are complementors, but as well the record companies for each other. By participating in Google's free of charge service, the possibility of choice for consumers and therewith the attractiveness of the whole service, including downloads from competing record companies compared with illegal sources, increases. Figure 1 illustrates the respective value nets for the example.

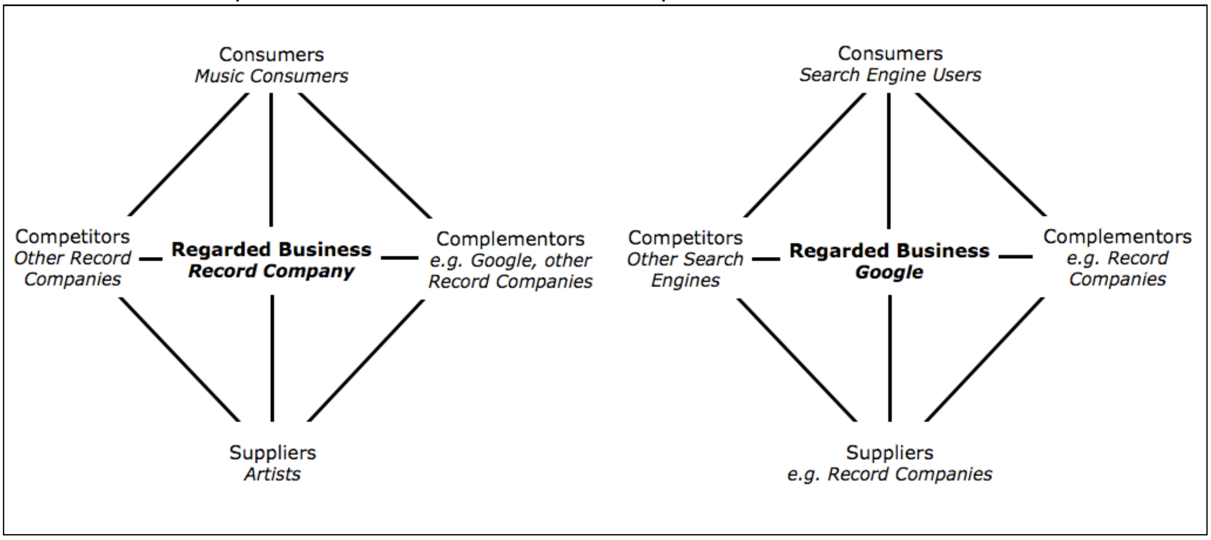

Figure 1: Example of Value Nets of Record Companies and Google (On the basis of Nalebuff, Brandenburger 1997; p.30)

On the basis of the added value concept, the particular amount, with which the whole market volume for non-physical music-products would increase, if a certain record label decides to join in and to provide their respective music products to the online-retailers has to be estimated. In the example and from the perspective of the record companies, the questions have to be asked: How much more attractive is the search engine Google,

[6] The international inter-trade organisation of the music industry IFPI estimates an online piracy rate of more than 99 per cent in China (IFPI 2008).

how can that be measured, and how much more revenues would the competing and as well participating record companies gain, if we participate?

These kinds of co-operation between retailers and record companies require on the one hand informational as well as monetary flows along the supply chain. This means in the example that Google has to negotiate with every single record label. On the other hand, informational flows on a horizontal level, which means an exchange between competitors, is as well necessary in order to be able to evaluate the expected utilities of a participation. Considering the described multitude of new business models and new formats in the market for non-physical music products, a multitude of informational and monetary flows between the involved actors has to be accomplished by the respective supply chain management. The resulting complexity of negotiating processes that are necessary before an opportunity that arises from inter-relations between all the involved complementors can be availed leads to the risk of long-lasting licensing processes and therewith of overall inefficiencies in the market for non-physical music products. Hence, the question arises, how a supply chain management of record companies can cope with this complexity in order to shorten these licensing processes and therewith to increase the potentials that might emanate from suchlike opportunities. One concept that has been discussed in the logistics management literature as a possible approach to cope with complexity in international supply networks is the organisational principle autonomous co-operation (e.g. Huelsmann, Grapp 2005; Windt, Huelsmann 2007).

AUTONOMOUS CO-OPERATION AS AN ORGANISATIONAL PRINCIPLE IN THE SUPPLY CHAIN MANAGEMENT OF NON-PHYSICAL PRODUCT LOGISTICS

Autonomous Co-operation as an Organisational Principle

The origins of the organisational principle autonomous co-operation can be found in self-organisation-theory (Huelsmann, Wycisk 2005). Its main goal is to enable systems to cope with complexity and dynamics (Windt, Huelsmann 2007). According to Windt and Hülsmann autonomous cooperation describes *„[...] processes of decentralized decision-making in heterarchical structures. It presumes interacting elements in non-deterministic systems, which possess the capability and possibility to render decisions independently"* (Windt, Huelsmann 2007; p. 8). Decentralised decision-making means thereby that the single system‘s elements (human as well as non-human elements) are enabled to select between different action alternatives by them selves (Frese 1993). Decisions can therewith be rendered without the need to consult a hierarchically super-ordinate entity (Windt, Huelsmann 2007). Autonomy refers to the elements‘ resulting abilities to decide upon their next steps on their own (Probst 1987). However, in order to render decisions independently from external entities, the elements need to be able to gain access to resources like relevant information. Therefore, the system‘s elements have to be able to exchange these resources; in other words, they have to interact with each other. An essential pre-condition for these characteristics is an, at least to a certain degree, heterarchical order of the system. In a 100 percent autonomously controlled system, this would mean that no element has a super-ordinate decision-making power. In logical consequence, an impossibility would arise to predict future system states (Windt, Huelsmann 2007), which refers to the term non-determinism (Flaemig 1998).

Hence, with recourse to the aims of autonomous co-operation, which include the increase of a system‘s ability to cope with complexity, the question arises, if an increase of the degree of autonomous co-operation would lead to a decrease of the described inefficiencies in licensing processes.

Contributions and Limitations of Applying Autonomous Co-operation in the Supply Chain Management of Non-physical Product Logistics

From a system-theoretical perspective (Krieger 1998), the involved actors in licensing processes can be regarded on the one hand as the involved organisations (e.g. record companies, retailers). On the other hand these organisations can be regarded as systems themselves, which allows breaking this perspective down to single decision-makers within these organisations (e.g. digital sales manager).

Increasing the degree of the constitutive characteristics of autonomous co-operation leads to an increase of the respective system's overall decision-making capacity (Huelsmann et al. 2007). This results from the delegation of decision-making power from a central planning unit to the single entities (Windt, Huelsmann 2007). Notwithstanding, their respective single processing capacities might be lower than a central planning unit's one, but with a sufficient amount of participated entities the accumulated overall information processing and decision-making capacity would be significantly higher (Huelsmann et al. 2007). In consequence, this would contribute to realise the potentials resulting from coopetitive inter-relations. An increase of interaction, which means the exchange-processes of information between single actors of different organisations, would accelerate the process of identifying actors that can be seen as complementors and which ones as pure competitors. Once, complementors have identified each other, the added value of a participation in a coopetition has to be estimated. However, the large amount of inter-relations of different aspects that determine the respective added values leads to an impossibility to predict or to measure them in an inter-subjective comprehensible way. Due to the resulting uncertainties concerning the respective single utilities of participation, negotiation processes between complementors are necessary. In systems with a low degree of autonomous co-operation, the external control entities of the involved organisations (e.g. the respective CEOs) need to render most decisions in most negotiation processes in most inter-relations between complementors by their own. Compared to this, the time that is needed to come to agreements between complementors might be significantly lower, if the decision making abilities are delegated to the single involved elements (e.g. digital sales manager). In other words, an increase of the needed autonomy for decentralised decision-making might shorten the lengths of licensing processes in the supply chain management of non-physical product logistics. A pre-condition for this kind of delegation of decision making powers is on the one hand the overall agreement within the involved organisations to reduce hierarchies, which in reverse increases the heterarchical characteristics of the whole network. On the other hand, it has to be accepted that this would decrease also the possibility to predict future system states, which means accepting a non-deterministic system-structure (Windt, Huelsmann 2007).

Beside these potential contributions, some limitations accompany this approach. The top-management of involved organisations would forfeit the control of licensing processes by delegating control to employees. Additionally, it is not assured that the respective employees have the needed competencies to estimate and evaluate the particular added values of a participation in a coopetition. This affects their individual capabilities to render preferably rational decisions, which might lead also to inefficiencies in licensing processes. Therefore, this aspect is one essential barrier for increasing the degree of autonomous co-operation since it would be necessary, to train the respective employees in order to assure that all system elements that are able to decide on their own are equipped with the needed competencies. Furthermore, it is also not assured that the respective employees do not decide with regard to their own personal aims, instead of with regard to the overall aims of the respective organisation. In this case, inefficiencies in licensing processes could as well not be avoided.

CONCLUSIONS

The super ordinate aim of this paper was to analyse possibilities and limitations for modifying licensing processes of non-physical music products between record companies and online-retailers in order to exploit the full potentials that result from distribution possibilities in the Internet. One possibility to exploit these potentials is to co-operate with actors that can be regarded as complementors. However, processes of identifying these complementors, estimating associated added values of a participation in a co-operation and negotiating with each other can lead to long-lasting licensing processes between record companies and potential online-retailers, which, in turn, lead to market inefficiencies. One possible approach to shorten these processes is to increase the degree of autonomous co-operation in the supply chain management of non-physical product logistics. This would increase the overall information processing as well as decision-making capacities, which might affect the efficiency of licensing processes positively. However, some restrictions are associated with the delegation of decision-making power to single elements in the supply network. Hence, the supply chain management of non-physical product logistics should consider an increase of autonomous co-operation in their licensing processes, but should be aware of doing so without equipping the single deciding elements with the needed competencies. Therefore, further research is required on the one hand concerning possibilities to evaluate individual degrees of autonomous co-operation with regard to the individual competencies of the involved actors in order to find the individual optimum degrees for the constitutive characteristics. On the other hand research is required concerning possibilities to equip single systems' elements with the needed competencies to render decisions themselves. Furthermore, empirical research would be necessary in order to proof the validity of the findings.

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REQUIREMENTS AND APPROACHES FOR A COMPLEXITY SCIENCE-BASED MODELLING OF INTERNATIONAL SUPPLY NETWORKS - LESSONS LEARNED FROM FINANCIAL MARKET MULTI-AGENT MODELS FOR THE SIMULATION OF COMPLEX ADAPTIVE LOGISTICS SYSTEMS

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ABSTRACT
International Supply Networks have to cope with changing customer demands, innovative technologies, and increasingly ecological awareness in a complex context, whereas the challenges' consequences are hardly predictable. Hence, a modelling concept might be useful to analyse and develop system designs and deduce design options, which can applied to the real world in order to enable the system to react to these challenges by adapting its behaviour. In order to identify a catalogue of requirements for the modelling of logistics systems, the paper intends to analyse the application of LeBaron's stock market model to logistics systems from a complexity theoretical perspective. Therefore, the feasibility and possible contributions of applying the introduced financial stock market model to logistics systems in order to learn from an existing modelling approach will be examined.

INTRODUCTION
Globalization combined with accelerating production times, new communication technologies and increasing ecological awareness forces companies to establish global alliances in order to develop and maintain sustainable competitiveness (Klaus & Kille 2006). These Global networks, having interconnections among their actors, work together to reach their goals and are therefore one approach to face these challenges (Hülsmann & Windt 2007). Therewith, the understanding of logistics systems has changed from linear structures to complex systems (Bowersox et al. 2002; Hülsmann & Grapp 2005). Hülsmann and Grapp (2005) describe the resulting logistics structures as International Supply Networks (ISN). ISN consist of heterogeneous agents (e.g. suppliers and manufacturers on macro-level and containers and cars on micro-level), which are to a certain extent autonomous, interactive and able to learn. In addition, the system as a whole co-evolves with other systems and its environment over time (Wycisk, McKelvey & Hülsmann 2008). These are the constitutive characteristics of the concept of Complex Adaptive Systems, which originates in complexity-science (Holland 2002). Hence, ISN can be described as Complex Adaptive Logistics Systems (CALS) (Wycisk, McKelvey & Hülsmann 2008). CALS are emerging (e.g. new kinds of orders evolve), evolving (e.g. the behaviour of the whole system adapts to environmental changes), self-organising (e.g. self-initiated changes of the system's structure and behaviour), dynamic (e.g. the system and its inter-relations change over time) and behave like living systems to a certain degree (e.g. CALS interact and act together to reach their goals) (McKelvey, Wycisk & Hülsmann 2009). Since complexity theory-based modelling considers these characteristics, it can be used for the designing of CALS (Choi et al. 2001). Financial markets feature parallel characteristics with CALS (McKelvey, Wycisk & Hülsmann 2009). These markets also consist of heterogeneous agents (e.g. traders having different information), which are to a certain extent autonomous, able to learn, and interacting. These markets as well co-evolve as a whole with their environments over time (LeBaron 2001a).

Considering the parallels in the characteristics of ISN and financial markets, a model approach for modelling financial markets could be applied to the modelling of ISN. As LeBaron's model has already shown its capabilities in representing and predicting complex market structures and dynamic market behaviour, it shall be used as a starting

point for developing an approach for modelling ISN (LeBaron 2003). The overarching objective of this paper is to analyse the feasibility and possible contributions of applying LeBaron's model to logistics systems in order to identify and describe a catalogue of requirements for a modelling and simulation of ISN.
Therefore, the paper proceeds as follows:
Firstly, the paper illustrates the motivation and requirements for modelling ISN to reason its demands and constraints. **Secondly**, possibilities and limitations for a multi-agent-based simulation based on an analogy between the characteristics and the behaviour of stock markets on the one hand and logistics systems on the other hand shall be identified. This section also introduces and describes Le Baron's stock market model as a feasible and well-performing investment-theoretical approach of modelling complex adaptive systems (CAS), like ISN are. Furthermore, an approach for the modelling of ISN based on LeBaron's model is presented in order to show, how the elements of LeBaron's model can be transferred to logistics systems. **Thirdly**, some contributions and deficits of the introduced approach are outlined regarding its fit to the goals and requirements of modelling ISN in order to identify potential benefits and limitations of the approach. **Finally**, the paper provides implications for future research on complexity science-based simulations of logistics structures and processes.

MOTIVATION OF MODELLING ISN

To develop an efficient functioning of ISN, timely responses to environmental changes are required to achieve the system's goals (Hicks & Gullet 1975), as these changes influence the input-output relations and therewith the efficiency of ISN. In consequence, frictions at the interfaces within ISN, which might occur due to different agents with different goals, have to be reduced (Hülsmann & Grapp 2007). There are e.g. suppliers, who want to increase their sales for maximizing revenues. On the other side, there are wholesalers aspiring for a minimal purchasing amount in order to reduce stocks. These conflicting goals might reduce the overall logistics system efficiency and compromise its goals (Tohamy 2005). Thus, and because a real world application and testing of ISN regarding critical elements for reducing frictions are very expensive and complex tasks, a model for simulating the behaviour and the dynamics of ISN is desirable (Macal & North 2005). In addition, problems like frictions or extreme events like butterfly effects (describing the system's sensitivity to initial changes) can be potentially minimized, if they become visible. In conclusion, weaknesses and the risk of critical incidents can be identified and potentially reduced while costs caused by new technologies can be estimated through designing ISN (Wycisk, McKelvey & Hülsmann 2008).

ISN could be modelled as networks of auctions, in which every single agent bids for resources (e.g. space on transports) (Moyaux 2007). Learning features and a set of rules shall directly be implemented within the agents' functionality (Bonabeau 2002). Due to the complexity of ISN, a model design requires as many details about the real world as possible in order to create a representation which is as realistic as possible (Pedahzur & Pedahzur Schmelkin 1991). As common modelling approaches do not cover the requirements appropriately in order to match the characteristics of ISN (e.g. emergent phenomena), agent-based modelling techniques can be applied to achieve the most sophisticated results (Bonabeau 2002). And the learning capabilities of ISN have to be considered in the designing process in order to realize the ability to react on changes in the environment (McKelvey, Wycisk & Hülsmann 2009). Due to the application of new information and communication technologies in ISN, the immanent complexity of ISN, and the usage of agent-based computational models, a complexity-based perspective considering the relevant characteristics for modelling ISN is useful (Choi et al. 2001).

Two modelling approaches in complexity-science, the fractal factory in production logistics (Warnecke 1993) and the approach from Scholz-Reiter et al. (2004) in transport logistics, shall give a briefly overview about the characteristics of existing approaches. They have four central elements in common: They are based on adaptive processes (1st), embedded in a topology of interconnectivity among the respective supply chain

(2nd), running autonomously without external interventions (3rd), and initiated by changing environmental constraints (4th) (McKelvey, Wycisk & Hülsmann 2009).

Current modelling approaches' software components and the decision support systems in particular are lagging behind their technical components. Thus, true market behaviour cannot be illustrated by these approaches (Crainic & Gendreau 2004). However, to avoid frictions etc. the planning and designing of ISN call for a market-based model including its behaviour comprised of agents, which have varying amounts of smartness.
The modelling of ISN aims for an illustration of true market behaviour to improve the understanding of real markets. The required smartness to achieve behaviour of the model as close to reality as possible shall be distributed among the agents of the supply chain (Roy 1998). Decentralized agent-based self-organization and the implementation of learning features in the functionality of the agents shall allow the system to adjust its behaviour in real-time, enabling it to react to changing circumstances (Srbljinovic & Skunca 2003). Thus, changes from macro-level affecting the micro-level (e.g. a new seaport is constructed offering new transport mode) and vice versa become visible to agents (McKelvey, Wycisk & Hülsmann 2009).

Some desired results can already be achieved by the mentioned examples. A better understanding of a system's behaviour is currently possible through them. This is how critical elements and interfaces can be identified and handled to a certain extent by implementing features into the agent's functionality that represent the capabilities resulting from new information and communication technologies in the real world. That might lead to a higher system flexibility and robustness (Hülsmann & Windt 2007). Finally, monitoring of processes and therewith tracking of agents offers further benefits (e.g. detecting of critical processes and package tracking). The reason is that potential problems caused by critical processes can be identified and handled at an early stage and package tracking offers additional quality and service to the customers.

However, by looking at the two examples there are some deficits remaining and the listed contributions need to be improved. For example, due to ISN complexity and dynamics, the learning features and self-organization to allow a high level of autonomy and interaction among the agents, are currently not realized at an adequate level (Macal & North 2005). Thus, the system remains vulnerable against unexpected changes and extreme events (McKelvey, Wycisk & Hülsmann 2009). At present, the illustration of the true system behaviour is not adequate due to missing software components for agent features. And finally, current software and hardware are lagging behind the theoretical research situation of complex systems (Crainic & Gendreau 2004). In consequence, current theoretical research approaches from complexity-science in the context of logistics systems cannot be appropriately transferred into and tested in the modelling world. Hence, an approach based on LeBaron's model is introduced in the next section.

A COMPLEXITY-SCIENCE BASED APPROACH FOR MODELLING ISN AS CALS

LeBaron's model (LeBaron 2001a, b, 2003) consists of three central elements: an **electronic market** (EM), a **neural network** (NN), and **learning traders**.

Firstly, an operating EM is created consisting of agents and their interrelations. This EM is well validated against dynamics and behaviour of stock-markets (LeBaron 2003). Thus, it is used as starting point for developing a modelling approach for ISN, which also have to cope with dynamics. Agents in LeBaron's model compete with each other in their trading activities, whereas the fittest agent regarding the fulfilment of his specific objectives survives and simultaneously the used strategy. This strategy is either represented by and internal rules or set of rules (LeBaron 2001b). Following this strategy, some agents are replaced by others in every cycle based on either a strategy or randomly. Thus, a more realistic representation of the market can be achieved. To further enhance this, different agents use different past information in deciding on their optimal trading strategies. Thus, encouraging the agents to interact heterogeneity of the agents is achieved (Wycisk, McKelvey & Hülsmann 2008). By following this approach (agents are replaced and use different past information), different strategies (e.g. more or less risky) leading to different results become available in the model. The second element of LeBaron's model is the NN, as basically described by Holland (1975). The NN observes market changes and keeps updating six investment strategies based on pre-defined criteria (current or past returns, price-dividend ratios, and technical trading rules). Thereby, the NN acts separated from the agents (traders) and can be regarded as a kind of "investment advisor", giving hints how to behave via updating the investment strategies, which serve as rules for the behaviour. Agents can choose from the strategies as if they would consult a real advisor. The third element of the model is intelligent traders with learning capabilities, which are implemented by a genetic algorithm (Mehrotra et al. 1997). These learning capabilities are based on 250 investment rules, which are, in combination with three different strategies, the basis for the genetic algorithm. This algorithm aims at adapting and changing learning capabilities. Initiated by changing conditions, the genetic algorithm evolves the investment rules in relation to the three different strategies. Following the idea of a genetic algorithm, rules are modified (mutation) or combined with parts of other rules (crossover) (Fogel 1995).

To pick up again the description of the parallels in the characteristics of ISN and financial markets and to continue it in more detail, the parallels shall be divided into three levels: the **individual level**, the **intra-systematic level** and the **inter-systematic level**.

On the individual level there are agents, which are present in both ISN and financial markets and distinguished by different features like rules, patterns of actions etc. Heterogeneity can also be found in both systems (ISN and financial markets) and results from different goals of the agents as well as from different features (Holland 1988). In ISN agents might strive for the fastest and most expensive transport versus the slowest but cheapest transport whereas agents in financial markets may differ in their attitude towards risk (low risk and low profit versus high risk and potentially higher profit). Interaction among agents is also given in ISN and financial markets. They exchange for example routing information depending on traffic or stock-information regarding price, respectively. One motivation is e.g. to work together in order to match logistics goals they could not fulfil as single agents (Hülsmann et al. 2006). In ISN, the agent's ability to learn is represented by their experiences (e.g. regarding traffic), which is considered via regularly updated decision rules. Thus, the performance of the system might be enhanced as experience is accumulated (Holland 2002). The same kinds of rules are used in financial markets to realize the agent's ability to learn based on past order experiences (e.g. experiences with placed orders).

On the intra-systematic level the system's organization is regarded. The characteristic autonomy is realized, described as self-initiated actions without being controlled by another entity (Holland 2002). As in ISN for example agents allocate required space for goods autonomously the same characteristic is present in financial markets, where agents place orders for stocks by themselves. Self-organization is another characteristic on this level, which occurs in both systems. It results from the autonomous interaction of the agents enabling a system to adapt self-initiated to changing constraints.

The inter-systematic level contains the characteristics non-linear behaviour and co-evolution. Since agents act autonomously and respond to each other's actions, the system's structure co-evolves with other systems and the environment over time (Kaufmann 1993). Due to co-evolutionary processes within the system and the non-predictability of the systems' behaviour (caused by their autonomy and interaction), the behaviour of the whole system is non-linear. Thus, extreme events may occur compromising the system's goals (Surana et al. 2005).

Following McKelvey, Wycisk and Hülsmann (2009) the three main elements of LeBaron's model (electronic market (EM), Neural Network (NN), and learning traders) are assigned to categories one to three, whereas each category consists of two or more designing alternatives. In each category, all designing alternatives have at least the functionality of its predecessor(s) and those, which are explained additionally.

Category one (EM) starts with the designing alternative *'Baseline Model'*. This model comes from a graph-theoretic perspective and consists of a set of nodes and links. Agents (goods, components etc.) are represented by nodes and the links connecting the nodes can be streams of goods, financial etc. There is neither communication between non-human parts nor any kind of artificial intelligence. In consequence, the parts are totally dumb and the only data companies exchange within the supply chains is about orders. In conclusion, this reflects the traditional concept of supply chain management. The second designing alternative is *'Baseline Model with Speculative Reserve Space'*. This alternative enhances the Baseline Model by adding a human space-cost speculation. Humans for example try to get cheaper space on transports through very early or late bidding, respectively. In addition, they try to reserve big amounts of space in order to receive sales discounts. This strategy causes a higher risk as reserving the required space immediately, because early bidding might be more expensive than late bidding whereas late bidding includes the risk, that available space might be insufficient.
In category two (NN), *'NN'* in its basic form as the first designing alternative watches the market on a timely basis. It offers much shorter update periods than LeBaron's model (minutes or less versus weekly updates). Parts are still dumb, but they are constantly connected to the NN and the NN always tells the parts which alternatives to take (e.g. which transport vehicle or route). The parts have no choice, their progress is tracked and they are routed by the NN. The second designing alternative in category two is *'NN Auction-based'*. An own auction house is set up as a central kind of a buyers/sellers portal. Sellers make their resources available on the auction and buyers can buy desired resources. The prices are varying in dependence of the characteristics of resources (e.g. a faster ship is more expensive than a slower one). However, the parts still remain dumb. The third designing alternative is *'NN with Less Dump Parts'*. Parts check in to the NN to get the best strategies. They can also keep checking in and update their strategy, if a better one becomes available over time. However, the total number of options depends on the information given by the NN. Additionally, parts are not able to share information with other parts and the use of resources is limited by the options offered by the NN, which itself only can offer resources preliminarily obtained by a human.

The first designing alternative of the third category (learning traders) is '*Smart Parts learning from the NN'*. The NN makes options available to the parts and it constantly watches the market. Parts can now choose which option to take as the NN offers various transportation strategies. The next designing alternative is '*Smart Parts learning from the NN and from Each Other'*. Parts are able to learn from the NN and from other parts. In the designing alternative '*Smart Parts with Grouping Capability'* Parts can decide either to reserve required space or to bundle similar requirements to one bigger reservation to get better conditions. The fourth designing alternative *'Smart Parts having Full Choice'* is currently the vision of a fully-designed smart part model. Parts can learn from the NN, from each other and from the environment. In addition, all available options are accessible for each part and each of the parts can decide which one to take. In certain situations (e.g. extreme events), both, the NN and the smart parts, may benefit from human guidance. The last designing option of category three '*Speculating'* adds the idea of speculation to the model. As described above this causes a higher risk. Since the last designing alternative has the most sophisticated features regarding smartness of the agents, its contributions and deficits are evaluated in the next section.

CONTRIBUTIONS AND DEFICITS OF THE INTRODUCED MODELLING APPROACH:
The following table gives a briefly overview about some selected contributions and deficits of the designing alternative '*Speculating*':

Selected Contributions	Selected Deficits
- true market behaviour illustratable - better understanding of markets - monitoring and tracking of agents - smart agents are autonomous, interactive and able to make decisions - system can adapt to changes	- market behaviour in the model inappropriate - approach abstracts from the real world - learning abilities in the model not adequate - software lagging behind theoretical and technical development

Table 1: Contributions and deficits regarding the introduced modelling approach

Several contributions and desired goals - as described in section two - are already attained through the designing alternative '*Speculating*'. An illustration of true market behaviour is theoretically possible, since interrelations and the behaviour of the agents are displayed. That leads to a better understanding of markets, as different scenarios can be applied and tested by the model. Monitoring of processes and tracking of agents is also currently possible. Hence, critical elements and interfaces in the system can be identified leading to potential higher system robustness. Agents would be completely integrated smart parts, acting autonomously and having full choice over the actions they take and the interactions between them. Thus, smartness can be distributed among the agents as desired in order to attain decentralized decision making. Thereby, self-adjusting of the system's behaviour through an agent-based self-organization would also be possible, since the agents are able to exchange information and interact without the need of a control instance. The implementation of learning features in connection with the other features (autonomy, interaction etc.) could enable the system to react to changing circumstances.

Currently, possible contributions of the designing alternative '*Speculating*' are limited by the missing of adequate software technologies, which are necessary to implement the required artificial intelligence in order to achieve an appropriate level of smartness within the agents. The deficits of modelling ISN remain due to the systems complexity and dynamics. Thus, the illustration of true market behaviour is theoretically possible indeed, but practically it is not appropriate since there are too many entities and interrelations between them. In consequence, a modelling has to abstract from the real world in order to create computable models. The learning abilities are not yet available at a desired level leading to a further gap between modelling and the real world regarding true market behaviour. Thus, the self-organization of the agents for self-adjusting the system's behaviour in real-time is insufficient and the vulnerability against unexpected changes persists.

Beside the basic contributions and deficits, there are some pre-conditions which need to be taken into account when applying the introduced model. First, in financial markets only information and immaterial goods are exchanged whereas in ISN the goods have both immaterial and physical character. Thus, physical limitations (limited transport space etc.) and transportation times have to be considered when adapting LeBaron`s model to logistics systems. That affects mainly the investment strategies in the NN. Second, different environmental constraints have to be regarded. Financial constraints (laws, prohibitions etc.) are different from trading constraints (e.g. dependencies on embargoes). And third, the agents in ISN themselves are both physical and non-physical (e.g. cars and the NN). Hence, the smartness realized within the agents also has to consider both non-physical and physical constraints.

CONCLUSIONS

This paper intended to analyse the feasibility and the contributions of applying LeBaron`s model to logistics systems in order to identify and describe a catalogue of requirements for the modelling and simulation of ISN.

The main contributions towards the described modelling approaches (Warnecke 1993; Scholz-Reiter et al. 2004) is the improvement in illustrating the market behaviour and therewith to realize a faster reaction to changes, since the approach explicitly focuses on the characteristics of ISN in order to realize a behaviour as close to reality as possible. In addition, some required pre-conditions are outlined in the previous section.

There are various parallels in the characteristics of financial markets and ISN. Significant similarities between both systems are existent. However, some adaptations have to be made, especially concerning different environmental constraints and physical properties of agents. If these aspects are considered, it is feasible to use the introduced approach for designing ISN. Therewith, some desired goals and contributions of simulating can be achieved (e.g. self-adjusting of a system to a certain degree) whereas some other still remain (e.g. vulnerability against extreme events). The achieved contributions are partially not in an appropriate quality (e.g. illustration of true market behaviour). Following the ten designing alternatives in the three categories, they are getting better regarding the realization of the characteristics of ISN from one to the next alternative in the order they are listed. The reason is, that the implementation of the characteristics of ISN is improved from alternative to alternative originated by enhanced features (e.g. smart parts getting smarter each step, new characteristics like interaction are realized from one step to another).

Further research should focus on the remaining deficits (e.g. true market behaviour not illustratable at adequate quality) to improve the model regarding the desired goals. The next step could be to develop and compute a real simulation model. Therefore, on the one hand the software technologies to further improve mentioned features like learning capabilities etc. have to be advanced in order to enable agents to interact and act autonomously. On the other hand, due to the complexity and dynamics, essential problems like vulnerability against changes and non-predictability of the system behaviour persist and have to be investigated.

At last, there are practical implications as well. Learning features in an ISN can lead to a higher system flexibility and adaptability and therewith to higher system robustness (Hülsmann & Windt 2007). Since there are lots of agents, relations, and resulting interactions within a model, the application of new information and communication technologies in order to enable agents to act autonomously is one possibility to implement the characteristics of ISN (Wycisk, McKelvey & Hülsmann 2008).

However, since the main contributions beside financial aspects of ISN are currently unknown (strategic benefits e.g. in form of system flexibility and adaptivity), they cannot be considered in the decision making process whether to implement new technologies or not. In addition, there are financial barriers for the implementation of the required technologies, as managers have to face that their decisions are always made in the context of profitability and strategic considerations (Bowersox et al. 2000; Bowersox et al. 2002) and the costs of the required technologies cannot be estimated easily.

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CAN INTER-FIRM NETWORKS ALLEVIATE SUPPLY CHAIN RISKS WITHIN GLOBAL FOOD SUPPLY CHAINS?

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ABSTRACT
The food supply chain is truly a global supply chain wherein finished products and raw materials are transported across continents to fulfil requirements of consumers. The networks of supply encompass different languages, cultural systems, regulations etc. The entire farmer to end user cycle spans multiple risks and uncertainties which can manifest themselves in form of financial losses to human fatalities. In the past there have been instances of product recalls and food contamination which have had serious consequences as witnessed by the China milk scare, the Sudan1 dye in Worcester sauce and the Tomato salsa recall amongst others. This paper presents a literature study of the issues surrounding these complex and multi-tiered supply chain structures. It also presents a secondary analysis of the literature pertaining to supply chain risks in the food sector. Inter-firm aspects specifically in terms of relationships, trust and governance are analysed and a conceptual model for mitigating risk is derived.

INTRODUCTION
Generically, a food supply chain starts from the farmer, who produces (grows) the raw food and then supplies this to food processors. Transport companies/ logistics providers link the farmer to the food processors. Sometimes, wholesalers/ marketers may be a part of the chain who will buy from the farmer and sell to the food processors. The exact supply chain path for a particular food product depends on the product characteristics, size and market power of the supply chain members (Maloni and Brown 2006). The 'farm to fork' cycle spans different organisation types, continents, cultural systems, regulations etc. As supply chain members increase, the complexity increases on account of issues related to trust, traceability and transparency. Roth et. al. (2008) have suggested that the major forces affecting traceability and transparency are globalisation, consolidation and commoditisation. Globalisation refers to the movement of the food supply chain model from regional to global in terms of both importing raw materials to exports of final products. Consolidation refers to the trend amongst food supply chain members to combine as many food categories as well as levels of the supply chain in pursuit of higher margins. Commoditisation refers to the distinction between food products as either value added or commodities. This highlights not only the high interlinking of the food supply chains but also the vulnerability of such chains. Inter-firm networks have been an important element of Japanese and Korean manufacturing supply chains. This paper studies the various factors driving inter-firm networks and considers the concept for alleviating risks in the global food supply chain.

FOOD SUPPLY CHAIN RISKS
Fearne, et. al. (2001) suggest that frequent food safety and security scares has led to an increase in the focus on the causes, effects and prevention of hazards. Peck (2006) in her report has identified a gap in the preparedness for business continuity management (BCM) as organisations tend to adopt a more reactive mode of crisis management than a proactive mode. One of the conclusions of her report was that the drive for efficiency and the just-in-time philosophy used by the food industry has progressively reduced stock levels throughout the supply chain - with the resulting damage to its resilience when an emergency occurs. Reduction of distribution sites due to consolidation means that the loss of a site due to events such as a fire or flood could also cause a disruption in the supply chain. Although the probability of these events happening can be ascertained, according to Peck (2006) due to larger and fewer distribution sites the impact of the event is greater. Kleindorfer and Saad (2005) classify risks as those occurring due to

coordinating supply and demand and those arising from disruptions to normal activities. Agiwal and Mohtadi (2008) categorise the risks on a very broad level including risks arising from either intentional or unintentional causes. They argue that intentional contamination is not very infrequent. Sheffi (2005) argues that robust and flexible systems need to be built to effectively handle contamination incidents and increase the risk management capability of the firm in the wake of an event. Sheffi and Rice (2005) advocate that managers need to look into increasing not just safety measures but also safety awareness and a proactive safety culture increasing supply chain resilience.

INTER-FIRM NETWORKS

Sydow and Windeler (1998) define an 'Inter-firm' network as an institutional arrangement among distinct but related for-profit organisations which is characterised by: 1) a special kind of (network) relationship, 2) a certain degree of reflexivity and 3) the logic of exchange that operates differently from that of markets and hierarchies. Ring and Van de Ven (1994) suggest that inter-firm network relationships demand more trust and loyalty and that the relationships are typically complex, reciprocal and relatively stable (Sydow, 1992). Sydow and Windeler (1998) when discussing about the need for reflexivity within inter-firm networks suggest that managers working in inter-firm networks are more likely to consciously consider process improvements that will cut across organisational boundaries, also they are more likely to keep these inter-organisational processes under control. Granovetter (1985) implies that the logic of exchange within an inter-firm network is the social embeddedness within the network, implying that stable relationships between the social actors shape the expectations and behaviours. This embeddedness thus combines co-operative and competitive elements, autonomy and dependence, trust and control (Sydow and Windeler, 1998). Inter-firm network practices create expectations that are based on the 'norm of reciprocity' (Gouldner, 1960) thus creating a 'collective logic' (Lincoln, et. al. 1996) of exchange within the network.

RESEARCH DESIGN

When considering the recent cases of food contamination and the percolation of the risk across national boundaries through the supply chain, the research questions that arose for this study were:

(1) Can inter-firm networks alleviate supply chain risks within global food supply chains?
(2) What are the factors that impact inter-firm networks?

In order to explore the research questions, a literature review was conducted on inter-firm networks and food supply chains. Also, the literature surrounding the recent food contamination cases was analysed using grounded theory principles to identify themes impacting inter-firm networks. The analysis identified that for inter-firm networks to work in managing and mitigating food supply chain risks the factors to consider are: Trust and Governance. These have to be supported by the appropriate Internal Controls which will eventually lead to a good Supply Chain Relationship.

CASE EXAMPLES

1) China milk scare

In November 2008, the milk scare materialised after milk and milk powder was found contaminated with Melamine. Kidney dysfunction caused by the Melamine led to 240,000 infants being affected with 50,000 hospitalised and six deaths were confirmed (WHO, 2008). Although this was a case of deliberate contamination the global dimension of the problem was only apparent when the contamination was confirmed in New Zealand. Despite warning signs and tests confirming contamination the issue became public and production at 'Sanlu' stopped only when 'Fonterra', a New Zealand based group who owns 43% stake in 'Sanlu', confirmed the contamination and informed the New Zealand Government which in turn notified the Chinese Government and the WHO (Vaudine England, 2008). This led to a trade recall of products with Chinese milk derivatives in it and at least eleven countries stopping all imports of Chinese dairy products. Non fatal cases were reported from Asian countries like Hong Kong and Taiwan and contaminated products were identified as far as the Netherlands and USA. Besides milk, Melamine was also found in derivatives like frozen yogurt dessert, biscuits, candies and in coffee drink. The recalls cascaded down leading to major recalls by global giants like Tesco recalling the white rabbit candy from its UK stores, Cadburys recalled all 11 products made in its Beijing factory supplying to Australia, Hong Kong, Taiwan besides China (Reuters, 2008a). Heinz, Nestle, Unilever and Starbucks also responded with similar recalls or substitutions in Southeast Asia (New Mexico Business Weekly, 2008; Coghlan, 2008). News articles suggest that this was not an isolated case and that Melamine has been used previously by poor farmers, milk collectors and milk dealers as "protein powder" to enrich test results for milk produced by weak or malnutritioned cows. Also, the literature suggests that Melamine can enter the food chain through the use of pesticides like Cyromazine. Testing at lower levels of the supply chains like farmers and marketers is difficult as it can be expensive and time consuming (Coghlan, 2008; Reuters, 2008b ; Fairclough, 2008).

2) Sudan 1
Another recent case of food contamination which affected the UK was the detection of Sudan 1 dye in Worcester sauce produced by Premier foods, a UK based food manufacturer. Sudan 1 dye was identified as a contaminant in chilli powder and is associated with increased risk of cancer. Sudan 1 was first identified in a consignment of Worcester Sauce exported to Italy. This led to a recall of over 580 products mostly ready meals, snacks, sauces and drinks. (FSA, 2005; BBC, 2005). Although inspection requirements were in place to test Sudan 1 on all chilli powder being imported into the UK since 2003 but the contaminated consignment identified in 2005 was reported to have originated before 2003. Considering the long shelf life of both chilli powder as well as the final products like sauces and snacks the recall of products required extensive coordination between local authorities and the Food Standards Agency (FSA). A review of the incident was commissioned to be carried out by an independent panel. The report identified major failures in communications and coordination between agency, industry and the local enforcement authorities (FSA, 2007).

FACTORS AFFECTING THE ABILITY OF THE INTER-FIRM NETWORK TO ALLEVIATE SUPPLY CHAIN RISK

1. Trust
A high degree of trust between the partners in a buyer-supplier relationship is favourable for co-ordinated behaviour, whereas low trust leads to competitive behaviour (Anderson and Narus, 1990). Long- term relationships and trust encourage effective communication, information sharing and joint pay-offs (Dwyer, et. al., 1987; Ring and Van den Ven, 1992). Liker et. al. (1995) link the concept of trust to mutual dependency, "Trust as mutual dependence suggests that each party realizes that it has much to lose by endangering the relationship." Within a food supply chain trust is very important when traceability and transparency are difficult to achieve. In the food industry, as in others, one strategy for safeguarding quality is investment in long term relationships with trustworthy suppliers, rather than chasing lower prices by constantly putting contracts out for bidding (Roth, et. al., 2008). Trust built up through long term relationships also requires a mutual agreement to meet international certification standards and other auditing requirements. Alternatively, certification programs, shared values and reciprocity in benefits can help in developing trust and long-term relationship.

2. Governance
As food supply chains get global and complex it is getting extremely difficult for individual companies in the supply chain to monitor the supply chains themselves. To add to this, legal obligations to consumers have increased for supply chain entities: for e.g. under the

EU law, retailers and brand owners have a legal responsibility for their brands (Business Standards, 2008). Food certification programs provide an alternative to purely market or regulatory mechanisms in the global marketplace (Roth, et. al., 2008). ISO 22000 standardises global food safety standards and emphasises interactive communication and traceability right through the supply chain. The **Sanitary and Phytosanitary Measures Agreement** or **SPS** is an international agreement on food safety and animal and plant health standards that sets out the basic rules. However, it allows individual countries to set their own food safety standards. Member countries are encouraged to use international standards, guidelines and recommendations where they exist. If an exporting country can demonstrate that the measures it applies to its exports achieve the same level of health protection as in the importing country, then the importing country is expected to accept the exporting country's standards and methods (http://spsims.wto.org/).

3. Relationship

Supply chain relationships have been seen to be an important aspect of managing supply chains. Research has concentrated on the actual dynamics of the supply chain and the role of each entity at the inter-organisational boundary. Some of the researchers have tried to work on developing Relationship assessment programmes (Lamming, et. al. 1996) which have tried to focus more on Vendor assessment. The emphasis upon managing the supply chain as a source of competitive advantage has led many organisations to reassess the role of the supplier within their own ability to achieve or sustain competitiveness and customer service. Within the food supply chain, better relationships could help to reduce opportunistic behaviour and facilitate better implementation of food safety thus reducing the proliferation of the food risk through the global supply chain.

4. Internal controls

Some of the Internal controls which an organisation within the food supply chain can utilise to manage/ mitigate supply chain are:

IT disaster recovery plans.	Mission critical assets and activities identification
Recall procedures	Scenario planning
Crisis Management Team / Incident Management Team	Relocation readiness
Risk registers	Continuity planning with suppliers and customers.
Risk analysis and categorisation (Likelyhood/ Impact)	Supplier compliance audits and risk diagnosis

DISCUSSION AND CONCLUSION

The paper has presented insights from a preliminary qualitative study conducted to explore the effect of Inter-firm networks on alleviating risks within the international food supply chain. The analysis of literature and the case examples (two of which are depicted in the paper) showed that four factors were important for managing and mitigating risks within the international food supply chain. These factors are depicted in figure 1 below:

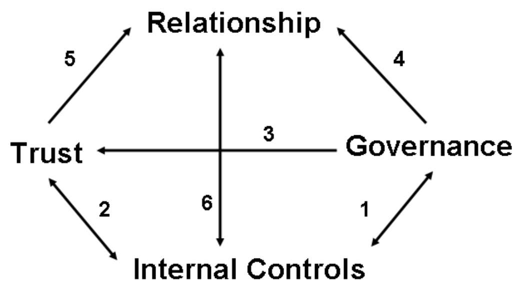

Figure 1: factors important for an inter-firm network

Since inter-firm networks tend to create motivation and social contracts for working together towards a common goal, it can be implied that in relation to international food supply chains and issues regarding food safety and contamination, the formation of inter- firm food supply chain networks may invoke a collective sense of responsibility towards managing and mitigating risks. In order to create these networks, the factors depicted in figure 1 are important. It can be argued from both sides: that these factors may facilitate inter-firm networks, whereas having inter-firm networks may facilitate trust among the supply chain entities, lead to better governance and eventually form 'win-win' supply chain relationships. The focus of this paper however, is in considering these factors only from the point of creating enablers and drivers within the food supply chain to manage and mitigate risks across international boundaries. With reference to figure 1 the links can be explained as follows:

1) Governance will define the internal controls required within individual organisations and the network, reciprocally, when the internal controls are set in it will lead to better governance of the food supply chain,
2) Setting up of the appropriate internal controls will lead to trust among the supply chain members, reciprocally, trust within the members will lead to common network – spanning controls,
3) Implementing internationally recognised governance mechanisms will lead to trust among the members,
4) Implementation of governance mechanisms within the network will help to form better relationships among the supply chain members, coupled with,
5) Trust will help in maintaining and sustaining the relationship and the required motivation and collective focus to manage and mitigate risks,
6) A good relationship among the members will mean that each member will follow the network- spanning controls, reciprocally, a good supply chain relationship will enable the members to modify and implement new controls on a dynamic basis.

Although, the model seems to be simplistic, the relationship between the four factors as depicted through the links is complex and dynamic. A vertical Keiretsu, which is a form of inter-firm network has been an important part of the Japanese industry (widely used within the Japanese automotive sector). Williamson has suggested (1985, pg. 120) that the 'unusual relationship' between Toyota and its' subcontractors arose as Toyota could emphasise to the network that they all faced a common destiny. According to Edwards and Samimi (1997), the lead firm in the vertical keiretsu (inter-firm network) developed punishment and reward systems to maximise co-operation, i.e. relational contracting, continual monitoring of supplier performance, etc. This suggests that controls and governance will play an important role in the operation of an inter-firm network. Hagen and Cho (1998), mention that institutional sanctions help to foster cooperation and eventually trust. Hence, in order to reduce food contamination and increase cooperation between the food supply chain partners the factors leading to inter-firm networks should be studied in detail. The next phase of the research will endeavour to operationalise the links and empirically test out the factors for their strength in alleviating food supply chain risks.

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THE ROLE OF TRUST AND TECHNOLOGY ON COLLABORATION AND SUPPLY CHAIN PERFORMANCE

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ABSTRACT
Purpose of this paper is to examine the relationship between trust and technology in achieving collaborative supply chain partnerships and the impact of collaborative supply chain partnerships on supply chain performance. A conceptual framework identifies the roles of trust and technology in achieving collaboration and supply chain performance. For the purpose of this study three hypotheses were developed and tested with a sample of 81 buyers of retail convenience stores and suppliers of FMCG goods. The Findings suggest that trust and technology have strong relationships with collaboration while collaboration has a moderate relationship with supply chain performance. This study is limited to the retail industry. The study provides insights into why trust and technology are important in the retail and FMCG business sectors.

INTRODUCTION
Supply Chain Management is the process of planning, implementing and controlling the operations of the supply chain as efficiently as possible, and this includes transactions raw materials, through work in process inventory, to point of consumption. Collaboration is a part of Supply Chain Management, and involves the use of application tools like EDI, VMI, and CPFR to facilitate the process. Research conducted by AC Nielsen in Thailand reports that the retail sector (convenience) has grown from 12 % in 2002 to 15% in 2005 and there are huge opportunities to explore the benefits of collaboration to help reduce costs and maximize profits. However, for a successful collaboration two determinants are needed, namely trust and technology. This paper endeavours to provide some insight into the implementation of a successful collaboration programme by examining the relationship between these determinants and the desired outcomes.

LITERATURE REVIEW AND HYPOTHESES
The theoretical model guiding the research largely builds upon business relationships theory (e.g. Morgan & Hunt, 1994) and inter-organizational relationships theory (e.g. Malone, 1998) as it addresses the following research questions:

- How do trust and technology exchange affect collaboration in supply chain relationships?
- Is there a level of supply chain performance which affects the strength of collaboration?

Collaboration is the degree to which partners are able to work together in joint fashion toward their respective goals (Frazier, 1983) and has emerged as a key construct in the study of supply chain partners. Collaboration can both achieve significant cost savings and increase the overall competitiveness of the supply chain (Womack et al., 1990; Spekman et al., 1998). Collaboration is the crux of CPFR (VICS 1998, 2002)

Trust and Collaboration
Trust is frequently defined as a willingness to take risks (Mayer et al., 1995) and a willingness to rely on an exchange partner in whom one has confidence. Morgan and Hunt (1994) argued that trust exists when one party has confidence in an exchange partner's reliability and credibility. Many theories have identified the role of trust in business relationships, where trust has been found to contribute to better cooperation, thus leading to communication openness and information sharing (Morgan and Hunt, 1994; Ring and Van de Ven, 1994; Cummings and Bromiley, 1996; Smith and Barclay, 1997). Trust is the degree to which partners perceive each other as credible and benevolent (Doney and Cannon, 1997; Ganesan, 1994; Kumar et al., 1995) and is expected to have a positive effect on the degree of collaboration in supply chain relationships. If parties expect each other to be both able and willing to perform the necessary tasks, they are also likely to collaborate (Mohr and Spekman, 2005; Morgan and Hunt, 1994). Moreover, for supply chain

partnerships to become truly collaborative in nature, trust is not only a desired characteristic, but a necessary one (Spekman et al. 1998, p.635). Hence, H1. Trust in the relationship between buyer and a supplier is positively related to the degree of collaboration in the relationship.

Technology and Collaboration

The role of IT has been demonstrated to support exchange between trading partners (Pramatari 2007). Nohria and Eccles (1992) suggest that electronically mediated exchange contributed to increased collaboration because it empowered front-line workers with information, enabled direct communication between individuals at low levels in the organization across time and space and blurred organizational boundaries. Electronically mediated exchange refers to the degree to which partners communicate through electronic media such as the internet, intranets, electronic mail or electronic data interchange (EDI) systems (Kulchitsky, 1997). In the supply-chain context, integrated information flows often reduce uncertainty (Alliare and Firsirotu, 1989) as well as reduce system volatility induced by information delays (Towill 1992). The common theme is that electronically mediated exchange supports inter-organizational collaboration by facilitating interaction and dissemination of information at all organizational levels. Myhr and Spekman (2005) found that collaborative partnerships can be achieved both via trust and through electronically mediated exchange (e.g., information technology). Because electronically mediated exchange assists people at the operational level who need up-to-date information to carry out their roles effectively in supply chain relationships, electronic mediated exchange is likely to have an immediate impact on the construction of collaboration. Hence, H2. Technology used between buyer and suppliers is positively related to the degree of collaboration in the relationship.

Collaboration and Supply Chain Performance

Performance measurement is the process of quantifying the effectiveness and efficiency of action (Neely et al., 1995). Effectiveness is the extent to which a customer's requirements are met and efficiency measures how economically a firm's resources are utilized when providing a pre-specified level of customer satisfaction. Performance measurement systems are described as the overall set of metrics used to quantify both the efficiency and effectiveness of action. There are number of approaches to performance measurement, including the balanced scorecard (Kaplan and Norton, 1992), the performance measurement matrix (Keegan et al., 1989), performance measurement questionnaires (Dixon et al., 1990), criteria for measurement system design (Globerson, 1985) and computer aided manufacturing approaches. Efficiency and effectiveness have been used as key indicators measuring supply chain performance (Beamon, 1999; Holmberg, 2000; Li et al; 2006; Tan et al., 1998). Two well known indicators are cost and reliability. The cost indicator includes the costs of transport into and out of the process, warehousing costs and the costs of holding inventory. Reliability indicators address such areas as order fulfilment rate, inventory turnover, safety stocks, inventory obsolescence and number of product warranty claims.Supply chain collaboration facilitates the cooperation of participating members along the supply chain to improve performance (Bowersox, 2000). The benefits of collaboration include revenue enhancements, cost reductions, and operational flexibility to cope with high demand uncertainties (Fisher, 1997). Hewlett-Packard, IBM, Dell and Procter and Gamble, firms that have worked closely with their partners, are several examples of companies that have captured the advantage of collaboration (Barratt and Oliveira, 2001; Callioni and Billington, 2001; Dell and Fredman, 1999). Hence, H3. Collaboration between buyer and suppliers is positively related to supply chain performance.

Figure 1: Conceptual Framework

METHODOLOGY

This research used a survey approach to test the impact of trust and technology on collaboration and supply chain performance. The research aimed to gather and use the data using a questionnaire survey to evaluate the three hypotheses.The conceptual model developed for this study is based on the theoretical perspectives which were found to be relevant based on the theories about trust in business relationships, inter-organizational relationships theory (IOR) and technology based mechanisms in collaborative supply chain. These theoretical perspectives contributed to an understanding of the potential strengths and weaknesses of trading partner relationships in collaboration.

Respondents and sampling procedures

The respondents were the buyer and supplier executives in the business-to-business (B2B) retail industry for fast moving consumer goods (FMCG). The research draws on the collaboration and supply chain performance between B2B retail industry and suppliers who are involved in supply chain relationships in Thailand.

Data Collection Method

Data used in this study was first based on secondary sources e.g., peer-reviewed journal papers, industry reports, government statistics, etc. Then the primary data was collected. A total of 81 questionnaires were administered in the period January to March 2008. To make the process of filling of questionnaire easier for the respondents, the questionnaire was translated into Thai, using the back translation method. The sample was selected randomly based on the Retail Association of Thailand Directory, 2007. Invitations to participate in the survey were sent out, followed by the survey instrument.

ANALYSIS

Construct Reliability and Validity

After the data were collected, the measures were subjected to a purification process assessing their dimensionality, reliability, and validity. The psychometric properties of the four constructs (trust, technology, collaboration and supply chain performance) were evaluated in separate confirmatory factor models using AMOS (Maruyama 1998). Because of the small sample size (n = 81), this approach was selected rather than a single confirmatory factor analysis model to fit the constraints of a five-to-one ratio of sample size to parameter estimates (Bentler and Cho 1988).

The model fit was evaluated using GFI, AGFI, NFI (Joreskog and Sorbom 1993). The specific items were evaluated based on the item's error variance, modification index, and residual covariation (Anderson and Gerbing 1988; Fornell and Larcker 1981; Joreskog and Sorbom 1993). Construct reliability was evaluated using the procedures suggested by Fornell and Larcker (1981), including examining the parameter estimates and their associated *t* values and assessing the average variance extracted for each construct (cf. Anderson and Gerbing 1988; Bagozzi and Yi 1988). Also, construct reliability was assessed using the Cronbach's Alpha and all the constructs had a value of above 0.70 (Nunnally and Bernstein 1994). Discriminant validity was assessed in a two-step process. An initial level of discriminant validity was established by calculating the shared variances between each pair of constructs and verifying that it was lower than the average variance extracted for the individual constructs (Fornell and Larcker 1981). This was the case for each average variance extracted/shared variance scenario in both samples. Next using a procedure recommended by Anderson (1987) and Bagozzi and Phillips (1982), pairs of constructs were assessed in a series of two factor confirmatory factor models using AMOS. Each model was run twice, once constraining the Phi coefficient to unity and once freeing this parameter. A chi-square difference test was then performed on the nested model to assess whether the chi-square values were significantly lower for the unconstrained model (Anderson and Gerbing 1988). The critical value ($\Delta\chi^2[1] > 3.84$) was exceeded in all cases, indicating that discriminant validity exists between the scales used in this study. Overall, the measurement suggested that the four scales employed were reliable and valid in the context of this study. The results of the measurement analysis for each construct are presented respectively in Tables 1, 2, 3 and 4, which includes means, standard deviations, construct reliabilities, and fit indices.

TRUST *(Alpha = 0.842)*	**Mean**	**S.D**	**χ^2**	**df**	**GFI[1]**	**AGFI**	**NFI**
Reliability	4.02	.836	11.19	5	.94	.89	.91
Cooperation	3.93	.818					
Information sharing	3.88	.765					
Communication openness	3.84	.887					
Exchange resources	3.73	.775					
We keep promises we make to each other	4.10	.800					
Each party believes the information provided by the other	3.91	.854					
We both find each other trustworthy	3.98	.821					
Each party communicates with an open mind	3.98	.851					
Each party think in long term view	3.94	.780					

TABLE 1: SUMMARY OF THE MEASUREMENT ANALYSIS FOR TRUST

TECHNOLOGY *(Alpha = 0.736)*	**Mean**	**S.D**	**χ^2**	**df**	**GFI**	**AGFI**	**NFI**
Fax	3.98	1.012	3.91	5	.98	.94	.94
Intranet	3.65	.964					
Internet	4.25	.981					
EDI(Electronic data interchange)	2.68	1.321					
VMI (Vendor Management Inventory)	1.57	.851					
CRP	1.21	.439					
ECR	1.35	.710					
Technology is an important enabler in this relationship	3.98	.806					
We are linked electronically so that we can share information of mutual interest	4.10	.800					
We emphasize integrated information systems	4.12	.781					
We frequently communicate through electronic media e.g., the internet, intranets, electronic mail or EDI systems	4.10	.957					
To make technology a success requires trust	4.25	.751					

TABLE 2: SUMMARY OF THE MEASUREMENT ANALYSIS FOR TECHNOLOGY

COLLABORATION *(Alpha = 0.703)*	**Mean**	**S.D**	**χ^2**	**df**	**GFI**	**AGFI**	**NFI**
We are achieving our long term goals together	3.90	.735	4.09	5	.98	.94	.93
In this supplier (buyer) relationship, we share ideas, information, and/or resources	3.86	.848					
Working together with supplier as a team	3.57	.921					
People from both companies work together informally	3.41	.959					
We have set KPI together (you and supply chain partner set objective and measure together)	3.69	.785					

TABLE 3: SUMMARY OF THE MEASUREMENT ANALYSIS FOR COLLABORATION

PERFORMANCE *(Alpha = 0 .701)*	**Mean**	**S.D**	**χ^2**	**df**	**GFI**	**AGFI**	**NFI**
Total cost competitiveness	3.96	.993	3.24	5	.98	.95	.95
Perfect order	4.02	.866					
Lead-time response	3.86	.802					
Packing quality	3.86	.787					
Customer satisfaction	4.81	.503					

TABLE 4: SUMMARY OF THE MEASUREMENT ANSLYSIS FOR SUPPLY CHAIN PERFORMANCE

[1] Note: GFI = Goodness of Fit Index, AGFI = Adjusted Goodness of Fit Index, and NFI = Normed Fit Index

Inferential Analysis
Table 5 reports the results of the hypothesis testing. Structural equation modelling with AMOS was used to simultaneously test the relationships proposed in Hypotheses 1 through 3 (Joreskog and Sorbom 1993). The fit indices of GFI, AGFI, CFI, and NFI range between .92 and .98. The relative ability of the hypothesized antecedents (trust and technology) to explain variation in collaboration, as measured by R^2 value, was 97.9 percent. The relationship between collaboration and supply chain performance had an associated R^2 value of 37.1 percent. The findings for each hypothesis are presented in Table 5.

Path	Loading	t-Value	Significance	R^2	Fit Indices
H1 (Trust → Collaboration)	.88	2.396	P<.05	.97	χ^2 = 271.987 df = 149 GFI = .98, AGFI = .92 CFI = .97, NFI = .92
H2 (Technology → Collaboration)	.45	2.229	P<.05		
H3 (Collaboration → Performance)	.60	2.360	P<.05	.37	

Note: H = Hypothesis, GFI = Goodness of Fit Index, AGFI = Adjusted Goodness of Fit Index, CFI = Comparative Fit Index, and NFI = Normed Fit Index

TABLE 5: STRUCTURAL EQUATION RESULTS OF HYPOTHESIZED MODEL TESTING

FINDINGS AND DISCUSSION

Antecedents of Collaboration

The results suggested a positive relationship between trust and collaboration (loading = 0.88) and between technology and collaboration (loading = 0.45). Hence, both Hypotheses 1 and 2 were supported. Interestingly an in-depth analysis of the path loadings and the associated t-values suggests that behavioural antecedent trust [0.88, (2.396)] has a higher impact on collaboration than technology [0.45, (2.229)]. That means technology is merely an enabler to effective collaboration, while behavioural aspects of collaboration are much more important to make collaboration a reality.

Outcomes of Collaboration

The analysis provided support for Hypotheses 3. The relationship between collaboration and supply chain performance had a loading of 0.60. The empirical investigation first provided support for the conceptualization of collaboration as a mediating construct between trust, technology, and supply chain performance. The behavioural characteristic of the proposed construct, trust, makes it instrumental to audit collaboration and supply chain performance. In addition, the measure of collaboration calls for managers to integrate a number of activities that may already be performed by their organization but that often remain independent from one another. An example of this is the type of technology used e.g., EDI, fax, internet, intranet. Firms within the same supply chain are more likely to reap mutual benefits if they create connectivity across these various technological tools and monitor them as a whole.

Antecedents and Outcomes of Collaboration in the Supply Chain

The study findings suggest that collaboration plays an essential role in achieving better supply chain performance. This result highlights innovation as another benefit of collaboration in the supply chain beyond the achievement of greater performance. The importance of innovation has been identified in past research (Ellegaard, et al., 2003; Mikkola and Skjott-Larsen 2006). The findings also indicate that the greater the trust and technological capabilities, the more the proactive the collaborative efforts. However, cooperative behaviours do not need to come at the expense of competitive values.

The present analysis clearly demonstrates that trust and technological capabilities are systematically associated with enhanced levels of collaboration. In turn, better collaboration among supply chain partners contributes to better supply chain performance.

Limitations and Directions for Future Research

Despite efforts to provide a meaningful conceptualization and measure of collaboration, the research is not without limitations. First, the study relied solely on the information provided by executives of the firms operating within the FMCG industry that are listed in the Retail Association of Thailand (RAT) directory. Thus, the data gathered are reflective of managerial evaluations of collaboration and performance. Future research could address this caveat by relying on multi-informant research designs.

A second limitation of the study is that it provided an overall assessment of the relationships considered regardless of business size and industry type. There is some evidence in previous research that business size and industry type may influence the propensity of organizations to engage in collaborative efforts.

Finally, the research included only two antecedents of potential collaboration. This focus entails a limited depiction of the role of collaboration. Future research could incorporate more comprehensive antecedents of collaboration. Other antecedents could include the level of commitment displayed by managers. This research constitutes a preliminary attempt to gain a holistic understanding of collaboration. This empirical investigation suggests that sharing information with supply chain members does not come at the expense of performance levels.

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LOGISTICS BENCHMARK STUDY OF THE EAST WEST ECONOMIC CORRIDOR

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ABSTRACT
The main purpose of this paper is to analyse and benchmark the current status of the East West Economic Corridor (EWEC) logistics system[2]. The EWEC is one of most recognised program of the Asian Development Bank (ADB) within the Greater Mekong Sub-Region (GMS) initiative. This development program is named after the physical linkages in the transportation network from East to West across 4 GMS countries, i.e. Myanmar, Thailand, Lao PDR and Vietnam. The rationale behind EWEC logistics benchmark analysis is to provide policy makers with a detailed illustration of the "AS IS" situation and the issues currently constraining integration. Logistics development polices are then proposed to enhance EWEC integration.

INTRODUCTION

The East-West Economic Corridor stretches from Mawlamyine in Myanmar to Danang in Vietnam through several cities in Myanmar, Thailand, Lao PDR and Vietnam. The 1,110-kilometre route is currently utilised, albeit some missing links. Infrastructure was constructed in order to support the physical linkages within the EWEC such as the 2nd Lao-Thai friendship bridge between Mukdahan (Thailand)-Sawanakhet (Lao PDR) and the Hai Van tunnel in Danang, Vietnam. Today, physical connections within the EWEC are almost complete with some links needing rehabilitation in Myanmar.

LOGISTICS EVALUATION FRAMEWORK

The objective of this paper is to evaluate and benchmark the logistics system for each EWEC countries and therefore deliver an appropriate development policy framework based on a "win-win" situation. An evaluation model based on an in-depth understanding of the "AS IS" situation of the logistics system of a geographical area is used as the measurement basis for four logistics related dimensions (Banomyong et al, 2008). A "snapshot" methodology to graphically illustrate logistics corridors based on logistics corridor activity mapping (Banomyong & Beresford, 2001) is also utilised for an in-depth corridor understanding.

According to Banomyong (2009), a regional or a macro logistics system, is composed of (1) shippers, traders, and consignees; (2) public, private sector logistics and transport service providers; (3) provincial and national institutions, policies, and rules; and (4) transport and communications infrastructure. These four logistics-related dimensions are inter-linked to determine the overall capability of the macro logistics system within the scope of the geographical area under scrutiny in terms of system capability and performance.

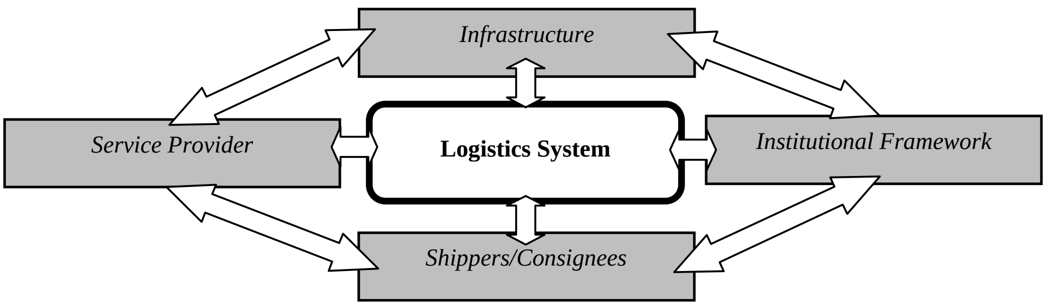


Figure 1: Macro Logistics System Components

[2] The authors would like to acknowledge the Asian Development Bank Regional Technical Assistance Program (RETA 6262): *"Enhancing the Development Effectiveness of the GMS Economic Cooperation Program"* in financially supporting the research.

Roads are still the dominant mode of transport infrastructure in all 3 EWEC countries. Thailand possesses the most developed road network and facilities. The new national airport, Suvarnabhumi, and modern seaports, such as Laem Chabang, support the movement of international freight. Lao PDR, on the other hand, is comparatively less developed. Even though the EWEC road in Lao PDR is physically complete but supporting logistics facilities are still limited. Vietnam's infrastructure has been improved to cope with the new trade flow but maintenance issues will become critical in the near future.

In the EWEC, trade and transport facilitation frameworks are in place but their implementation is still lacking. There is also a myriad of facilitation related agreements that have coverage over different geographical areas. The 4 EWEC countries are parties to both the Cross Border Transport Agreement (CBTA) and the ASEAN Framework agreement for the facilitation of goods in transit (signed in 1998 in Hanoi). There are also bilateral facilitation agreements for goods in transit between Thailand and Lao PDR as well as between Vietnam and Lao PDR. The role of logistics service providers, the use of logistics outsourcing and information technology in managing logistics is relatively well developed in Thailand whereas these practices are still lacking in Lao PDR and Vietnam. From a Lao or Vietnamese perspective, modern logistics practices have not been fully implemented yet. Thai, Lao Vietnamese logistics service providers have developed rapidly and have played a strong supporting role to the manufacturing sectors. However, these companies are often small and cannot compete directly with multinational firms (e.g., TNT, FedEx, and DHL). Logistics service providers in the 3 EWEC countries have different strengths and weaknesses. A common strength is their in-depth knowledge of the local market. Vietnam is currently facing an acute shortage of qualified human resources, while the market in Lao PDR is still based on traditional logistics services such as customs brokerage and physical transportation. Thailand providers may seem to be more competitive but this is only true if the comparison is made with other EWEC providers.

Logistics integration in the EWEC is mostly hindered by the institutional framework that is in place. A facilitating institutional framework is currently being implemented and details still need to be addressed, especially on how to apply all the various facilitation measures. This poses a challenge for all related agencies and stakeholders as new rules and regulations are being put in place with field operatives not knowing how to apply these new measures.

It can be said that Lao PDR is lagging behind in terms of logistics developments when compared with Thailand and Vietnam. Vietnam and Thailand would still not be considered as "world-class" but both national logistics system can be considered to be "fair" (i.e. more or less adequate). However, both countries still require massive infrastructure and institutional development to meet the ever increasing international standard in order to sustain their competitiveness in the global market.

EWEC CORRIDOR ANALYSIS

A corridor analysis will reveal the actual development status of the existing route. This assessment is based on the assumption that a corridor can be defined as:

- Transport corridor: Corridor that physically links an area or region
- Multi-modal corridor: Corridor that physically links an area or region through the integration of various modes of transport.
- Logistics corridor: Corridor that not only physically links an area or a region but also harmonise the corridor institutional framework to facilitate the efficient movement and storage of freight, people and related information.
- Economics corridor: Corridor that is able to attract investment and generate economic activities along the less developed area or region. Physical linkages and logistics facilitation must be in place in the corridor as a prerequisite.

This framework is used to assess the existing development level of the EWEC corridor. The approach is based on a segmented perspective of the EWEC where each individual leg/section in each EWEC country are identified and assessed. The following assessment of the EWEC is presented in Table 1.

Section	Corridor Level Assessed
Tak-Mukdahan	Logistics corridor
Mukdahan-Sawanakhet border crossing	Transport corridor
Savannakhet-Dansavahn	Logistics corridor
Dansavanh-Lao Bao border crossing	Transport corridor
Lao Bao-Danang	Logistics corridor
OVERALL ASSESSMENT	**Transport Corridor**

Table 1: Corridor Assessment Level

The overall assessment level of the EWEC is based on the weakest link of the corridor. It must be noted that logistics corridors do exist but only within the boundary of a country and not at the EWEC or cross border level. The current status of EWEC border crossings is still based solely on existing physical links as the institutional framework facilitating border crossing has not been totally implemented.

EWEC ROUTEING

There are 2 main veins that exist within the EWEC (1) the route from Tak to Danang which is the original EWEC route, designated by ADB and (2) the private sector EWEC routeing that is currently being used which includes Bangkok and its industrial estates, Hanoi, Hai Phong and Ho Chi Minh City in Vietnam as its origin and destination points.

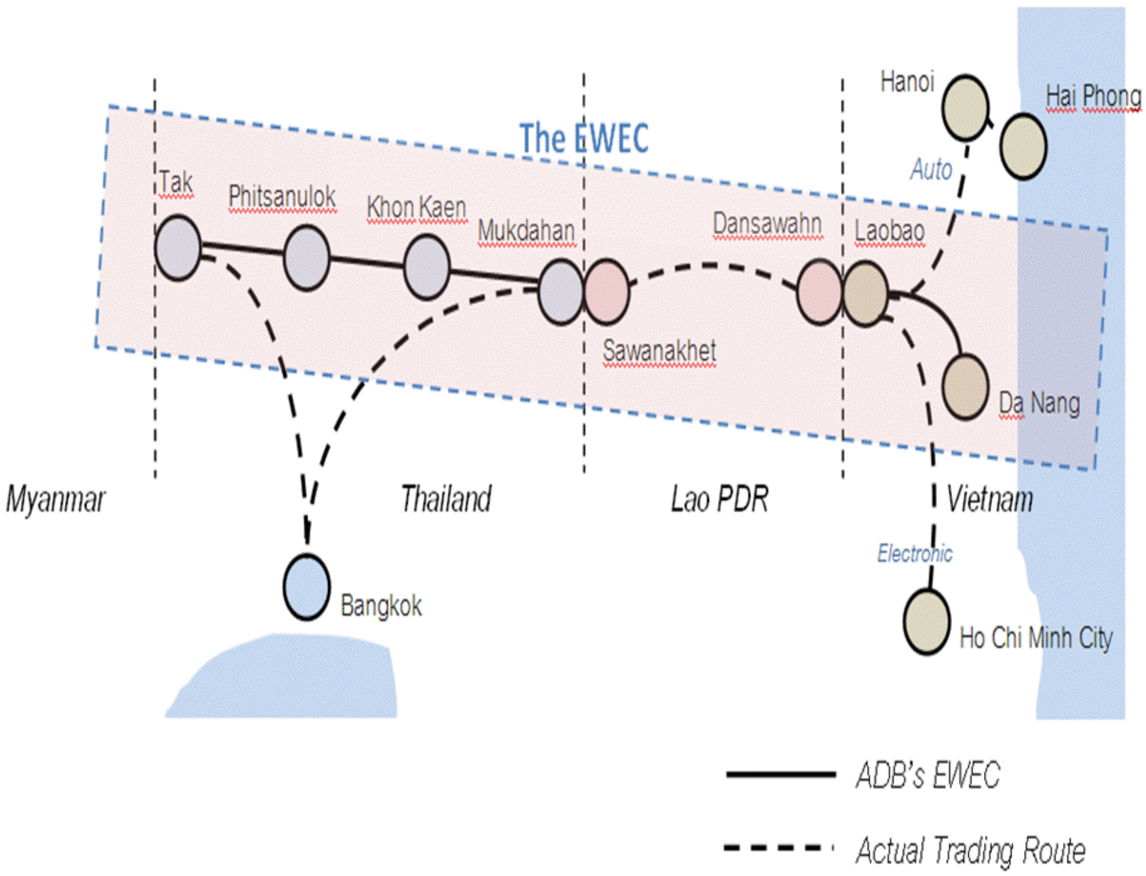
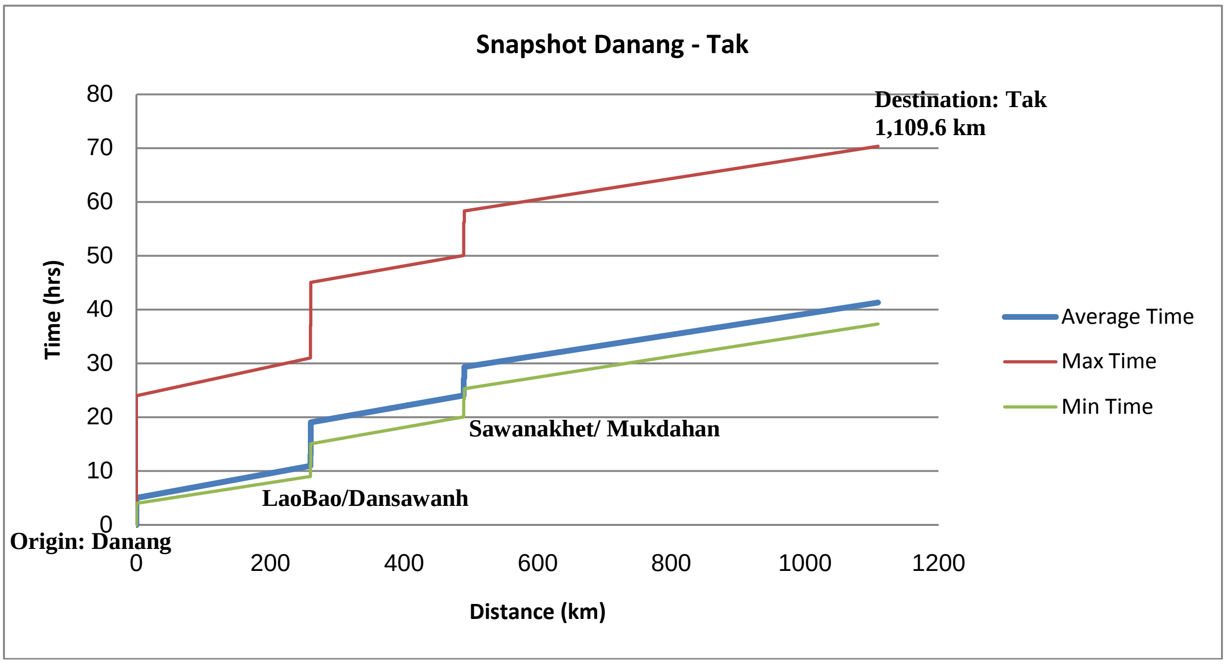
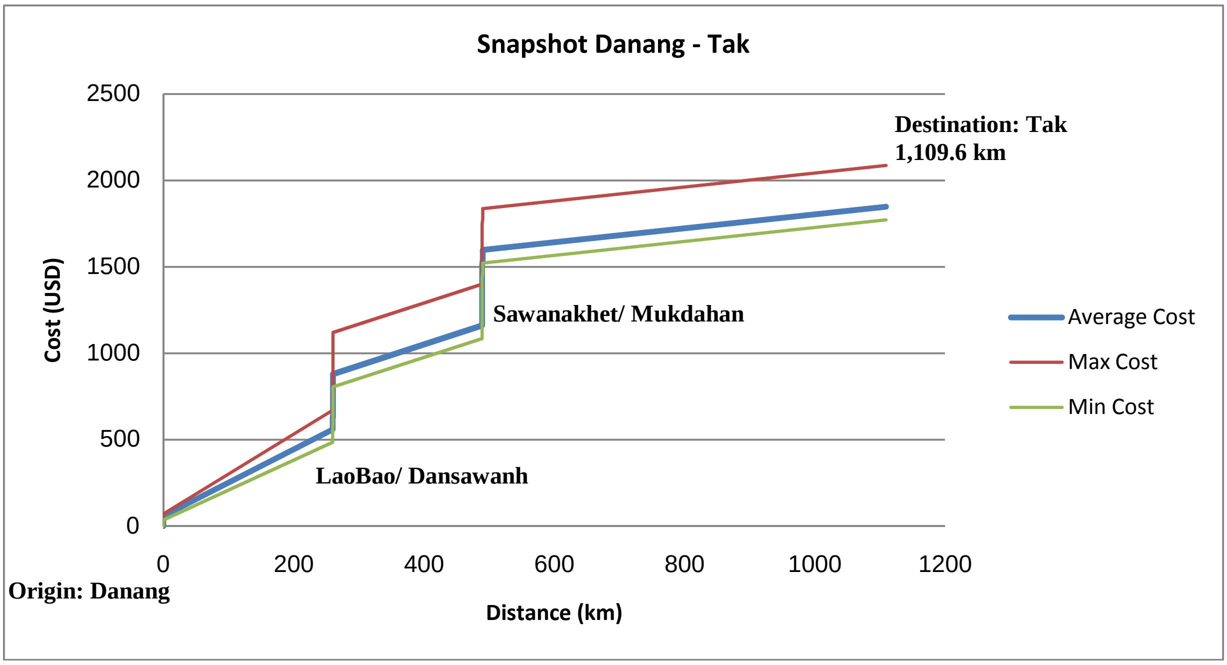


Figure 2: EWEC Network

Currently, commodity flows on ADB's EWEC are almost inexistent (Than, 2005). The main existing product flows within EWEC are mostly from/to Bangkok/Laem Chabang of Thailand and from/to Hai Phong (automotive products) and Ho Chi Minh City (electronics products) of Vietnam. Current existing flows are illustrated by the "doted" line in figure 2. However, the scope of the paper is on the ADB's version of the EWEC which means that there is in reality no real flow of goods between Danang to Tak province at the border with Myanmar. A "snapshot" of EWEC route based on information collected will be presented hereunder. As seen in the model, transportation in itself is quite reliable as there is not much difference in terms of service time. The area which is the less reliable from the graphical model is the border crossing and the entry into Vietnam. This wide variation is based on a number of factors. The most common factor that increases the unreliability within the EWEC is the lack of appropriate import or transit documentation.Based upon the empirical evidence collected on the route between Danang and Tak, it is noticed that nearly a half of a total 41.3-hrs transit time (18 hrs, equivalent to 43.5%) are in fact taken at customs or border crossings based on each country's administrative formality. The non-synchronisation and complicated institutional framework are clearly bothering the smooth flow of goods across borders. From a cost-perspective, 42.6% of the door to door transport costs are collected at customs and border crossings. The amount is almost equivalent to the cost of physical transportation. This evidence is frightening and must be solved. The international institutional framework must be better arranged or implemented, if they have already been agreed upon.



(a) Transit time from Danang to Tak



(b) Transportation cost from Danang to Tak

Figure 3: Snapshot of EWEC, Route Danang to Tak

In terms of reliability, it is noticed that Thailand and Vietnam are slightly more reliable than Lao PDR in term of infrastructure, administrative and business operations. However, as an economic chain, the problem with the administrative process reliability is still evident in majority of the EWEC area. There is not much confidence on administrative processes. Reliability of local business operators is also considered to be limited compared to the multinational firms that are now entering the EWEC logistics market.

SUMMARY

This paper has tried to assess the logistics capability of the EWEC and explored the numerous barriers for the free flow of freight, vehicles, people and information along the corridor. The physical route is currently completed but the supporting and administrative procedures are still lacking. Each EWEC country is still at an early stage in term of logistics development based on the 4 logistics dimensions. The EWEC infrastructure is more or less completed but some of the border facilities are still insufficient and inefficient. In addition, local service providers lack in technology and logistics skills, resulting in strong competition from foreign owned service providers LSP. From the snapshot methodology, trans-loading and border crossing still remains a barrier to the seamless movement of freight, people and vehicles along the EWEC.

It is important that policy recommendations are made and presented hereunder in order to improve the logistics integration of the EWEC for the purpose of transforming the EWEC into a full-fledged economic corridor. Each proposed project concept is based on specific findings of issues associated with the EWEC logistics benchmark study. Priority should be given to the proposed pilot implementation of trade and transport facilitation measured along the EWEC as ADB led trade and transport facilitation measures have yet to be fully implemented. Figure 4 illustrates the proposed projects classified by issues identified in the study as key to the development of logistics in EWEC.

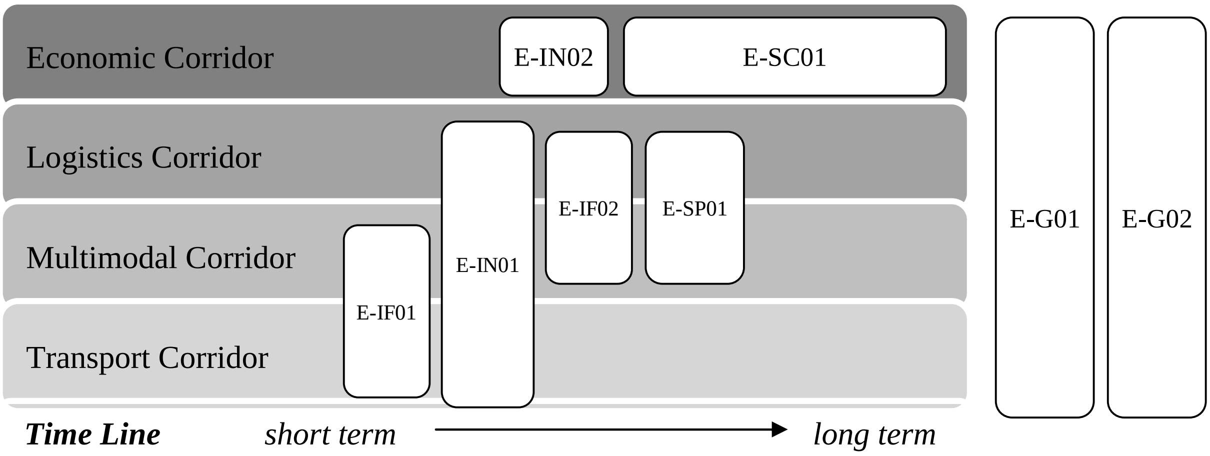


Figure 4. EWEC Policy Recommendation Framework

In each policy dimension, specific programs are proposed. These specific programs are again based on the study's empirical findings.

1. **<u>Infrastructure-Based Program:</u>**
   1.1E-IF01: EWEC Basic Infrastructure and Logistics Facility Development
   - To improve and develop basic logistics infrastructures along EWEC in order to facilitate commodities movement; The developments includes (i) road improvement, (ii) border crossing facilities and (iii) supporting facilities

   1.2E-IF02: Information Technology Development for EWEC Development
   - To develop an appropriate information technology infrastructure for the development of EWEC and to promote IT utilization in business procedures as well as for border crossing activities
2. **<u>Private Sector/Traders-Based Programs:</u>**
   E-SC01: EWEC Investment Forum and EWEC Trade Facilitation Sub-committee
   - To establish an international forum focusing on accelerating and attracting investment and promoting EWEC to local, regional and international traders
   - To establish EWEC Trade Facilitation Sub-committee under ECF (Economic corridor forum) aiming at promoting trade collaboration, establishing business network and facilitate any initiatives to develop EWEC economics
3. **<u>Institutional Framework-Based Programs:</u>**
   3.1E-IN01: CBTA Promotion, Clarification and Full Implementation
   - To promote an accelerate the full implementation of the CBTA

   3.2E-IN02: EWEC Business and Officials Capacity Building
   - To increase businesses' and officials' strengths using knowledge management concept
4. **<u>Service Provider-Based Program:</u>**
   E-SP01: EWEC Local Service Provider (LSP) Promotion and LSP network Development
   - To promote local logistics service provider and develop clusters and networks of regional service providers.
5. **<u>Other Programs:</u>**
   5.1E-G01: EWEC Road Map Development
   - To develop an appropriate road map and development direction for EWEC countries and within the EWEC itself.

   5.2E-G02: EWEC "Reality-Check" Study
   - To explore the current situation and understand why EWEC development has diverged from ADB's initial plans.

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SUPPLY CHAIN INTEGRATION, ITS ANTECEDENTS AND CONSEQUENCES

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ABSTRACT
The purpose of this research is to test the mediating effect among antecedents of internal and external supply chain integration as well as among integration, production performance and firm performance. Although several studies have investigated correlations between these variables, they have mainly focused on the direct relationships. Therefore, this study examines the mediating effect on these variables. Particularly, it tests the mediating influence of internal trust and internal conflict on the correlation between internal communication and internal integration between production and purchasing departments within companies. Similarly, the research examines whether external trust and external conflict mediate the effect of external communication on external integration between a company and its suppliers. Finally, it also investigates whether the relationships between internal and external integration and firm performance are mediated by production performance.

The data was collected by questionnaire. In total, 261 completed questionnaires were received from production managers. The findings predominantly support the research hypotheses. This study expands the literature by examining the mediating effects of antecedents on supply chain integration as well as this kind of effect between supply chain integration and firm performance by functional performance. Furthermore, this research also helps managers understand more the relationship among factors and the way these factors affect supply chain integration and firm performance.

Keywords: Supply chain management, integration, antecedents, firm performance.

INTRODUCTION

Supply chain management (SCM) has been of increasing interest since the 1990s because of the benefits of SCM implementation for firms. Integration is a topic of interest and importance in the supply chain management field because it has been considered as a source of competitive advantage (Gimenez and Venture, 2005). Several studies have explored the antecedents of supply chain integration in order to find a way to improve integration both internally and externally. However, they have predominantly focused on the direct effect of these antecedents on supply chain integration. This study thus examines the mediating effects of these antecedents on supply chain integration.

Similarly, previous studies have examined the relationship between supply chain integration and firm performance. Nevertheless, most of these also concentrate predominantly on the direct correlation between integration and firm performance. Therefore, this study investigates the mediating effect of functional performance, such as production performance, on firm performance.

LITERATURE REVIEW AND HYPOTHESES

The relationships among integration, functional performance and firm performance have been studied in previous research. First, some studies have found evidence for a relationship between integration and functional performance such as logistics performance (Vargas et al., 2000; Stank 2001; Gimenez et al., 2003; Gimenez and Venture, 2005; Sanders and Premus, 2005; Rodrigues et al., 2004; and Germain et al., 2006). Second, the literature also reports that integration has a direct effect on firm performance (Vickery et al., 2003; Droge et al., 2004; Vargas et al., 2000; and Sanders and Premus, 2005). Furthermore, integration not only had a direct effect, but also indirectly impacts on firm performance (Vickery et al., 2003; Droge et al., 2004; Germain et al., 2006). Finally, some studies also discovered that functional performance affects firm performance (Germain et al., 2006). For example, loose integration can negatively affect financial performance directly or indirectly because of low inventory turnover rate and lengthy delivery lead-time, which in turn leads to high inventory costs and finally influences financial performance (Germain et al., 2001). However, this previous research does not test whether functional performance is a moderator of the relationship between integration and firm performance.

Although integration has several antecedents, communication, trust and conflict are often cited as the three most important. However, to date research has focused on testing the direct effect of these antecedents on integration. For example, internal integration is impacted directly by communication (Le Meunier-FitzHugh and Piercy, 2007a; Gupta et al., 1985; Souder et al., 1998; Maltz., 1997; Pagell., 2004; and Rouzies et al., 2005), and conflict (Mollenkoft et al., 2000; Le Meunier-FitzHugh and Piercy, 2007a; Le Meunier-FitzHugh and Piercy, 2007b). Similarly, external integration is influenced by communication (Mohr and Spekman., 1996; Ellram., 1995; Wu et al., 2004), trust (Mohr and Spekman., 1996; Morgan and Hunt., 1994; Ellram., 1995; Wu et al., 2004; Anderson and Narus, 1990), and conflict (Jaworski and Kohli., 1993; Mentzer et al., 2000). In addition, communication has an impact on both conflict (Le Meunier-FitzHugh and Piercy, 2007b) and trust (Morgan and Hunt, 1994; Anderson and Narus, 1990). Therefore, another question that arises from these studies is whether trust and conflict are moderators of the correlation between communication and integration.

Based on a review of the literature, this study proposes four hypotheses, which were also used to derive a research framework, as shown in Figure 1 below.

Hypothesis 1: Internal trust and internal conflict are moderators of the relationship between internal communication and internal integration between purchasing department and production department.

Hypothesis 2: External trust and external conflict mediate the correlation between external communication and external integration between a company and its suppliers.

Hypothesis 3: Production performance has a mediating effect on the relationship between internal integration and firm performance.

Hypothesis 4: Production performance mediates the effect of external integration on firm performance.

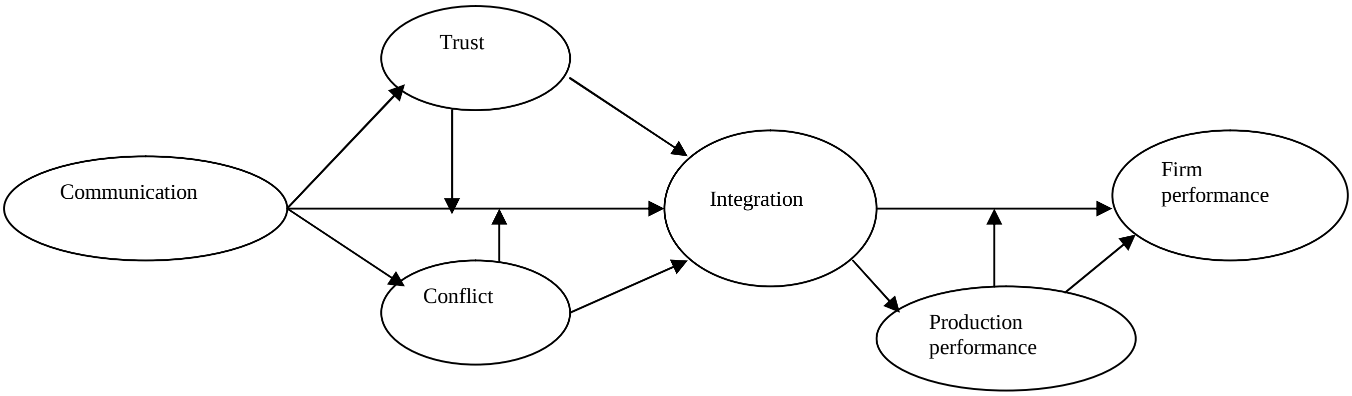

Figure 1: Research Framework

RESEARCH METHOD

This research follows the sequential stages of questionnaire development, pilot test and final survey, and data analysis.

The process of developing the questionnaire followed the procedures which are suggested by Sperber et al (1994). First, the original questionnaire was collectively drafted based on the previous studies in English and then translated into Vietnamese. Next, the questionnaire in Vietnamese was sent to five PhD Vietnamese students in the United Kingdom (UK), the United States and Australia to seek feedback on its content and wording. The Vietnamese questionnaire was then translated back into English by five other PhD Vietnamese Students in the UK. The back-translation questionnaire in English was compared with the original one by the researchers to determine any significant differences between them. Finally, the authors discussed the differences with back-translators and experts in Vietnam to further adjust the Vietnamese questionnaire.

A pilot survey was then conducted to test the reliability of the items in the questionnaire. Sixty questionnaires were sent to production managers. After two weeks, 42 completed questionnaires were collected in person. The result showed that Cronbach's Alphas of all factors were over 0.80, indicating that the research instrument has a highly acceptable degree of reliability. After the pilot test, some minor changes to the wording, structure, format and content of the questionnaire were made.

The final survey was carried out immediately after the pilot was completed. The population consists of manufacturing and production organisations, including for example those in the textile-garment, food and drink and construction sectors. The potential participants were identified from the database of the Vietnamese Ministry of Plan and Investment by a randomly stratified sampling. Three hundred and twenty questionnaires were sent in person to production managers of these companies. After three months, two hundred and sixty one questionnaires were collected in person (the rate of response is 87%).

The data analysis was conducted through a strict process consisting of sequential steps. Firstly, Skewness and Kurtosis criteria were used to check multivariate normality of items of factors. Then these items' reliability was assessed based on Cronbach's Alpha. Next, the validity of factors on the measurement was assessed by exploratory factorial analysis (EFA) and confirmatory factorial analysis (CFA). Furthermore, the assumption of variance homogeneity and the main effect and interactions among control variables on participants' ratings were examined by Levene's test and ANOVA. Finally, research hypotheses were tested. SPSS and AMOS were used for the data analysis process.

The mediating relationship was tested in two steps. The first step was to enter all of the independent variables (*Xi*) into the prediction of the dependent variable (*Y*) to determine the total effect (*βtxi*) of each independent variable. The second step was to repeat step 1, but to take all mediating variables (*Mj*) into consideration to determine the total effect (*βmi*) of each of the mediating variables and the coefficients (*βxi*) of each independent variable. If *βtxi* is different from *βxi*, the relationship between *Xi* and *Yi* is mediated by the mediators. Furthermore, if the coefficient of *Xi* in the second model is nonsignificant, there is a full mediation; however, if this coefficient is reduced but remains significant, there is just a partial mediation.

RESEARCH FINDINGS

Multivariate normality was examined by univariate distribution (Kline, 2005). Extreme univariate nonnormality exists when absolute values of the skewness index are greater than 3 and that of the Kurtosis index are greater than 5. The results show that all values of Skewness and Kurtosis indices are less than these thresholds. Thus, the assumption of multivariate normality is satisfied. In other words, all items distribute normatively and this sample data was applicable to further multivariate data analysis.

Measurement reliability concerns the extent to which measurements are repeatable. Cronbach's Alpha was used to examine the reliability of multiple-item scales in this study. The interpretation of the Cronbach's Alpha coefficient was based on Nunnally's (1978) recommendation that a reliability of 0.70 or higher can be accepted. The finding showed that all reliabilities are greater than 0.70. Furthermore, all values of corrected item- total correlation are greater than 0.25 (Field, 2005). These results indicate that the measurement of items in this study is highly repeatable.

Analysis of EFA and CFA provide robust evidence of the extent to which the measurement set represents a theoretical concept. In fact, the validity of a measurement set refers to the ability to link the empirical indicators to the underlying abstract concept or variable to an acceptable degree. While, EFA is necessary to provide insights into the underlying latent variables (factors) linked to the measuring items, CFA is used to confirm the results of EFA. The finding showed that all *p*-

values of chi-squared statistics are greater that 0.05. This indicates that the measurement models fit the data and have statistically acceptable validity. Other statistical tests of good fit also supported this conclusion. All of the values of GFI, AGFI, CFI are beyond 0.90 and even quite close to 1. Furthermore, all RMSEAs are less than or equal to 0.06. Overall, the measurement sets have been found to fit the data well and are therefore statistically valid.

The assumption of variance homogeneity was examined by Levene's test. The purpose of this test is to verify the significant differences in means of variables across categories within the demographic variables (industry type, ownership, and firm size). The results show that heterogeneity of variance is significant in 3 variables and nonsignificant in 10 variables. It thus indicates that in general the variances of the sample's data are reasonably homogeneous across categories of industry type, ownership and firm size.

The result also shows that the variable "firm size" has a significant effect on the levels of the internal integration factor and the variable "ownership" influences that of five factors including internal integration, external integration, external communication, external conflict, and environment. However, the variable "industry type" does not impact these factors at all. Furthermore, there are no interaction effects among these three control variables on levels of the factors.

To test the first hypothesis (H1), a mediated hierarchical regression (Tabachnick and Fidell, 2007) was employed in which three control variables including industry type, ownership and firm size and the dependent variable (internal integration) were entered. Then, the independent variable (internal communication) was entered (model 1). Next, the two mediating variables (internal trust and internal conflict) were individually entered into model 1, which changed model 1 to model 2 and model 3 respectively. While model 2 consists of three control variables, the dependent variable, and the internal trust variable; model 3 has the same variables but internal trust is replaced by internal conflict. Finally, these two mediating variables were put together into model 1 again to become model 4. Results reveal that the first hypothesis (H1) is accepted. Particularly, the variance explained (R^2) of model 2, 3, and 4 are greater than that of model 1 when the mediating variables were added. Furthermore, the coefficient of mediating variables are significant in models 2,3, and 4; while that of the variable "internal communication" in these models is no longer significant as it is in model 1. In other words, either the individual or a combination of internal trust and internal conflict between the purchasing department and the production department mediate the effect of internal communication on internal integration fully between these two functions.

The process used to test the second hypothesis (H2) is the same as that of the first hypothesis. The result showed that the second hypothesis (H2) is also accepted. R^2s of models 2, 3, and 4 increase compared to that of model 1. However, whereas the coefficient of external trust and external conflict are significant in models 2 and 3, only external conflict is significant in model 4. This means that external trust and external conflict individually mediate the relationship between a company and its suppliers fully. However, the combination of both these factors does not. Only external conflict mediates the effect of external communication on external integration fully. In this case, external conflict may influence the effect of external trust on the relationship between external communication and external integration.

The procedure of testing the third hypothesis (H3) was done similarly to hypotheses 1 and 2. The first step was to enter the control variables (industry type, ownership, and firm size) and the independent variable (internal integration) (model 1) into the prediction of the dependent variable (firm performance). Then, the mediator variable (production performance) is added into model 1 to become model 2. The findings showed that variance explained R^2 in model 2 is greater than that of model 1. Furthermore, the coefficient of both the mediator and independent variables are significant in model 2. However, the coefficient of the independent variable is reduced. Therefore, production performance only mediates the effect of internal integration on firm performance partially.

Testing of the fourth hypothesis (H4) was the same as for H3. However, internal integration is replaced by external integration (mediator variable) in model 1. The findings also showed that variance explained R^2 in model 2 is greater than that of model 1. However, while the coefficient of the mediator is significant, that of the independent variable is no longer significant in model 2. This indicates that production performance mediates the relationship between external integration and firm performance fully.

DISCUSSION AND IMPLICATION

The study supports the SCM literature in that internal integration between departments in a company influences firm performance. However, this research expands the literature through discovering that the relationship between internal integration and firm performance is mediated by production performance. Particularly, production performance mediates the effect of internal integration between production and purchasing departments on firm performance. Similarly, this research also develops the literature by showing that the correlation between firm performance and external integration between a firm and its suppliers is also mediated by production performance. In addition, an interesting point is that while production performance moderates the effect of internal integration on firm performance partially, it moderates the relationship between external integration and firm performance fully. Therefore, companies should enhance integration both among departments inside the organisation as well as between companies and their suppliers in order to improve firm performance. Furthermore, companies should also pay attention to improving their production performance because it impacts the effect of integration on firm performance. In particular, if production performance is improved significantly, the effect of external integration on firm performance is increased significantly too.

This study also supports the literature on the effect of internal communication between departments and on internal integration between these departments in a company. However, one additional contribution of this study compared to previous studies is that we have demonstrated that the correlation between internal communication and internal integration is mediated fully by internal trust and internal conflict between the departments. Particularly, internal trust and internal conflict between the production and purchasing departments mediate fully the effect of internal communication on internal integration between these two departments. Companies thus need not only to enhance the communication between functions in their organizations but also to increase trust and reduce conflict between the functions to further improve internal integration.

Similarly, this research also agrees with previous studies that external communication between organizations has an effect on the external integration between these organizations. In addition, external trust and external conflict between organizations are very important because they mediate the relationship between external communication and external integration fully between these organizations. However, the interesting point herein is that while trust and conflict individually mediate the correlation between external communication and external integration between organizations fully, only external conflict mediates this relationship fully. External trust does not when both these variables are put together into the regression predicting the relationship between external communication and external integration. Thus, companies should increase trust and decrease conflict between themselves and their suppliers; however, they should pay more attention to external conflict than external trust.

CONCLUSION AND LIMITATION

This research has contributed to SCM theory and practice. The first contribution of this research lies in firstly examining the mediating effect of trust and conflict on the relationship between communication and integration inside and outside a company. While previous studies only focused on the direct effect of communication, trust and conflict on integration, this research expands the literature by investigating the mediating influence among these antecedents on integration.

The second contribution of this research is that it is the first study to investigate the mediating influence of functional performance on the correlation between integration and firm performance. Although some previous studies have provided evidence that integration has an indirect effect on firm performance through other variables such as firm competitive advantage, these studies have not however examined the mediating influence of functional performance on this correlation.

Nevertheless, this study has some limitations. First, it does not examine the relationship between the antecedents of integration and firm performance in which integration may be the moderator of this relationship. Second, this research also does not test the relationship between internal and external integration, which may lead to some interesting findings. Third, this paper only provides the results from the production manager's perspective. It would be interesting to include the purchasing manager's perspective on the antecedents of supply chain integration. Finally, this research was conducted only in Vietnam, and it would be of benefit to extend the study to other countries in order to generalise the conclusions. These provide the starting points for further research on improving internal and external supply chain integration.

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COMMUNICATING CREDIBLY SUPPLY MANAGEMENT'S VALUE CONTRIBUTION: ASSESSING FINANCIAL PERFORMANCE MEASUREMENT IN FRAGMENTED RELATIONSHIPS

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ABSTRACT

Category: Conceptual Paper

Purpose: Purchasing and Supply Management (PSM) has a constant credibility problem with its financial performance reports. The paper analyses underlying factors that cause these credibility concerns. It describes how general characteristics of PSM hinder PSM on convincingly communicating its value contribution.

Design: We use principal-agent theory to derive general characteristics that cause problems when measuring PSM's performance. We further derive problematic manifestations of these characteristics that should be observed if PSM's financial performance is inappropriately measured.

Findings: We find three underlying characteristics of PSM that hinder a credible communication of its value contribution: (1) Its organizational embedding in fragmented, incomplete relationships; (2) its high resource dependence, and (3) its double information asymmetry. These characteristics create doubts on the correctness of PSM's performance reports, disputes on the origin of performance, and isolation of PSM from corporate strategic and financial planning.

Value: We introduce a new perspective on measuring PSM's performance, shedding light on general characteristics and the problems it causes when performance measurement is not adjusted to it. Despite our focus on PSM, the results of our research apply to all functions in comparable organizational embeddings, e.g. to logistics.

INTRODUCTION

Purchasing & Supply Management (PSM) is a strategic and value adding function (Ellram & Carr, 1994), who's actions have an impact on a firm's performance (Carr & Pearson, 2002). Starting from this position, PSM scholars and practitioners demand a larger span of control for PSM in terms of elevated strategic responsibility (Trent & Monczka, 1998; Leenders et al., 2002) and a higher involvement in top-management decision making (Mol, 2003; Paulraj et al., 2006). Yet, it is observed that PSM is only weakly integrated in strategic activities (Johnson & Leenders, 1998a, 1998b). It seems that despite its organizational position (Narasimhan & Das, 2001) and despite its positive self-perception in terms of strategic relevance (Tassabehji & Moorhouse, 2008), PSM failes to convince other organizational entities in a firm of its value contribution and strategic relevance. The fact that PSM is not seen as a strategic contributor and equal partner by its counterparts supports this view (Tassabehji & Moorhouse, 2008).

We believe that solid financial performance measures would underline PSM's value contribution and help to convince its organizational counterparts of its strategic relevance. And, principal-agent theory supports our argument: In a principal-agent setup, the information contained in a performance indicator is the critical basis of the contract between the principal and an agent and, hence, constitutes the basis for the agent's compensation (Levinthal, 1988). The theory further points out that solid financial performance measures are especially critical for functions such as modern PSM: If an agent's operations are characterized by a large span of control, high interaction with operational partners, and strong complexity, they turn out to be strongly unobservable and are consequently not directly assessable. Therefore, performance measures play a critical rol. They function as proxies for the actions of these agents and indicate their effort and achievements. Since the agent's actions are unobservable, solid performance measures are vital for contracting such agents effectively. The intuition behind this logic is that a principal can elicit the desired actions on the agent without observing his action only by linking compensation payments to solid performance measures (Eisenhardt, 1989; Levinthal, 1988). Since a CEO's payment normally depends on the financial performance of the firm and since he intents to maximize his utility, solid financial performance measures might be included in the contracts with his agents. Yet, studies show that current financial performance measures only partially satisfy this need (e.g. Nollet et al., 2008).

In our opinion this deficit is not caused by the wrong choice of measures-we are rather convinced that traditional financial performance measures are inappropriate to account for very basic aspects that lie in the nature of PSM itself. In our paper, we now take a closer look on general characteristics of PSM in order to investigate how they hinder current financial performance measures from reflecting PSM's value contribution.

LITERATURE REVIEW

A considerable body of literature deals with the design of performance indicators for PSM. In 1984, Van Weele extended the understanding for PSM's performance to logistics costs and organizational efficiency (van Weele, 1984a). By that, he paved the way to a more holistic perspective on PSM's performance, including qualitative aspects and not only cost savings. Nevertheless, cost savings are still at the center of PSM's performance, because of their neutral character (Mol, 2002) and are subject to recent studies like in Nollet et al. (2008). We could only identify one single attempt to shift PSM's performance to its contribution to firms' profits (Beidelman, 1987).

A second body of literature deals with the usability of PSM performance measures to communicate PSM's strategies (Axelsson et al., 2002; Cousin & Spekman, 2003) and specific antecedents of measuring PSM's performance like the level of internal and external cooperation and leadership (Goh et al., 1999; Fredendall et al., 2005) and PSM's maturity (Schiele, 2007).
Moreover, a third large body of literature investigates PSM's impact on firm's performance. Some use budgets and financial statements to make PSM's impact visible (Paperman & Shell, 1977; Ellram & Liu, 2002; Chen et al., 2004). Others successfully tested the link between PSM's practices (Narisimhan & Das, 2001; Day & Lichtenstein, 2006), affiliation to strategic purchasing (Chen et al., 2004; Day & Lichtenstein, 2006), the responsiveness of PSM to customers (Chen et al., 2004), and PSM's internal integration (Narisimhan & Das, 2001) to the firm's overall performance.

Even though research on measuring PSM's performance has a long history, PSM is still one of the more difficult functional areas to evaluate (Easton et al., 2002; van Weele, 1984b): Van Weele (1984b, 2002) proposes that the lack of supply performance definitions, the lack of formal object and performance standards, the lack of accurate measurement, and the difference in the scope of supply management activities are the major problems in measuring PSM performance. Nollet et al. (2008) finds that even basic yet critical questions like soundly defining cost savings remain unsolved. Only recently, Easton et al. (2002) found a way to make PSM's performance comparable across multiple firms.

At large, most authors try to make up for the deficit of sophistication of PSM's performance measurement and evaluation systems (Monczka et al., 2005) by analysing the design and implementation of performance measurement for PSM or of the impact of PSM's actions on a firm's performance. What stays widely ignored are general characteristics of PSM that make the measurement of its performance special and that have a strong impact on the ability of PSM's financial performance measures to prove its strategic relevance. Our paper aims at filling this gap.

GENERAL CHARACTERISTICS OF PURCHASING & SUPPLY MANAGEMENT

PRINCIPAL-AGENT-BASED ORGANIZATIONAL SETUP

To capture the relevant characteristics of PSM with regard to financial performance measurement, we adopt a principal-agent perspective. Taking this view on PSM makes sense, because of the fundamental role performance measurement plays for contracting in principal-agent relationships. In this way, we identified important characteristics and their problematic manifestations when PSM's financial performance is measured inappropriately. We believe that through this manifestations, PSM fails to communicate its value contribution.

We set up a principal-agent relationship between the CEO as the principal and the PSM function, represented by the CPO, as the agent. Defining the CEO to be the principal who contracts PSM is visible if we consider that the majority of CPOs report directly to the CEO or a group vice president (Johnson & Leenders, 2008). As in normal principal-agent setups, the principal specifies the contract of the agent, receives the information on the agent's performance, and pays a compensation in accordance.

In the course of its operations, PSM creates value jointly with other operational functions in the firm (Cavinato, 1992). During the paper, we will refer to these other functions as the operational counterparts of PSM. We assume that these operational counterparts are each for themselves managing a dedicated value creating project of the company (e.g., a building to be constructed or a product to be launched). The obligation of PSM during this project is to provide the service of integrating external value creation with the value creating activities performed by each operational counterpart (Chen et al., 2004; Ellram et al., 2002; Narasimhan & Das, 2001). Note that we assume PSM to have a multitude of operational counterparts. Since PSM serves all functional areas of the company. By performing its actions, PSM "handle[s] complex commodities, find[s] competent suppliers who deliver high quality material on time, and within or below budgeted cost" (Hendrick & Ruch, 1988, p. 25). The performance of PSM is a product of its actions and represents a certain contribution to the value of each project. Since the operational counterparts specify their requirements towards the necessary external value and since they receive the outcome of PSM's actions (e.g., price reductions), they are the interaction partners of PSM during the projects.

The operational counterparts are also contracted by the same principal as PSM that is the CEO.
Information asymmetry exists between the principal and the agents, because the principal cannot observe the agent's actions. Furthermore, the operational counterparts only observe the outcome of PSM's actions, but have problems aligning this outcome to PSM's actions themselves for the same reasons as the principal is unable to observe these actions. Consequently, there exists also an information asymmetry between PSM and its operational counterparts.
The general characteristics of PSM that we would like to investigate are derived from this principal-agent set-up. The target is to identify characteristics that cause significant problems when it comes to observing, verifying, and evaluating information on PSM's actions.

STRUCTURE OF CONTRACTS

To describe the structural setup of contracts in which PSM is embedded, it is necessary to understand in detail the character of the principal's relationship to PSM and the operational counterparts.

PSM and its operational counterparts are both contracted by the principal. PSM's contract states that it should contribute value to the operational counterparts' projects. The financial performance of PSM is measured by this contribution. The operational counterparts are contracted by the principal to manage their projects and create value. The contract of PSM states that the value contribution of PSM's actions is transferred directly to the operational counterparts. But, the contract of the operational counterparts states that the value contribution of their actions is directly transferred to the principal as the outcome of the project.
In other words, the contract of the operational counterparts ensures the principal a direct connection to the project managers' value creation, while the contract of PSM lacks this direct

connection. If we use the classification framework of Hallén & Johanson (2004)[3] we can conclude that PSM and the operational counterparts are operating in fragmented relationships as they are governed and compensated exclusively by the principal but do not operate together with him. Furthermore, PSM's exchange level relationship is incomplete, because in contrast to the operational counterparts only the governance and the payment of the compensation happen with the principal. PSM does not transfer its value contribution to him, but to its operational counterparts[4].

Based on this argumentation, a first proposition for a general characteristic of PSM is

P1: *PSM's contract specifications lead to an incomplete exchange level relationship to the principal.*

STRUCTURE OF VALUE CREATION

Strategic purchasing is a cross functional task that requires a team effort from both PSM and its operational counterparts (Cousins & Spekman, 2003; Trent & Monczka, 1994; Williams & Giunipero, 1994). The core obligation of PSM in the relationship is to add value by integrating external and internal value creation. It is important to note that in this context PSM's job is to give advice concerning whom to purchase from at what price and which conditions (Hendrick & Ruch, 1988) -but never to pay. PSM in this sense is a provider and the operational counterparts are the receivers of a support service (Ellram et al., 2002). The service itself is enhancing the operational counterparts' resource productivities. In the end, the principal receives the outcome of the operational counterparts' projects, which include the value added by PSM's service. It never receives an outcome directly derivable from PSM's actions.

This structure of the value creation activities makes PSM highly dependent in its action on the decisions and behaviour of operational counterparts (Goebel et al., 2003). This resource dependence (Ruekert & Walker, 1987) is our second general characteristic of PSM:

P2: *PSM's actions are highly determined by the decisions and behaviour of its operational counterparts in the sense of resource dependence.*

INFORMATION ASSYMETRY

The principal can easily access the efficiency of PSM's actions through the use of additional management information systems. These performance measures enable the principal to participate in increasing PSM's efficiency. They reduce the information asymmetry, reveal the agent's true action and yield a more realistic compensation payment (Antle & Fellingham, 1995).
Agency theory further suggests that incentivizing this behaviour is not necessary up to a certain degree (Antle & Eppen, 1985) because PSM yields additional utility from maximizing its efficiency. Therefore, we exclude the measurement of the efficiency of PSM's actions from our analysis and focus on the measurement of PSM's effectivness.

[3] Hallén & Johanson (2004) find that interaction between two actors can happen on two levels: "On the exchange level, the governance […] and the resource exchange processes" between the interacting actors take place, while on the use level, the actors use "internal resources […] in various combinations with resources acquired from external sources" (Hallén & Johanson, 2004, p. 154) to create value. According to them, relationships can be integrated and fragmented: If two actors interact with each other on both levels, the relationship is define as integrated, if an actor interacts with one actor only on the exchange and another only on the use level, his relationships are fragmented (Hallén & Johanson, 2004).

[4] One can argue that at 16% of the cases where PSM is reporting to a manager concerned with operations (Johnson & Leenders, 2008), PSM's exchange level relationship is complete and PSM is furthermore operating in integrated relationships. For the other 84% of all cases, our argumentation would be suitable.

Information asymmetry leads neither the principal, nor the operational counterparts to be able to directly observe PSM's actions. Nevertheless, both want PSM to maximize the outcome of the operational counterparts' projects (Dumond, 1991).

The problem with measuring the effectiveness of PSM's actions in the sense of good increase of existing resources' productivity is that no objective information exists on it. This is due to the fact that an increase in resource productivity represents no tangible value stream and consequently finds no direct reflection in the company's financial accounts. It is only indirectly incorporated in all its operational counterparts' expense accounts (Carpenter & Beckmann, 1979). Hence, performance measures that indicate the effectiveness of PSM's actions cannot build on objective accounting information.

Because of *P2*, it is also impossible for the principal to deduct the effectiveness of PSM's actions from the outcome of the operational counterparts' projects. As the principal per definition cannot observe the actions of the operational counterparts, it is also impossible for him to identify the right financial performance measures to elicit the best value contribution of PSM. As a result, PSM and the principal agree in PSM's contract on a set of performance measures that PSM and its operational counterparts found relevant for assessing the effectiveness of PSM's actions. Typical measures for this purpose include e.g. savings or value analyses (Beidelman, 1987).

The consequence is that a set of private financial performance indicators is created. As these do not build on objective data sources, they are highly intransparent and consequently do not produce verifiable information (Wickramatillake et al., 2007). Therefore, they do not reduce the information asymmetry between PSM and the principal or the operational counterpart, because solid information on PSM's actions is not necessarily provided by them. This frequently leads to PSM following financial indicators, which neither the principal nor the operational counterparts can connect to their financial results. Consequently, they are not useful for PSM for conveying its strategic value contribution to them (Ellram & Liu, 2002). Following this argumentation, we propose a third general characteristic of PSM:

P3: *Compared to their internal customers, traditional financial performance indicators of PSM do not reduce the information asymmetry between PSM and the principal or the operational counterparts.*

OPERATIONALIZATION OF THE PROPOSED GENERAL CHARACTERISTICS

In order to assess if and how the proposed general characteristics hinder traditional financial performance measures from reflecting PSM's value contribution, we derive problematic manifestations of these characteristics that would be identifiable in case of traditional measurement of PSM's financial performance. They function as indicators for the impact of PSM's general characteristics and indicate that the operational counterparts or the principal do not agree with reported value contribution of PSM.

For *P1,* we found that PSM's incomplete exchange level prevents the principal from observing and verifying PSM's value contribution when traditional financial performance indicators are applied.

This is caused by the fact that the operational counterparts and not the principal receives PSM's value contribution directly. Consequently the principal can only subjectively judge whether PSM reports a true picture of its performance (Carpenter & Beckmann, 1979).

The principal further cannot use an external auditor to verify the report[5], because the effort to extract PSM's value contribution from objective sources like the financial accounts of PSM's operational counterparts is considerably high[6].

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[5] For the usage of external auditors for external verification of performance see, e.g. Antle (1982), Baiman, (1990).

Since the financial performance reported by PSM is neither observable, nor externally verifiable for the principal, doubts on the accuracy of the report should be constantly present if the exchange level relationship is incomplete.

Consequently, we propose that

M1: *PSM's incomplete exchange level relationship manifests through doubts on the accuracy of PSM's performance reports*.

The strong resource dependence as proposed in *P2* leaves PSM only partly in control of its activities. Much of its behaviour and decisions are limited by the actions of the operational counterparts. Consequently the value contribution of PSM as assessed by traditional financial performance measures is diluted by the effects of the operational counterparts' actions and exogenous shocks on both actors' sides. As argued in the chapter of information asymmetry, it is not possible for the principal to ex-post separate these factors-neither in the outcome received from the operational counterparts, nor in the traditional performance report of PSM. Consequently the traditional financial performance measures fail in solving the role conflict between PSM and the operational counterparts (Chao et al., 1993). It is assumed that the conflict prevails:

M2: *The strong resource dependence is manifested in regular disputes on the responsibility for and origin of the performance reported by PSM.*

The existing high information asymmetry between PSM and the principal and the operational counterparts respectively causes problems since they cannot connect PSM's reported value contribution to their own financial results. Since operational counterparts only have regard to performance indicators of PSM if they were directly related to them, sophisticated individual performance indicators tend to have only little presentation value for PSM (Cavinato, 1987). For traditional financial indicators of PSM it has been shown that they are of little use for convincingly connecting PSM's value contribution to the firm's financial results (Ellram & Liu, 2002). As neither the principal, nor the operational counterparts see the direct link of PSM's actions to the overall performance of the company, they might tend to exclude PSM from joint financial and strategic planning procedures on corporate level, as observed in the literature (e.g., Johnson & Leenders, 1998a, 1998b). Hence we propose:

M3: *The failure to reduce the information asymmetry between PSM and the principal or the operational counterparts respectively leads to an exclusion of PSM from corporate financial and strategic planning procedures.*

CONCLUSION AND FURTHER RESEARCH

The paper provided a theoretical argumentation on characteristics that influence the ability of PSM's financial performance measures to communicate PSM's value contribution. We adopted a principal-agent perspective to cover the contractual aspects, the value creation aspects, and the information asymmetry of PSM's organizational embedding and showed how they hinder the credible communication of PSM's value contribution. The goal of the paper was to lay the foundation for further empirical research on how to best communicate PSM's value contribution given the general characteristics outlined. For further research, case study analyses could be performed to confirm the identified general characteristics and its problematic manifestations. The cases would further uncover hints on how an appropriate performance measurement system needs to be designed with respect to PSM's general characteristics.

[6] Compare the effort of conducting such an analysis with the effort to directly calculate a cash flow statement. To do so, all the payments received need to be added up and the payments proceeded need to be subtracted, which is practically impossible for most firms.

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DEVELOPING A SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEM: CASE STUDY OF DAMIETTA PORT IN EGYPT

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ABSTRACT
Seaports compete through high quality services, reducing operating expenses, developments in port infrastructure and effective port performance. Port managers aim to meet the satisfaction and expectations of both ship owners and cargo owners. Port clients require high quality service standards, reduced ship-turn around times in ports, reliable and proper cargo handling equipment, available storage areas with relevant capacity, reduced cargo dwell time, appropriate facilities at terminals and in-port transportation infrastructure. In order to achieve such requirements, the operations on a daily basis have to be effectively controlled. Port assets should be economically utilised and cargo dwell times have to be reduced. There are many variables that have a great impact on port performance. A reliable supply chain performance measurement system needs to be developed to represent the actual port performance. Within this research regression analysis will be conducted in order to develop a more customised and effective port supply chain performance measurement system in Damietta port of Egypt. Multiple regressions have been developed using key variables and indicators used in daily port operations.

Key Terms: port performance measurement – ship turn-around time – total cargo dwell times

INTRODUCTION
From the available literature, there is no performance measurement system that has been recommended as a valid tool in measuring ports' performances. This is due to the emphasis on containerisation aspects.

Current systems focus on measuring container port, container terminals, or container cargo, with no regard to other types of cargoes and terminals in seaports. Thus, current systems represent the performance of certain terminals rather than the performance of ports. Also, current supply chain measurement systems in ports consider cargo handling as a key activity, regardless to other activities which play an important role in improving port performance, such as storing, waiting time, land-leg connections and loading/discharging rates. Also, other factors have been ignored in current systems, such as equipment efficiency, berth occupancy and total dwelling times. Multiple regressions have been developed to present the actual port performance.

The general purpose of regressions system (Pearson, 1908) is to define the relationship between those key factors in Damietta Port. It helps to find "what is the best predictor of port performance". It helps also to assess the statistical significance of the estimated relationships.

CURRENT DAMIETTA PORT PERFORMANCE MEASUREMENT SYSTEM
Before developing a more effective performance measurement system, it is important to analyse the current Key Performance Indicators (KPIs) in Damietta Port. The port managers rely mainly on some KPIs in the measurement process.

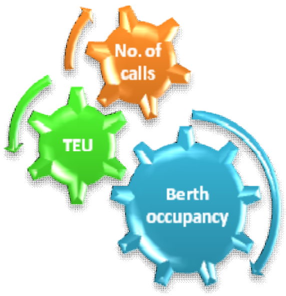

Figure 1 – Current KPIs in Damiettaport

Figure 1 shows these KPIs which represent the three-measuring areas in Damietta port; ship, cargo and equipment. In fact, measurement system differs from one port to another (Chung, 1993), because each system in every port depends on a combination of different KPIs. The available literature shows that there are more than 138 KPIs currently applied in seaports worldwide. Fig.1 shows that Damietta port measurement system relies currently on three KPIs; berth occupancy, TEUs in containerization and number of ships' calls. The port managers believe that those KPIs represent the actual performance of Damietta Port. Number of ships' calls is being used as an indicator to determine the quantity of total imports and exports handled in the port. TEUs are being used, for commercial purpose, to refer to container terminals performance and the port capacity. Berth occupancy refers to productivity improvement in Damietta port in terms of increasing number of berths, increasing the efficiency level of port equipment and improving gang productivity.

However, the current system does not show the actual performance of the port for many reasons; Some KPIs cannot be applied in measuring all types of cargoes, such as twenty-equivalent unit (TEU), which is used only for containerised cargoes. Thus, there is clearly ignorance towards other types of cargoes. Additionally, the port managers focus on cargo handling equipment performance of containers, with no regard to the performance of that equipment in moving, handling, lashing and stripping other types of cargoes (Castilho & Daganzo, 1993).

In fact, waiting times in the port, standing times and operation times are being affected, to some extent, by the performance of equipment and loading/discharging rates (Lai & Lam, 1994). Previous research focused on using, for example, double cycling instead of single cycling at berths which can reduce a ship turn-around time (Goodchild & Daganzo, 2004). Key performance indicators in the current Damietta port measurement system are not effective enough, as they do not imitate the daily operations in the port, nor present the actual port performance.

EFFECTIVE MEASUREMENT SYSTEM INPUTS

Building an effective performance measurement system in the port requires importantly considering some procedures and inputs. At the end, a performance measurement system can be designed and developed. The procedures include the following:

Ship turn-around time

Ship turn-around time refers to total hours that a ship stays in port. Firstly, ship owners are always willing to reduce ship turn-around time in order to increase ship productivity. Secondly, port authorities work on reducing total hours that ships stay in port in order to improve port performance and productivity. When ships stay longer time in loading and discharging cargoes, it refers to low port performance.

In fact, there are a number of factors that influence ship turn-around time; such as availability of cargo handling equipment, sufficient storage yards and ganging productivity. Ship turn-around time directly affects ship productivity. Also, it indirectly affects cargo dwell time in ports. Any delay in handling cargoes would increase cargo dwell time. It is essential to meet the requirements of port managers in terms of reducing both ship turn-around time and cargo dwelling time because the port is simply neither a vessels laid up berths nor a cargo warehouse or a stocking point. Figure 2 illustrates a ship turn-round times

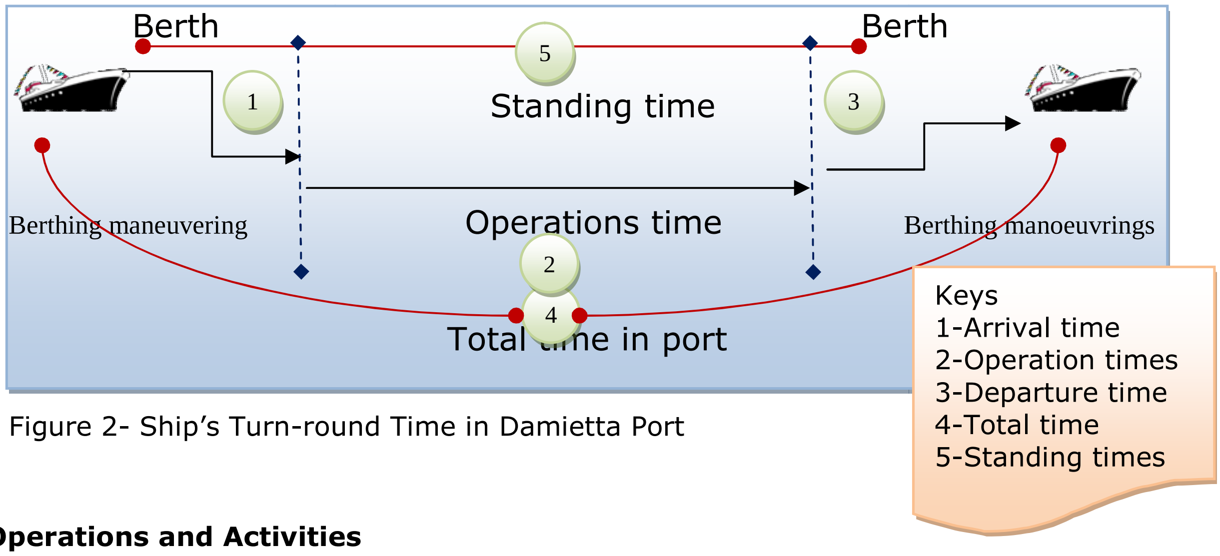

Figure 2- Ship's Turn-round Time in Damietta Port

Port Operations and Activities
Port activities and operations have been grouped by the researcher into five groups. Figure 3 illustrates main operations in seaports. Those groups imitate the daily operations in Damietta port and in other seaports. Each group includes different activities that have same purpose. Those groups are;

- Ship-side activities, which involve loading and discharging cargoes, berth occupancy, standing time at berth, number of calls.
- Land-side operations, which involve in-port transportation cost and distance from and to the port.
- Equipment operations, which involve number of available equipment, their capacities and crane efficiency.
- Storage operations, which involve types and number of warehouses and their storage capacities.
- Logistics services activities, which involve a number of factors that influence cargo dwell times in ports; such as low IT application, documentation, customs, etc.

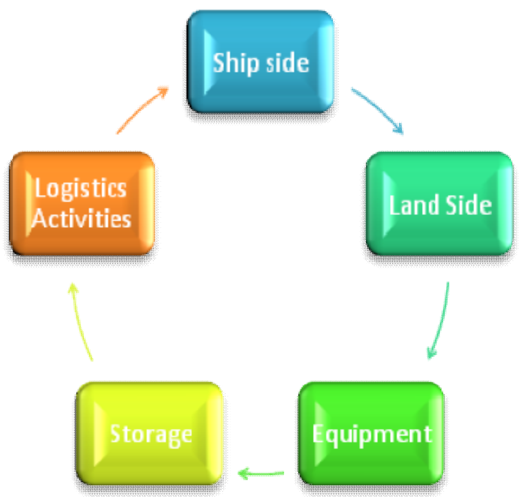

Figure 3- Grouping Activities and Operations in Damietta Port

Considering other types of cargoes, as well as containerisation

The analysis carried out within this research will take into consideration four types of cargoes that are being handled in Damietta Port: containers, general cargo, dry bulk and liquid bulk. This aims to develop an understanding of the relationship between these different elements with the scope to build a more effective measurement system for Damietta port. The performance measurement system will represent the actual port performance rather than the individual performance for a certain terminal in the port.

Dwelling times in ports

- *Cargo dwelling times*

The essential factor for any type of cargo is how long they stay in the port, which is known as cargo dwell times. Cargo dwelling time refers to the time that cargoes remain in port in-transit storage area. In order to shorten the cargo dwell times, following procedures should be considered:

- Using high degree of mechanisation in cargo handling;
- Participation of highly-skilled workforce;
- Availability of sufficient space for storage;
- Proper facilities for quick evacuation of cargoes.

In other words, inadequate port capacity, limited cargo handling facilities, high down time of equipment, low labour productivity, all contribute to the low efficiency of the port. In fact, higher the dwell time leads to lower in the efficiency. Thus, the developed measurement system aims to reduce total cargo dwell times in Damietta Port.

- *Transport dwelling times*

Reliable transportation network to and from Damietta port as well as inside the port, certainly, will lead to improve transport services and consequently port efficiency. Yard capacity is an important factor in transportation efficiency, it is considered as the main reason for the bottlenecks of cargo movement to and from terminals and ports (APMT-ROT, 2008). Transport dwell time is one of the main variables that influence yard capacity. Bad plan of inland transport, customs blockage and rolled due to over-booked vessel, poor transport infrastructure and high transportation costs can lead to increase transport dwell time. Also, land-leg side, either inside a port or the inland transport networks that links a port with their hinterlands, all affect transport dwell times. Higher transport dwell time, higher is the cargo dwell time and lower port performance.

- *Storage dwelling times*

Competition between ports and shipping lines takes many forms. Setting free time or increase storage density are the most common forms. It is essential to evaluate the effect of storage dwell time and storage policies on storage density. Storage dwell time occurs when there is shortage of storage space, shortage of handling equipment or workers. Higher storage dwell time, higher is the cargo dwell time.

- *Logistics services dwelling times*

The port communities, which are being supported by PORTNET, compete in using IT application in pilot services, booking berths, tracking and billing. The entire berth system, ship planning, yard planning system, resource allocation system and flow of cargoes through port gates are done electronically. Thus, Many Ports & Terminals utilize what is known as state-of-the-art real-time management information systems, such as E-Commerce and EDI. In Damietta port, there are regulatory restrictions lead to higher cargo dwell time, such as low IT application, mainly due to prevalence of too many manual documents, archaic systems and procedures.

- *Equipment Efficiency*

Improving the efficiency of cargo handling equipment is a way for reducing cargo dwell times. Port managers are working always on how extensively and intensively their assets are being utilized. There are key indicators are determined in relation to the availability of equipment, their capacity and efficiency.

DEVELOPING AN EFFECTIVE PORT PERFORMANCE MEASUREMENT SYSTEM

Figure 4 shows the correlations of relationships between these inputs and procedures that have been discussed above. All those inputs affect the port performance and they should be taken into consideration as all into an effective performance measurement system. There are several measures that have to be included in the performance measurement system. All those measures focus on minimizing total cargo dwell times in the port. The shorter cargo dwell times in the port leads to the higher port efficiency and performance. Shorter cargo dwell times can be achieved by cooperation between both; ship owners and port authorities (Convention on Facilitation of International Maritime Traffic, 1965, Annex B). It starts with eliminating both; ship turn-around times and total time cargoes stay in port.

Ship owners will be satisfied when the port authority keeps a ship turn-around time to a minimum. While the port productivity is generally measured in terms of the tonnage of cargo handled per unit of work station. It starts from moving cargoes from berth until delivering it to the port gates where customers are waiting their shipments. Thus, public authorities and port administrations work together on eliminating the total times the cargoes stay in the port through reducing all procedures and arrangements for embarkation and disembarkation, loading, discharging and documentations. All participants in seaports aim to reduce total cargo dwell times.
Port managers would normally *split total times* in port into times at berth and times off the berth. And within each, it would be easily to record for each service activity the amount of operational and non-operational times. The efficient measurement system should consider both; operational and standing times, either where cargoes handled at berth or off berth. Thereof, *total cargo dwell time* is an important variable that affects port performance and it is being affected by many activities in the port. Practically, developing measurement system in Damietta port will include three types of cargoes total dwell times:

- Dwell times at berth involve standing times (non-operational times).
- Operations dwell times (Dwell times off-berth) involves the five-dwell times in ports that have been discussed above.
- Total cargo dwell times involves both dwell times at berth and off-berth.

Data have been collected in a variety of ways and from different sources. In Damietta port, the port records and archives provided the required information and details for all activities and operations within the port on monthly basis. Data have been grouped per type of cargo; containers, general cargoes, dry bulk and liquid bulk. Also, data has been collected for all types of dwell times.

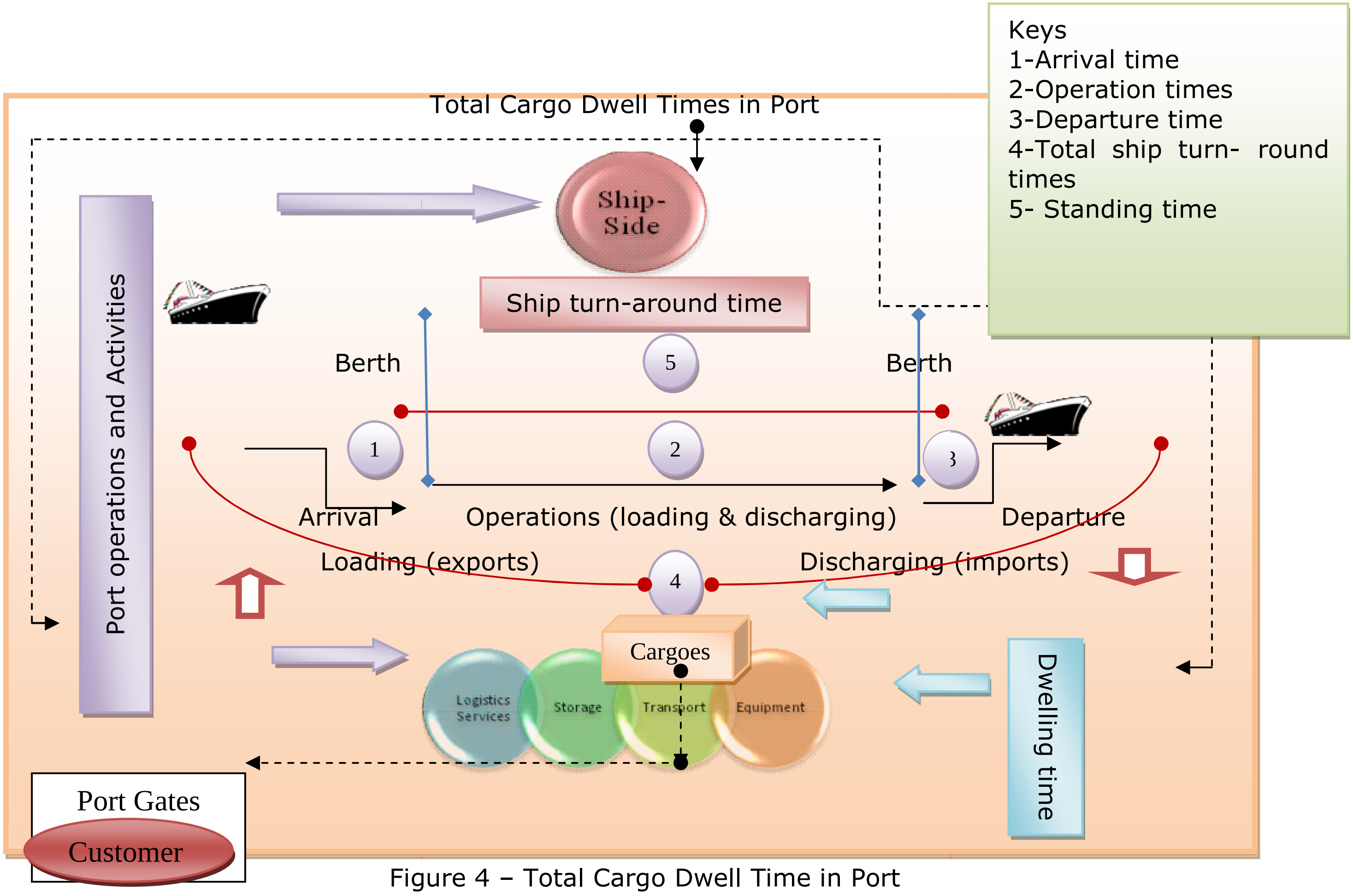

Figure 4 – Total Cargo Dwell Time in Port

CORRELATION ANALYSIS

Regression analysis has been applied as a method for explanation of phenomena and prediction of port supply chain performance. In the multiple regression analysis, the set of predictor variables is used to explain variability of the criterion variable Y. The criterion variable is total cargo dwell times in Damietta Port. Predictors involve those activities and operations that influence cargo dwell times. Actually, multiple regressions have been applied partially for the three types of dwell times.

The first part presents the dwell times at berth that elapsed in ship-side. The second part presents the operation dwell times (dwell time off-berth) that elapsed in moving cargoes from berth to storage area. Finally, the third part presents total cargo dwell times in the port. Multiple regressions have been applied separately for each type of dwell time. The findings in this research conclude many equations. This paper gives, for example, the operations dwell times in Damietta port, for general cargoes. The equation is:

Operations dwell times= 13 -0.000532 Imports + 0.00109 Exports - 0.00097 discharging/loading rates + 3.74 Standing time + 0.00703 storage capacity

The equation above illustrates the operations dwell times for general cargoes in Damietta port. It represents the dwell times starting from receiving cargoes from and to vessels, until delivering cargoes to the warehouses. Before applying the above equation to predict the port performance, table 1 provides some indicators that are important to be considered:

- The highest number of calling ships was in June 2006 in the port. However, the more standing times, non-operational times, were in the same month. It might be due to unavailable handling equipment or storage areas, which made ship-queuing. This was clear in Feb 2004, where standing times were low due to lowest number of calls.
- Loading and discharging rates are not relative to total imports and exports handled in the port.

Table 1- Observational Port Performance

Indicators	Observations	
No of calls	June 2006	Many
	Feb 2004	Fewest
Operations Times	March 2006	More
	Feb 2004	Less
Standing Times	June 2006	More
	Feb 2004	Less
Load/Disch rates	Sep 2007	Highest
	Dec 2005	Lowest

Table 2 shows the actual port performance in terms of operations dwell times. The above equation has been applied to the last 60 months. Three observational cases have been selected to discuss and investigate the operations dwell times.

- In case 1, operations dwell times was slightly high because 126 ships called the port. There were three reasons have been observed; increasing standing times, decreasing loading and discharging rates and decreasing the number of storage areas.

- In case 2, the port performance improved in terms of decreasing operations dwell times. It was clear that standing times reduced by 57%, and handling rates increased by 4000 tonnes per day.

- In case 3, the operations dwell times was unexpected. There were only 27 ships called the port in this month, but the dwell times were sharply high. Each ship needed about 65 hours in the port for full operations. These cases show that reducing operation dwell times can be achieved in case of;
  (i) Increasing loading and discharging rates per day,
  (ii) Increasing storages areas, and
  (iii) Reducing standing times.

Table 2- Damietta Port Performance Measurement – Dwell Times off-berth

Actual Port Performance

Case	Samples	Operations Dwell Time (hr)	Imports	Exports	Load/Disch Rates	Storage	Standing Time	Equipment efficiency *(constant)*
1	Jun 2006	6,688	323270	249229	19000	66650	1638	2,027,718
2	Sep 2007	4,002	426050	120468	23000	71850	936	
3	Feb 2004	1,754,34	72398	33495	15200	63350	351	

Predictable Port Performance

Scenario	No. of calls	Operations Dwell Time (hr)	Imports	Exports	Load/Disch Rates	Storage	Standing Time	Equipment efficiency *(constant)*
1	*127*	↓ *6,685*	323270	249229	↑ *23000*	66650	1638	2,027,718
2	*72*	↓ *3,904*	426050	120468	↓ 19000	71850	936	
3	*27*	↓ *1,746,774*	72398	33495	↑ 23000	63350	351	

The second part of above table shows three different scenarios as predictable performances for Damietta port. They aim to help the port managers improve their port performance in future.

- Scenario (1): proposes that when there is 127 calling ships (the highest number of ships called Damietta during the last five years), increasing storage areas and handling rates will lead to increase dwell times by approximately 1000 hours. But, increasing handling rates only, with keeping the capacity of storage areas the same, leads to decreasing dwell times, slightly.
- Scenario (2): sometimes, lower handling rates per day leads to decreasing operations dwell times. But, it has negative impacts on the port assets as there will not be optimum utilisation of equipment.
- Scenario (3): also, handling rates can affect dwell times. It is clear that increasing storage areas is not efficient. Investing in handling equipment in case of Damietta port should have a priority rather than investing in storage yards.

CONCLUSIONS AND RECOMMENDATIONS

Total cargo dwell time in Damietta port is the key variable that could represent the actual performance of the port. It refers to those dwell times that elapsed in ship-side, equipment, transport-leg side, storage operations and logistics services. Multiple regression analysis has been developed as a tool to measure the port performance in terms of total cargo dwell times. Three scenarios have been mapped, for operations dwell times for example, to help the port managers improve their port performance in future. More regressions are still under development for cargoes dwell times and ship dwell times.

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MODELLING PERFORMANCE MEASURES FOR SUPPLY CHAIN SYSTEMS USING DISCRETE EVENT SIMULATION

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ABSTRACT
Performance measures are designed and modelled within a supply chain to evaluate and control its efficiency and effectiveness. This paper aims to emphasise the modelling aspects linked to performance measures intended for simulated supply chain systems. Literature concerning simulated supply chain models and the performance measures used is provided here. The paper also captures a critical discussion concerning issues linked to the aggregated performance measures. A simulation model is developed here which represents a multi-echelon supply chain. The model analysis focuses on evaluating the way in which performance measures can be built when simulation is used.

INTRODUCTION
Performance measures can be classified in customer service, cost, time based measures and work in progress. The classification of measures within literature has received considerable attention over the past years where measures have been classified in cost, time, flexibility and assets or time, cost, reliability and quality. These categorisations are very useful tools in systems analysis. Measures within a category can be compared and analysed, so that performance measure selection within a category may be easier. The problem becomes more complicated for a supply chain system, due to the fact that each individual echelon in the system may use different performance measurement criteria.
Different sets of performance measures have been used to design, model, analyse and control supply chain systems. Beamon (1999) classified supply chain models in deterministic analytical models, stochastic analytical models, economic models and simulation models, where the most used models have been identified as the analytical ones.
Simulation models are used more and more for analysing supply chain systems. The way in which supply chain systems are designed affect the modelling of their performance measures. It has been argued in the literature that measures are not consistent among different echelons along the supply chain. Research also shows that attempts to develop measures for use in extended supply chains has been constrained by the conflicting goals between echelons. Although complex modelling approaches have been adopted lately for design and analysis of supply chain systems, the performance measures used within these analyses are still very limited.

SUPPLY CHAIN PERFORMANCE MEASURE ANALYSIS USING SIMULATION - A REVIEW
There are many papers in the literature which address performance measures systems and their classification. Still there is a limited amount of literature that seeks to address the modelling aspect of the performance measures for supply chain systems in the context of simulation. It can be argued that simulation can provide managers with valuable insight into supply chain behaviour, in measuring the performance of the relevant supply chain configuration and scenarios by pointing out the ones which would provide the most appropriate results. Simulation can also be used to understand the interrelations and dependencies between different factors within a supply chain.
In recent years simulation has been used more and more for modelling and design of supply chain systems. They have been used to assess suppliers' capabilities, to understand inventory policies, to test multi-optimisation patterns, to validate different planning and scheduling techniques and so on. Performance measures were used within these simulated systems although the modelling aspect of the performance measures

was not always detailed. Using simulation it can be observed that changes to system parameters affect the response of more than one performance measure modelled for that system. If measures are missed or not considered as part of the modelling framework,
system behaviour will not be fully clear or understood. This could lead to erroneous decisions especially when system change or reengineering is required.

The extent to which current models were simulated together with their set of performance measures used is considered relevant therefore a review of the literature is provided here.

Wikner et al. (1991) uses simulation to determine which strategies are the most effective in smoothing the variations in demand pattern, where the main performance measures used for this simulation were cost and customer responsiveness.

Souza et al. (2000) use simulation to design a modified beer game model with iThink2 software in order to reduce the dynamics of a supply chain system. Four performance measures were considered here. They are the cost of each echelon within the simulated supply chain, cost of the entire chain, the dynamics of order and dynamics of inventory. The dynamics of orders are defined as a function of the difference between orders and demand during a time period, where the dynamics of inventory are seen as a function of the difference between the required inventory and the current inventory for a particular echelon and its back order.

Tahar and Hussain (2000) applied the ARENA software package and simulated the management of operations for a container terminal. The simulation models include berth assignment, crane and prime movers assignment. The main performance measures used for this simulation are throughput and resource utilisation, where it is concluded that appropriate assignment and coordination of operation within the port can improve the port efficiency and reduce operational and maintenance cost. Throughout this research there is no clear indication on how these costs are calculated or modelled for this simulation.

Beamon and Chen (2001) developed a model using AweSim! v2.0 (using Visual SLAM) to model a conjoined, four echelon supply chain system where five measures were considered. They are average periodic inventory level, average transportation cost, stock out fraction, backorder fraction and volume flexibility. Regression analyses were also carried out between different factors such as inventory system stock-out risk, supplier lead time, demand distribution, transportation time and processing time. It has been observed here that each of the elements were significant in the regression estimate of at least two of the performance measures considered, which tells us that there is a link between different elements of a complex performance measure. It is also concluded in this work that the use of multiple performance measures can provide a deeper understanding of the critical relationships in the supply chain.

Chan et al. (2002) argues that in terms of supply chain performance measures such as lead time and WIP (work in progress) are not considered very appropriate, whilst delivery speed and reliability are more appropriate in the context of supply chain. They use simulation to model a simplistic supply chain process with the aim to release orders into the process in order to improve customer service. They use a commercial software package *Simprocess*. Within their study the only two measures used are customer service and cycle time, where quality and cost are assumed constant. They define a function as business value in the form of VALUE = f(customer service, cycle time), whilst cycle time is presented as delivery speed^{-1}. Although the aim here is to consider only two measures it can be seen that other measures are defined in relation to the original once. Another relevant point captured within Chan et al. research is that customer service is defined as delivery reliability as they argue it is easier to quantify compared with flexibility or responsiveness. Therefore the argument here is that the preferred measures used within simulated models are the quantitative ones.

Persson and Olhager (2002) use discrete event simulation (Taylor II) to model a mobile communication supply chain system where the key performance measures considered are quality, cost and lead-time. The interrelation between them is demonstrated here and concluded that the total cost increases more than linearly with lead-time and

increases non-linear with poorer quality levels.
A multi-echelon supply chain simulation model was developed by Ng et al. (2003) using Microsoft Visual C++, with inventory cost, demand variance and safety stock considered as main parameters.
Other modelling techniques have been such as Excel spreadsheets-based models with @Risk add-in software that incorporates the effects of variability in demand, forecast and lead time Kumar and Kropp (2005). The performance measures used in this case are customer service, cost and flexibility.
There is clear evidence that measures are considered for simulated supply chain systems, however the number of measures used are limited. It is also discussed that measures can have common elements and they can be dependent to each other.

CRITICAL ISSUES FOR COMPOSITE MEASURES

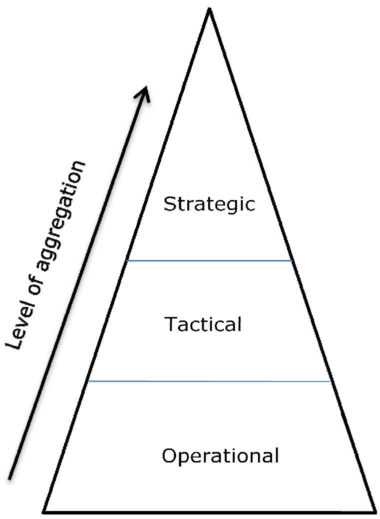


Figure 1 – Performance measures level of aggregation

Performance measures are constructed depending on system requirements. They exist at different levels of aggregation (Tipi et al., 2008). There is the vertical aggregation where the level of aggregation is different from a strategic to an operational level (see Figure 1). At a strategic level, measures are modelled with the aim to present the overall performance where this is easier to interpret by different players within the supply chain as well as being easier to communicate to different parties within the extended chain. There is a tendency to work with less performance measures at a strategic level in a supply chain. At tactical and operational levels the number of measures used increases also they do not have the same degree of aggregation. Therefore aggregated measures are important within an integrated supply chain to give a summary to stakeholders of the complex, multi-dimensional issues accumulated from different levels within an individual supply chain.
If referring to extended supply chains where performances are assessed by suppliers or customers, horizontally aggregated measures are modelled to give an overall view of individual echelons within a supply chain system.
It offers a good way of summarising a set of performance data, where they are also accompanied by a selection of drawbacks as will be discussed here. Research into performance measures with the associated advantages and disadvantages of aggregated measures are also mentioned in (Wouters and Sportel, 2005) and further discussed in (Jacobs et al., 2007).
Using aggregated measures to evaluate and control supply chain systems could create difficulties in identifying the source of the problem for which a change decision is required. Using a model and a modelling system can help to identify the source of the problem by monitoring individual elements that comprise the aggregated measure. It is also the argument where managers have to operate with a very large number of measures, some which could be obsolete or inconsistent. By consolidating performance measures the obsolete ones can be removed. However if any of the obsolete measures are part of an existing aggregated measure, the process of removing measures from a system requires considerable attention from a modelling point of view.
Before aggregation, extensive testing and verification procedures need to be carried out for individual elements, after which they can be consolidated into a single more meaningful measure.
Aggregated measures could contain elements which can be contradictory and cancel each other out when added together. For example, if the composite elements of the customer satisfaction are the number of returns, the number of reported defects versus

the number of sales, potentially, parts of these elements could cancel each other out when not modelled correctly. Each element should be individually analysed and the dependency between each one of them needs to be identified, as the number of returns does not necessarily mean unsatisfied customers, as it could mean that a product was returned due to a defect.
The process used to measure individual elements within an aggregated measure should be consistent, otherwise the final result may not be validated.
When data has form of both quantitative as well as qualitative values it is very difficult to compile measures into a comprehensive measurement system.
Although there are a number of issues to be considered when building composite measures for a supply chain system, they are necessary especially within a complex supply chain environment.

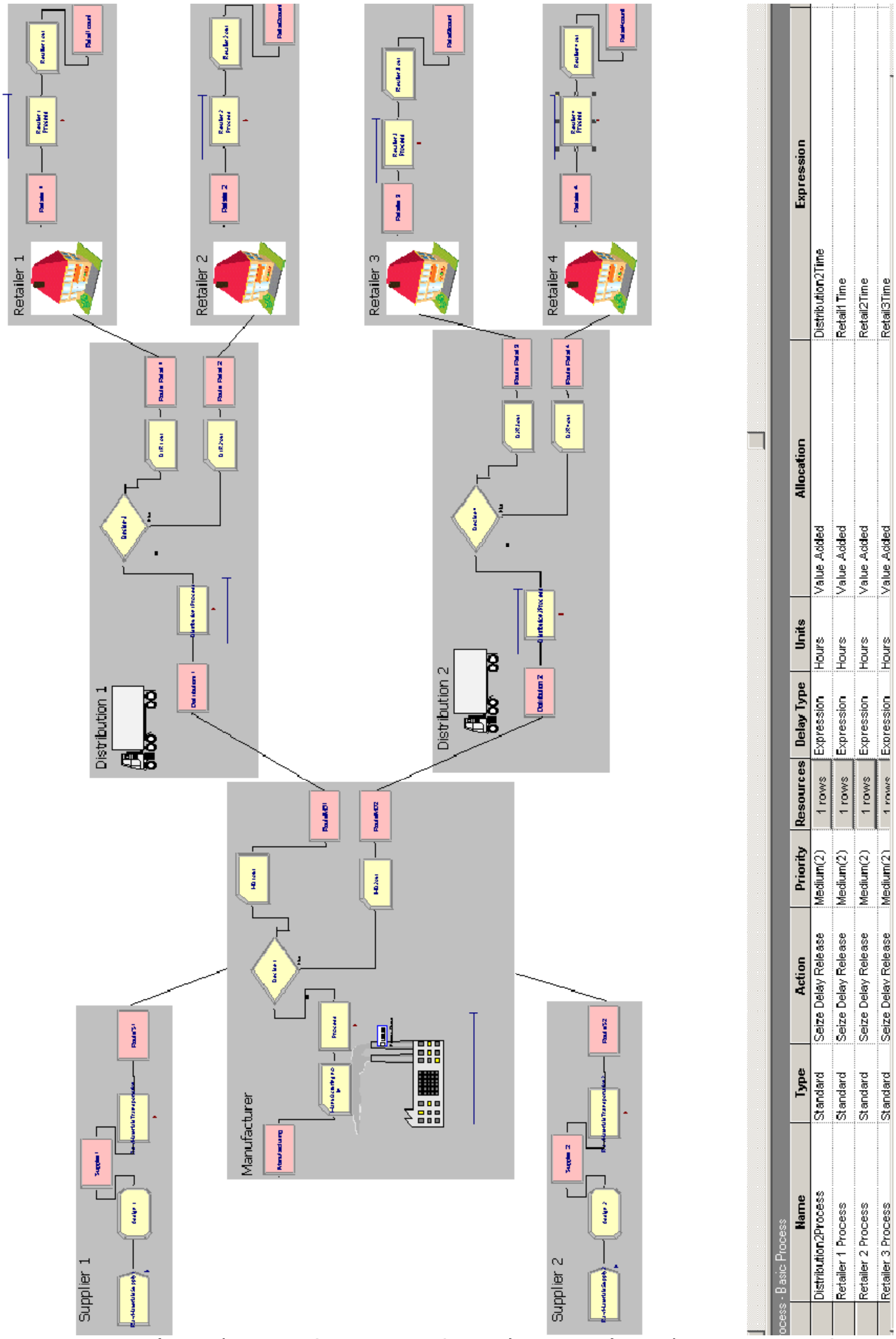
A SIMULATED SUPPLY CHAIN MODEL

Many simulation software packages and many simulated models have been used and developed over the years. Simulated models must be easy to understand, implement and change in order for them to be adopted by industrialists. They also have to allow rapid assessment of current processes and operations within the supply chain and allow opportunities to increase system quality and efficiency.
To exemplify the issues linked with composite measures within a supply chain a simulation model is considered here for a multi-echelon supply chain. A commercial simulation software package ARENA is used to simulate this model. The system used is in the form of a discrete event simulation where different dedicated ARENA blocks have been utilized to build the model.

The system considers two suppliers, one manufacturer, two distribution centres and four suppliers (see Figure 2). The two suppliers are providing raw materials to the manufacturer, who processes them and then sends them to two similar distributors. The distributors are then sending the finished products to four similar retailers.

Different processing times are used at the manufacturing plants, distribution centres and at the retail sites. The value of the processing time is given in the form of a distribution for each of the sites. The processing time plays an important role as it is one of the composite elements for different measures such as cost, resource utilisation, work in progress. Variations in the value of processing time result in changes or variation to measures such as cost, resource utilisation, throughput and on time delivery. Although the processing time measure is not directly considered in the formulation of, for example, resource utilisation measure, it is still a critical influencer for this. Considering a situation where the resources are balanced, a decrease in the value of processing time will result in a decrease in the value of the resource utilisation. Having the current resources underutilised, a strategic decision could be in the form of reducing the number of resources used. This can be easily exemplified using a simulation model such as the one presented above.
The processing time measure together with the resource utilisation measure can also influence the work in progress measure. The value for the processing time will directly affect the time jobs are waiting in a queue to be processed. The longer the processing time the longer the jobs have to wait in a queue to be processed.
Work in progress (WIP) measure in this case is calculated as the total number of jobs waiting in each of the queues within each echelon of the supply chain. Total work in progress is therefore a sum of individual work in progress jobs along the supply chain.

Figure 2 – ARENA Supply Chain simulation system



Total WIP = nq(Manufacturing Process.Queue) + nq(Distribution 1 Process.Queue) + nq(Distribution 2 Process.Queue) + nq(Retail 1 Process.Queue) + nq(Retail 2 Process.Queue) + nq(Retail 3 Process.Queue) + nq(Retail 4 Process.Queue), where *nq(ManufacturingProcess.queue)* – represents the number of jobs waiting in the queue for the Manufacturing Process to be executed.

Another definition for the Total WIP can be given as:

Total WIP = Total Throughput – Total Input

The second formula is valid for specific supply chain systems (jobs for which the number of inputs can be expected to equal the number of outputs – for example jobs which do not require assembly of different parts). The second formula is also valid for specific parts within the system for example a supply chain from which the analysis takes only after the manufacturing process is complete. However, the two formulas used are very different. There are arguments toward both formulas used to calculate the total work in progress where the final result will be different.
The first formula used here will only look at jobs waiting in queues to be processed, to be distributed and jobs waiting at the retail sites, where it does not look at jobs currently in process. However, this is a complex formula but it is very clearly split between different parts of the supply chain. Still, some can argue that using this formula there could be missing elements such as the number of jobs being processed at any one time in the supply chain.
The second type of formula appears to provide a more accurate answer as it does consider all jobs currently waiting in a supply chain which have not left the supply chain. Although this formula will provide a more accurate answer it cannot capture individual echelons details therefore it will be very difficult for managers to understand the system and make appropriate process changes which could lead to an effective and efficient supply chain system.

For a different supply chain system Tipi and Bennett (2000) also argue that very small variation to processing time influences the majority of the performance measures for the selected supply chain system, and go further to argue that these type of changes disturbs the system from its steady state.

In spite of the type of formula used for total work in progress measure, it is clear that this is directly linked to the throughput measure, where the longer the jobs are waiting in a queue to be processed the smaller the numbers of jobs are to be finished. For the supply chain presented above the calculation for throughput is the total sum of jobs leaving the system at the retail sites.

Total Throughput = nq(Retail 1 out) + nq(Retail 2 out) + nq(Retail 3 out) + nq(Retail 4 out),

where *nq(Retail 1 out)* represents the number of jobs leaving the supply chain at the Retail 1 station.

The main aim for the total throughput measure in this case is to maximise the number of jobs leaving the supply chain at all four retail sites. The way in which the throughput measure has been constructed here appears to be an aggregated measure taking into consideration the output at each retail site. Unless individually monitoring per retail site is conducted, it would be very difficult to make a process change to improve the total throughput result. Using a simulation model as the one presented above different scenarios and what if analysis can be constructed here in order to maximise the total value of throughput for the supply chain. Different changes or improvements along the supply chain will be reflected in the total throughput performance measure. For example doubling the processing capacity at the manufacturing site will be reflected in an increase in the total throughput for the supply chain.

Continuing this analysis the longer the jobs are waiting in a queue the higher the cost. Therefore the cost performance is directly linked to the work in progress performance measure.
The formula used for the whole supply chain cost performance measure is presented in the following:

Total Supply Chain Cost = Total Supplier 1 Cost + Total Supplier 2 Cost + Total Transport Cost from S1M + Total Transport Cost from S2M + Total Manufacturing Cost + Total Transport Cost from MD1 +Total Transport Cost from MD2 + Total Distribution 1 Cost + Total Distribution 2 Cost + Total Transport from D1R1 + Total Transport from D1R2 + Total Transport from D2R3 + Total Transport from D2R4 + Total Retail 1 Cost + Total Retail 2 Cost + Total Retail 3 Cost + Total Retail 4 Cost

The formula for Total Supply Chain Cost described above represents the sum of total cost for each individual echelon forming the supply chain as well as the total transport cost. It is also evident that the formula used here depends very much on the supply chain design. As the supply chain changes its form or design the cost formula requires changes. Each individual total cost represented here can be further developed for example

Total Manufacturing Cost = Holding Cost + Processing Cost + Setup Cost + Miscellaneous Cost

Decomposing each individual cost can provide a clearer picture of activities and operations present within an individual echelon of a supply chain. In general the overall value of cost or profit of an organisation is made available, the way in which the formula used to calculate this value is not always made clear.
Any process or strategy change will have an effect on an individual cost measure. As an individual cost measures are part of a different of bigger measure it will ultimately have an effect on other performance measure.

Other performance measures considered in this simulation system are on time delivery, and their derivation such as the number of jobs delivered on time, the number of jobs delivered late, flow-time as the total time a job spends in the supply chain and the number of jobs delivered early.

Another type of evaluation was looking at process flexibility. Changes to process designed were reflected in the overall supply chain performance measures. Using simulations appears one of most effective tool on understanding and evaluation supply chain design, re-design and process changes.

CONCLUSION AND FURTHER WORK
As it is known that the real competition is among the supply chains it is critical to understand the way in which they are evaluated and measured.
It is still the case that most of the performance measures used in industry are modelled and designed for individual echelons and not always for the whole supply chain.
A simulation system has been constructed here to emphasise some of the challenges faced by modellers when evaluating complex supply chain systems.
A strategic measure usually reflects the behaviour of a selection of operation. Having clear visibility of individual measures at an operational level can help the decision making process at a strategic level. Therefore is critical to understand measures from an operational to a strategic level as well to understand them from an individual echelon to complex supply chain systems.
Changes in supply chain design will generate changes in the overall structure of its performance measurement system.

This research is looking to further develop an understanding of the challenges presented by the design of performance measures for complex supply chain systems.

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INTER-FIRM PERFORMANCE FOR GLOBAL NETWORKS: AN OPTIMISATION MODEL USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT
Competitiveness in the global market requires efficiencies to improve the performance across the whole supply chain of inter-connected firms. Competitive and adversarial relationships in uncoordinated supply networks have traditionally impeded the improvement of performance. Hence the adoption of management techniques, that regard inter-connected firms (ICF) as integrated inter-firm networks (IFN), needs to be expanded for improved performance. An optimisation technique for determining performances and metricating their efficiencies on the basis of Pareto optimality is Data Envelopment Analysis (DEA). Despite DEA's diverse and widespread application, its potential for supply chain networks has not been fully explored. This paper proposes an optimisation model that measures performance in an inter-firm supply chain, in particular the efficiency of inter-firm collaboration. The algorithm requires that 'decision making units' (DMUs) are the inter-connected dyads of firms in the network which can be assessed comparatively to one another and ranked against the best performers. This paper therefore makes an original contribution to the study of supply chain management by providing an optimisation model to assess the effectiveness of inter-firm networks.

Keywords: Inter-Firm Networks (ICN), Performance Optimisation, Data Envelopment Analysis (DEA)

INTRODUCTION

The ever-changing global competitive environment, with economic and financial uncertainties, forces companies to assess their strategies to operate more efficiently. This can be achieved by adopting business models based on new management paradigms that regard the supply chain as an integrated IFN. The IFN is characterised as a value-seeking framework that adopts and uses information technology, global capacity constraints, resource limitations, and core competencies.

The global market requires competitiveness across and within the whole supply chain, and for all stakeholder-members participating in the 'value web' of a global IFN. Traditionally such a goal has been difficult due to the competitive and adversarial relationships amongst the players in supply chains and the diminished regard for the value of relationships in these networks. There were winners and losers, but in a Pareto optimal scenario there are definitely no losers.

Traditionally, successful company performance has been a perennial quest where market dominance and the incentive of financial rewards have motivated organisations to do better, to be better and to improve continuously to stay ahead (Dixon et al., 1990), usually by making comparisons with peer competitors or their industry. How companies have strived for improvement is by comparisons with; benchmarks and internal standards, stockholder and stakeholder demands, the achievements of competitors or recognised industry leaders, and by collaboration with supply chain partners. In seeking this, organisations adopt or develop appropriate metrics to interpret and describe quantitatively the criteria for performance measurement (Medori and Steeple, 2000). Traditional measures of performance have been financial metrics (Johnson and Kaplan, 1987), such as profit, dividends and return on equity requested by firms' stockholders. Primarily, theses stalwarts of performance have been assumed to provide an uniform metric which measures the same things for all, and is regarded as equally important to all. They are also well established measures, strongly supported by the various financial professions and consultancies which espouse currency by introducing newer financial arrivals such as Activity Based Costing and Economic Value Added (Stern et al.,2001), the implication being that they meet the needs of the present (Otley, 1999). However, there are still a number of criticisms that cannot be rejected (Kaplan, 1986). Accounting is 'backward looking' with performance measured historically and commonly within a short time horizon. Looking to the past promotes more of the same (Tarr, 1994). The other criticism is that financial/accounting measures do not provide uniform consensual metrics anyway. Figures can be manipulated, distorted and used to achieve desired outcomes. Hence, researchers have looked for better ways to measure and report company performance.

Other performance measures including multidimensional metrics such as the financial, customer, process, innovation and stakeholder perspectives, are consolidated under systemic frameworks that provide powerful performance models. The Balanced Scorecard (BSC) of Kaplan and Norton (1992) and the Performance Prism (PP) by Neely et al., (2001) are examples of successful widely used performance models. Those, however, are still operationally focused within the integrated enterprise and the main stakeholders rather than the holistic network of ICFs. In fact most firms have individualised frameworks and models, which may be designed around popular models, which use the firms' own key performance indicators (KPI).

Consequently, this paper proposes to establish a framework of comparative performance measurement to cater for the essential success factors in a competitive environment within the IFN. This new framework builds on the strengths of the BSC and PP and extends the critical performance dimensions into the supply chain networks, which allows the integration of intangibles measures which are difficult to quantify but essential for success of a supply chain. In addition, this paper will demonstrate how DEA can be applied as a performance measurement model within this framework. DEA is a multi-criteria optimisation model from operations research that is able to quantify those critical success factors that present viable results for increasing efficiency.

A CONCEPTUAL ICF FRAMEWORK FOR PERFORMANCE MEASUREMENT

There seems little debate about the 'need' to have performance measurement (Medori and Steeple, 2000). However questions about how to measure performance and what the metrics should be are widely discussed (Mills et al., 2002).Typically the KPIs or metrics are obtained to establish baselines and used as reference points to springboard improvement (Bititci et al., 2000). This applies internally in the firm as well as with ICFs. The improvement strategy is then set against desired goals. For example, (Wormack and Jones, 1994) suggest that the extraction of 'value' is the goal and this can be achieved from performance improvements. The supply chains through their ICFs can provide the opportunity to extract further value for supply chain partners.

The BSC was a quantum jump from established thinking on performance measurement models and it spurred a whole new approach (Kaplan and Norton, 1992). This model made special provision for forward planning as a separate entity to financial performance. It addressed the need for a balanced approach by including financial and future oriented non-financial performance measures (Kaplan and Norton, 1993). The BSC applies four performance dimensions.

First, the financial perspective drives stockholder value, next, the customer dimension considers their satisfaction, the internal dimension measures the operations of the particular firm, and finally the learning and innovation perspective gives strategic direction for the future (Kaplan and Norton, 1996). BSC has wide application and acceptance (DeWaal, 2003) and its strategy focus provides a solid base for an examination of market awareness and supplier development (Cousins and Hampson, 2000), a major reason for including these aspects of performance measurement in IFNs.

In recent times there have been attempts to go further than simply a balance of the factors under the control of the firm, and its closest ICFs. The PP from the Cranfield School is an example of a performance model that focuses on the stakeholder dimension (Neely et al., 2001). This focus is the critical and unique facet that earlier models overlooked. Hence the five facets; (i) stakeholder satisfaction, (ii) strategies, (iii) processes, (iv) capabilities, (v) stakeholder contribution, are directed by the needs and wants of the stakeholders.

There is a symbiotic relationship between the organisation and the stakeholder (Neely et al., 2001). Stakeholders in the PP are addressed as partners and contributors in the strategic approach to excellence in supply chains through value stream management (Hines et al., 2000), which by default includes the ICFs of a network. The PP is seen as a broad-gauged tool which provides multiple performance hierarchies, unlike other frameworks. However, it fails to address quantification of the performance. In particular, this is evident when the supply chain is considered as an integrated inter-connected entity with common goals, rather than a number of individual participants. Certainly the success of the PP lies in the competence of the user.

As deficiencies were revealed over time, evolution in the study of performance measurement took place. Starting from single measures and multiple-measures studies towards second tier models and lately to a macro level performance measurement perspective (Thorpe and Beasley, 2004; Rouse and Putterill, 2000). This perspective determines corporate success or failure by the strategy it adopts in competing in a social, political and commercial world involving multiple stakeholders with diverse interests and power.

The discussion that performance measurement must be studied beyond organizational boundaries leaves comprehensive existing models such as the PP and the BSC challenged (Norreklit, 2000). It appears that an all-encompassing model which explains performance measurement and provides the indicators to support it has not yet been developed, certainly not for the supply chain networks. Herein lies the potential to develop an unified approach. Certainly the concept that all can be enumerated in a performance scorecard is not novel in itself. Nevertheless it can be viewed as an evolutionary outcome of all the work that has been reported, but not fulfilled.

The proposed ICF-Framework, indicated in Figure 1, aims to fill that vacuum by presenting a business concept based on a ‘socio-economic commerce system’ model. In this concept the supply chain factors and those beyond have a role which can be measured as separate dimensions of a performance pyramid and incorporated into an aggregated performance score.

The three dimensions, which are internal operations of firms, operations involving suppliers and those concerning customers, describe the performance pyramid. These three dimensions are based on corporate governance and refer each to appropriate KPIs and a performance measurement model.

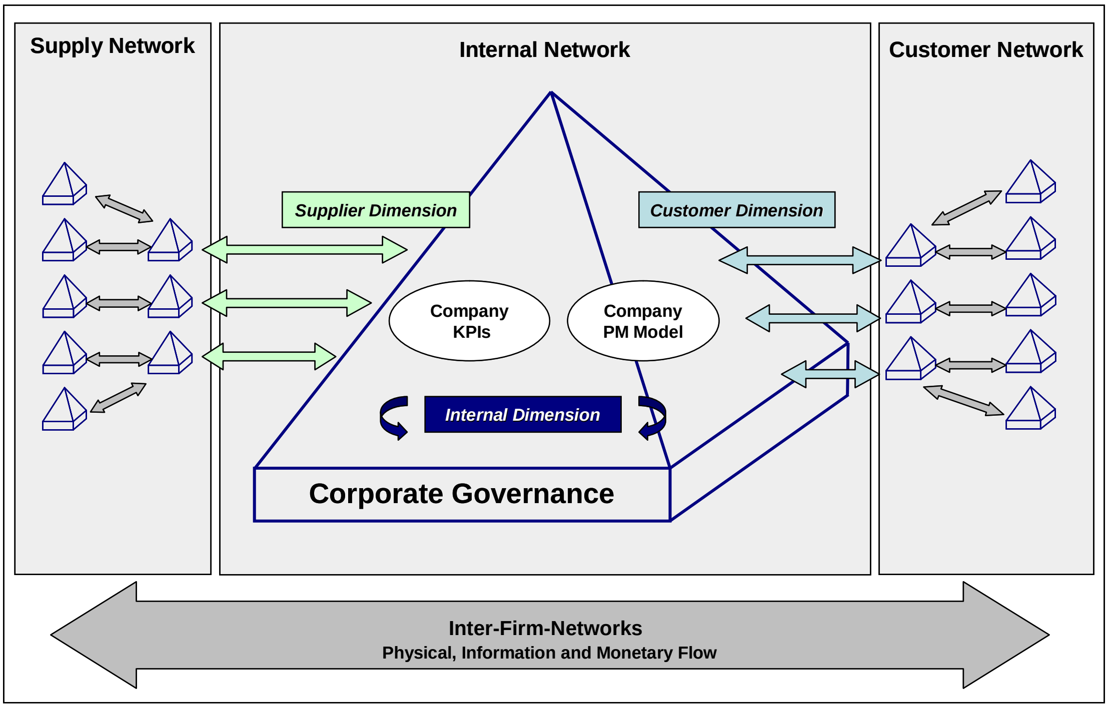

Figure 1: The ICF Framework for Performance Measurement

The performance pyramid is equally applicable to each ICF of a network. In other words, each company in the IFN will have its own performance pyramid since all firms have the same dimensions. So, while these dimensions apply to all ICFs, the firms can be studied individually. The main quest of this framework however is the comparative assessments of ICF relationships of dyads.

Commonly KPIs can vary between each ICF but may however, be similar. For example, all have human behavioural supplier-customer interactions that might be measured with different metrics allude to the same notion. The same notion based on different metrics can be translated into common factors. An important aspect in this framework is that performance measurement model is flexible enough to allow this translation, so that dyads relationships can be compared.
Hence, the novelty of this concept lies in the fact that it incorporates both tangible with less tangible, and financial with non-financial factors in a performance measurement framework of parametric and non-parametric indicators. Additionally, it can be used as a comparative assessment framework throughout the entire IFN or parts of it. This has been considered not possible previously because of the disparate nature of the various indicators and the non-coalescence of quantitative and qualitative variables. The dichotomy is addressed by adopting a performance measurement model which allows multi-criteria analysis of all factors through an optimisation process for firms to adopt internally, with important SC partners, or for the IFN.

DATA ENVELOPMENT ANALYSIS: A PERFORMANCE MEASUREMENT MODEL
The optimisation problem can be expressed as the result of a process; deciding what factors lead to optimum or non-optimum outcomes, deciding what the constraints on decision choices are, and what the overall objective of the mathematical programming exercise is. While it is recognised that business works to a complex set of objectives it is often the financial ones that feature prominently. These can all be expressed mathematically. For example the objective function in linear programming to maximize profit or minimize costs is suited to such a task (Ragsdale, 2004). However, when the variables are unable to be enumerated as explicitly as required, a linear programming-derived methodology designed for this particular purpose should be favoured. One of these is DEA (Ramanathan, 2003), which is a nonparametric method of operations

research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (DMUs). DEA was originally designed, and is very successful, to fulfil the task of assessing relative performance of non-profit organisations as well as environments where outputs are not quantifiable in conventional measures such as monetary units (Metters, 1999). The performance is expressed as the efficiencies of the output-input ratios. Outputs are the services produced, often intangibly defined, while inputs are the resources required to achieve these (Nyhan and Martin, 1999).

The first DEA model of Charnes et al. (1978) is referred to as the CCR ratio form. This was based on the extension of Farrell's (1957) technical efficiency measure of performance as a single input and a single output ratio, which at this time was gaining credence world wide (Sumanth, 1984) and was an economic tool for the measurement and comparisons of productivity at international, national, and industrial levels. Charnes et al (1978) by-passed the shackles of single input and output economical metrics by devising a mathematical model that generalize to multiple outputs and inputs. The independent and discrete relationships of inputs and outputs of selected units are related to as DMUs and are defined accordingly. Consequently, this model allows the generalisation of a virtual single-output/input ratio efficiency measure of a single DMU (X_i) by transforming multiple output/input characterizations through a fractional linear-programming formulation into a single measure (Charnes et al. 1994). DEA defines the efficiency of an arbitrary unit i as:

$$Efficiency \quad of \quad unit \quad i = \frac{\sum_{j=1}^{n_O} O_{ij} w_j}{\sum_{j=1}^{n_I} I_{ij} v_j}$$

$$Where: \quad Efficiency \ of \ unit \ i = \frac{Weighted \ sum \ of \ unit \ i's \ outputs}{Weighted \ sum \ of \ unit \ i's \ inputs}$$

And: O_{ij} represents the value of unit *i* on output *j*

I_{ij} represents the value of unit *i* on input *j*

w_j is the non-negative weight assigned to output *j*

v_j is the non-negative weight assigned to input *j*

n_I is the number of input variables

n_O is the number of output variables

Unlike parametric approaches requiring specific functional forms relating independent and dependent variables, as in a linear expression, DEA calculates the maximum performance of each DMU in relation to every other dyad DMU. These DMUs all exist on or below the 'external frontier' which depicts the optimum, and similar to the boundaries of the feasible and non-feasible regions in linear programming. The relative technical efficiency (Cooper et al., 2000) of each DMU is expressed as a percentage (or decimal value) of the 'best practice production frontier', the maximum output empirically obtainable with a given amount of input. Improvement for the lower performers is possible by various manipulations of this ratio such as, increasing the output while keeping input stable, decreasing input for an unchanged output or a myriad of these combinations (Charnes et al. 1994). In a pragmatic sense the choice of improvement strategy will depend on economic conditions; when the global economy is booming the strategy is to increase outputs with minimal increases in inputs, while when the economy is in decline or is stressed the better strategy is to focus on reducing inputs, which can include the disposal of 'non-performing resources/assets'.

DEA has an attraction to business activities because of three main factors; (i) each DMU has a single score to indicate relative efficiency, (ii) potential improvement for each DMU is benchmarked against the best-practice referent DMU, (iii) DEA obviates the need for alternate abstract inferential statistics. In contrast to descriptive and inferential calculations DEA focuses on individual observations as single measures per DMU, rather than population averages or regression relationships, expressed in terms of the input factors as independent variables and output factors as dependent variables. Multiple input and output measures using different units can also be accommodated, as can dummy (categorical) variables. While these factors are value-free they can be weighted to include a priori knowledge from the judgements of experienced and knowledgeable managers. Finally, the focus is on benchmarking against existing best-practice rather than deviation from central tendency. More specifically, the focus is on superior relative performances, hence those at the upper end of the distribution rather than the mean. The DEA approach for performance modelling is summarised in the diagram below.

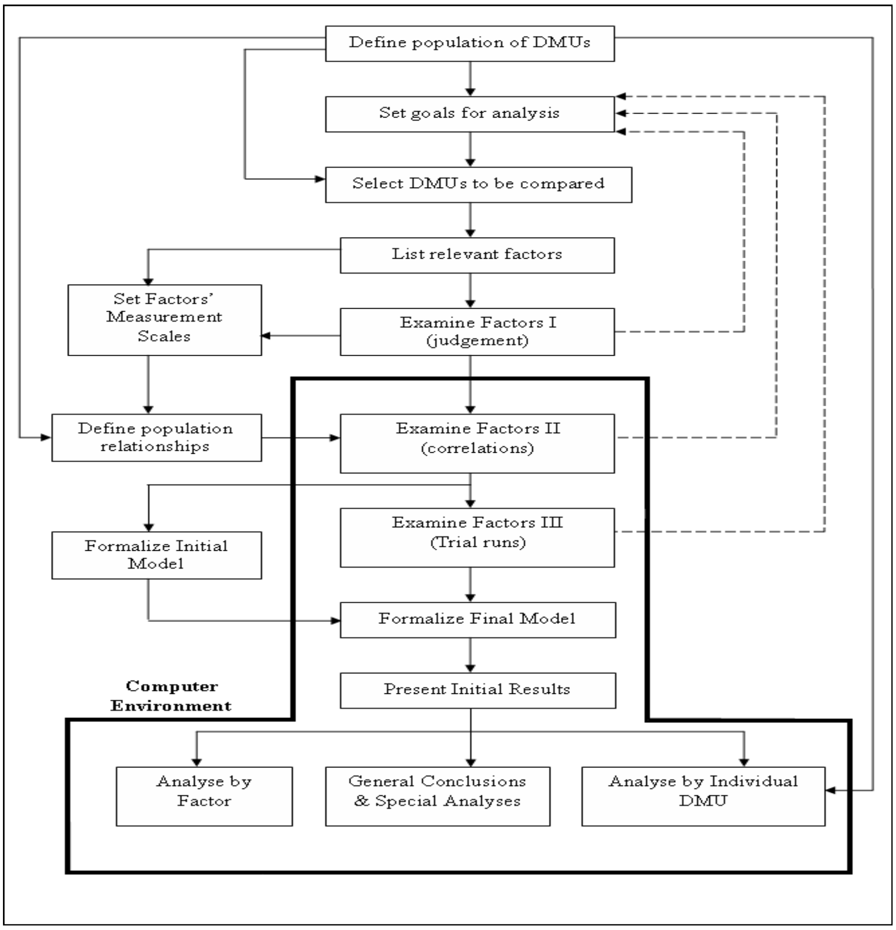

Figure 2 The DEA approach (Golany and Roll, 1989)

Little seems to have been reported on DEA studies of commercial firms and less on supply chains. Perhaps this is because the technique has been applied in non-commercial firms where traditional financial and accounting measures are not firmly established. There also may be no perceived need to use DEA for commercial intra-firm and inter-firm analyses since other established quantification systems suffice. This research, however, will attempt to legitimize the use of DEA beyond the firm because of its attraction as a multi-criteria decision analysis technique which allows weightings to be assigned to the measured units. If an organisation has identifiable input resources and definable outputs then DEA can be applied. The attraction of the organisational relationship between inputs and outputs lies in the ability to extend this relationship beyond the enterprise and into the supply chain. The outputs of upstream suppliers can be regarded as the inputs to the focal firm, and similarly its own outputs may be treated as inputs to its customers, because all firms in the IFN have inputs and outputs.

DATA ENVELOPMENT ANALYSIS: APPLICATION IN THE ICF FRAMEWORK

A simplified example chosen for illustrative purposes could be based on relationships between ICFs at inter-firm and intra-firm networks, as indicated in figure 1 earlier. Hence a vertically integrated corporation with several manufacturing plants, its own supplier and distributor subsidiaries, all under one corporate control can now be included in comparisons of external partners in the supply chain having similar input/ouput factors. Corporate head office controls and specific strategic planning and KPIs should not stymie comparisons between ICFs. The scenario in Table 1 indicates the decision units (ICFs) of inter or intra-firm networks labelled X_1 to X_{10}. These could all be ICFs of one corporation alternatively they could all be ICFs in the inter-firm network, or a mixture of corporate subsidiaries and external firms. They could also be firms selected from the network for a particular research purpose. Comparable input KPI factors could be; Direct Labour Hours per Unit and Indirect Costs per unit, while the comparable output KPIs could be profit as Return on Equity, Inter-partner Satisfaction (rated 1 to 10) and dialogue through Information Flow (percentage).

The inter-firm partners can be regarded as discrete DMUs, for DEA purposes, as long as the input and output factors for all ICFs are the same. The choice of whether these DMUs are firms upstream, downstream or across the whole supply chain depends on the motivation for the research. Part of the researcher's task therefore is to identify factors which are common to ICFs and important to each one's operations. This selection process is critical to the success of the DEA algorithm. Poor selection for example, may give a DEA computation result that erroneously labels many firms as efficient when there are only a few. The correct identification of these can involve some degree of trial and error following the DEA approach illustrated in figure 2, and there are heuristics that provide further guidance (Ramanathan, 2003; Sengupta, 2003; Cooper et al. 2001).

The computed results clearly identify the most efficient DMUs, based on the given input and output KPIs. In his research scenario ICFs X_2 X_5 and X_9 are equally efficient firms with a score of 1.00 (100%).

Table 1 Inputs, Outputs and Efficiency Results of DEA for One SC member

Inter Connected Firm (DMU)	**Input** (Input kpi1) Direct Labour Hours/unit	**Input** (Input kpi2) Indirect Costs/unit	**Output** (output kpi1) Return on Equity	**Output** (output kpi2) Inter-partner Satisfaction	**Output** (output kpi3) Information Flow	**Efficiency**
X_1	7.13	2.65	4.78	5.7	93	**0.878**
X_2	6.89	6.01	7.67	7.3	69	**0.847**
X_3	7.04	7.36	5.99	9.5	99	**1**
X_4	4.01	5.38	6.87	7.9	89	**0.911**
X_5	6.91	6.81	8.31	7.01	96	**1**
X_6	5.76	6.13	5.19	6.7	87	**0.903**
X_7	3.36	4.32	3.19	8.6	91	**0.719**
X_8	7.17	7.68	6.3	8.9	90	**0.773**
X_9	8.01	4.73	7.13	6.9	94	**1**
X_{10}	6.88	6.13	8.01	7.67	89	**0.987**

CONCLUSION

Performance measurement strategies to capture efficiencies of IFNs are often espoused as applications of popular models but if 'numbers speak louder than words' then DEA quantifies performance. Its computation is mathematically irrefutable and unquestionable in its interpretation once the correct parameters have been established. The established benchmarks and ratings of performance as well as the recognition of factors contributing to this standard will lead to the development and implementation of improvement strategy. The above illustrated example provides an indication that the underachieving ICFs, those less than 1.00, have potential for improvement. An analysis of the input and output factors of the best performers can provide managers with strategies that should pave the way forward.

While initial trials by the author have been encouraging, and this paper presents developments on embryonic work presented earlier it has not yet been fully tested on peers in IFNs. This new challenge is to identify and apply those input-output KPI factors for ICFs that will provide the efficiency computations for supply chain networks. Hence, future research proposes to test the applicability of this approach in a myriad of organisational settings across a variety of commercial enterprises in the Australian economy. In particular, the attraction of a standardized optimisation model which provides an algorithmic solution to the IFN performance question lies in its ability to metricate the contribution and importance of each part of the supply network.

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AN IMPORTANCE-PERFORMANCE ANALYSIS FOR SUPPLIERS ASSESSMENT IN FOREIGN-AID FUNDED PROCUREMENT

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ABSTRACT

Purpose - The supplier assessment process and the supplier assessment criteria used by the organisational buyers are considered critical elements for suppliers' choice process. However, little attention has so far been given for supplier assessment in foreign-aid funded procurement in the context of developing countries. Using a sample of Executing Agencies (EAs), Donor Agency Executives (DAE) and Supplying Organisation Executives (SOE) this study identified the supplier assessment criteria and their relative importance in foreign-aid funded procurement in Bangladesh. It also assessed the extent of match between buyers' requirements and suppliers' performance.

Design/approach/methodology - An instrument with 32 seven-point (1- rarely, 7 mostly) Likert scaled items was employed to gather data on the level of importance assigned by both buyers and suppliers on each item. In this study EAs and DAEs represent buyers, whereas SOEs represent suppliers. The importance-performance matrix (IPM) analysis was conducted to assess the gap between what is required by the buyers and what is provided by the suppliers, and to categorise the assessment items into four categories such as 'low priority', 'possible killer', 'concentrate here', and 'keep up the good work'

Findings - The results indicate that to provide better service suppliers must assign tasks to the knowledgeable sales personnel, provide better warranties with well-known branded products, and at a reliable quality level. The supplier organistions should organize a high caliber management system so that they are capable of providing services without constant follow-up by the buyers and response to buyers' enquiries promptly.

Originality/value - The results of the study could be adopted to design supplier assessment procedure in other developing countries.

Key Words - Assessment criteria, Developing country, Foreign-aid funded procurement, Importance-performance matrix.

Paper Type – Research paper.

INTRODUCTION

Foreign aid is a principal source of public sector revenue in many developing countries (McGillivray and Morrissey, 2001). It is the transfer of resources from developed countries to developing countries on terms that are more generous or 'softer' than loans at market rates. A major share of the aid money is used to procure goods and services, which originate from other borrowing/recipient countries. In 2007, the 22 member countries of the OECD Development Assistance Committee, the world's major donors, provided USD 103.7 billion in aid to developing countries (OECD, 2008).

Government departments or statutory organisations, in developing countries, commonly known as Executing Agencies (EAs), procure billions of dollars of goods and services against aid-funded projects. The main sectors of aid projects include agriculture, economic policy, education, energy, environment, finance, mining, oil and gas, population, health and nutrition, private sector development, public sector management, social protection, telecommunications, transportation, urban development, water supply and sanitation (World Bank, 2002).

Generally developed countries dominate overseas supplies purchased through foreign-aided funds. For instance, more than 77 percent of the total World Bank aid money which was paid to the overseas suppliers prior to 2000 went to developed country suppliers (World Bank, 2002). This is despite the fact that World Bank aid is not procurement tied and is open to all members of the World Bank. The expenditure on the aid projects is broadly directed by the donor countries and agencies (DAEs), and managed by the recipient nations through some type of EAs.

With a population of around 156 million (in 2006) in a land area of 47,570 sq. km and a population density of 868 people per sq. km, Bangladesh, is known as one of the most populous countries. In 2006 the GNI per capita was estimated at US$ 297 (World Bank, 2008b), which is one of the lowest in the world. Most major donor agencies provide aid to Bangladesh as nearly 50% of the population lives under the national poverty line (Five-year 2000/6 estimate- (World Bank, 2008a)). In view of this situation, Bangladesh offers a good prospect for investigating the supplier assessment process for the foreign-aid funded projects.

The broad objective of this study is to identify the supplier selection process by organisational buyers. However, the study specifically looks at the differences in assigning level of importance on the supplier choice criteria by two sides of the buying process, buyer (i.e., EAs and DAEs) and seller (i.e., SOEs), in the context of Bangladesh

The paper is organised as follows. A literature review is presented in the next section. This is followed by a discussion on research methodology and analysis. A brief conclusion is given in the last section of the paper.

LITERATURE REVIEW

For most procurement in the statutory organisations, the principal mechanism for allocating resources and controlling activity is the contract between buyer and supplier, and in most cases procurement against foreign aid funded projects is carried out by using the international competitive bidding (ICB) process. The bids are generally considered for award of contracts on the basis of an evaluated price, not necessarily on the basis of the lowest price, which may take into account a number of non-financial criteria such as 'quality, durability, availability of after sales service and spare parts, training, maintenance and operating costs' (World Bank, 2002, p. 3). Organisational buying behaviour is a complex structure of relationships (Sheth, 1973; Spekman and Stern, 1979) within and outside a buying centre (Webster and Wind, 1972). It may consist of a multi-stage decision process (Cardozo, 1983) and generally a wide range of determinants are associated with this process (Johnston and Lewin, 1996). The process of how the buying centre member acts in a group decision-making environment is also complex. Individual behaviour may vary depending on the organisational reward system (Anderson and Chambers, 1985), working under time pressure (Maule and Edland, 1997; Zakay, 1993) or having the capacity to posses and exercise power during the decision-making process (French and Raven, 1959). Moreover, the inability to fully specify rules leads to imperfect transactional instruments such as purchase rules and regulations, contracts and so on (Evans and Schultz, 1996; Ostrom, 1999).

In addition to a supplier's organisation (Johnston and Lewin, 1996), a buying centre may also require interaction with monitoring or regulatory bodies. The regulatory bodies are particularly important when buyers are from the public sector (Ostrom, 1999). From this perspective, EAs face a more complex environment. In addition to their own regulatory agencies, such as respective controlling ministry, they are likely to be responsible to multiple donors (Donor Agency Executives – DAE) with multiple control mechanisms

(Pearson and Entrekin, 1998; Williamson, 1998). Thus, it is critical that the EAs and DAEs use a set of predetermined selection criteria to reduce the complexity and ambiguity in the process of assessing suppliers.

Supplier Selection Criteria

Determining the optimal supplier who offers the best all-around package of products and services for the customer is an important aspect in organisational buying process (Swift and Gruben, 2000). Ittner et al. (1999) argued that greater use of advanced (supplier) selection and monitoring practices tends to increase profitability and product quality.

One of the earliest studies of supplier selection using multiple-criteria is by Dickson (1966). Based on the data collected from 170 purchasing managers, Dickson (1966) identified cost, quality, and delivery performance as the three most important criteria in supplier selection. Several other authors have evaluated the relative importance of cost, quality, delivery performance and other supplier attributes (Cardozo and Cagley, 1971; Dempsey, 1978). Based on 74 published articles, Weber et al (1991) provided a comprehensive review of the criteria that purchasing managers perceive important in the supplier selection decision. This study identified quality as the most important criterion followed by delivery performance and cost. A study by Ellram (1990) identified price, quality, lead-time, delivery reliability and technical service as five most important criteria for supplier selection.

Petroni and Braglia (2000) found that managers perceive quality to be the most important supplier attribute' and emphasized that 'managers should not select suppliers based on low cost only but should consider quality, delivery performance, and other attributes'(p. 64). Some studies found gender differences in using supplier selection criteria where female purchasing managers place a higher level of importance on support (breadth of product line, geographical proximity, warranty availability) and dependability (ability to keep delivery promises, technical support availability and service response) than do male purchasing managers (Swift and Gruben, 2000).

While the above studies significantly enrich the organisational buying literature, attention is yet to be given for supplier assessment in foreign-aid funded procurement in the context of developing countries. One of the rare studies conducted in the context of a developing country is by Karande et al. (1999). Karande et al. (1999) studied the comparative aspects of supplier choice criteria used by both public and private sector purchasers in India. A total of 39 items under four broad categories of supplier choice criteria i.e. economic, reliability, familiarity with the supplier, and other capabilities were used in their study. Karande et al. (1999) found economic criteria more important to private sector managers when compared with public-sector purchasing managers.

Multi-criteria supplier selection approaches

Literature reviewed in the earlier section suggests that the supplier selection decision problem is essentially a multi-criteria problem. The most common approach used to select suppliers is the linear weighting model (Wind and Robinson, 1968). It places a weight on each criterion and provides a total score for each supplier by summing up the supplier's performance on the criteria multiplied by these weights. This approach falls into the category of the compensatory model.

A more advanced scoring model that has been used for supplier selection decision process is the analytical hierarchy process (AHP). Among those who applied this method are Narasimhan (1983), Nydick and Hill (1992), Masella and Rangone (2000) Tam and Tummala (2001). Liu and Hai (2005) used the voting AHP which employed a more easier weighting method compared to AHP's pairwise comparison method. Ghodsypour and O'Brien (1998) presented a decision support system by integrating AHP with linear programming. Bhutta and Huq (2002) have compared the technique of total cost of ownership and AHP in supplier selection process. More recently, Chen and Huang (2007) developed an approach for supplier selection by integrating AHP with bi-negotiation agents. Verma and Pullman (1998) used a discrete choice analysis experiment and Mandal and Deshmukh (1994) used interpretive structural modelling to choice suppliers. Min (1994) used multi-criteria utility approach for international supplier selection. Other models such as linear programming (Weber and Current, 1993), data envelopment analysis (Liu et al. 2000) and goal programming (Karpak and Kasuganti, 1999; Chaudhry, et al. 1991) methods have also been used.

RESEARCH METHODOLOGY

Research Design

Data Collection Instrument

A data collection instrument with 32-seven-point (1-rarely, 7-mostly) Likert scaled items relating to the supplier assessment criteria was employed in this study. Thirty two items were then clustered into four higher-level constructs such as such as economic, reliability of the supplier, familiarity with the supplier, and other capability similar to Karande et al. (1999).

Respondents

Twenty four EAs, ten DAEs and nine SOEs were identified as the potential participants for this study who were involved in buying-selling process in the recent years. Since one of the authors personally distributed the survey questionnaire, all who received the instrument responded. However, four DAEs responses couldn't be used for used for analysis due to missing data. So the total number of buyers and suppliers were thirty and nine respectively.

Data Analysis

Importance-Performance Matrix Analysis

One of the more widely known importance-performance gap-based methods is the importance-performance matrix (IPM) analysis proposed by Martilla and James (1977). The utility of the IPM analysis lies in its capacity to represent both importance and performance perspectives with regards to the relative improvement priorities required in a competitive environment. It is relatively a simple to use, easy to understand and interpret, and a highly flexible technique (Skok et al., 2001). In recent times the method has been applied widely in service operations (Clarke, 1995, Skok et al.,2001, Lai and Cheng, 2003). An IPM analysis uses a 2 X 2 format. An example is shown in Figure 1. The vertical axis represents the perceived importance of the criteria from low to high, and the horizontal axis represents the perceived performance of the criteria from low to high. Thus, it generates four quadrants such as 'low priority', 'possible overkiller', 'concentrate here', and 'keep up the good work' (Figure 1).

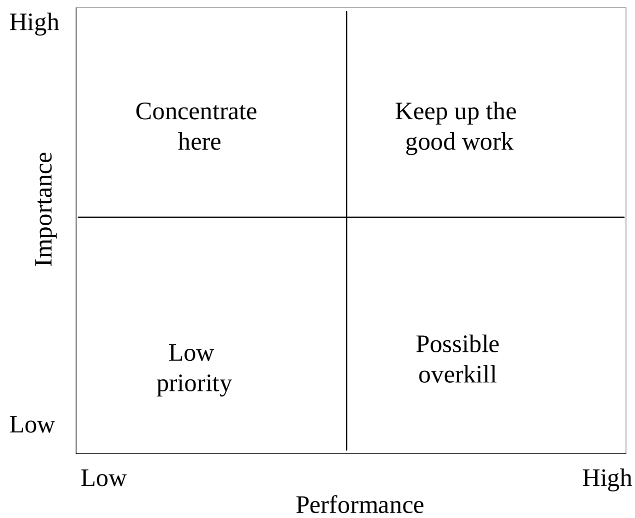

Figure 1: Importance-Performance matrix (source: Martilla and James, 1977)

ANALYSIS, RESULTS AND DISCUSSION

The IPM analysis was applied separately to each of the four assessment-categories: Economic category, Reliability category, Familiarity category, and Other capability category. The analysis was conducted in the following manner.

The mean values for four assessment categories on importance and performance were calculated. A *t*-test was conducted to ascertain the significance of difference between what is required by the buyers and what is provided by the suppliers. Thirty two assessment items that were located in the four IPMs are shown in Figures 2 - 5. The findings from the IPM analysis are reported in the following section.

Discussion of the Results

Economic Category assessment

As is apparent from the analysis that the top three assessment criteria in economic category as viewed by the buyers are price (mean = 5.6), better warranties (mean = 4.7), and volume discount (mean = 3.5). Whereas, the top three criteria as viewed by suppliers are price (mean = 5.9), cash discount (mean = 3.2), and better warranties (mean = 2.9). The difference between the means of importance and performance is significant for volume discount and better warranties only ($t > 2.0$). IPM analysis indicates that three items within the economic category (2, 3, and 4) fall into the 'low priority' quadrant; one (5) fall into the 'concentrate here' quadrant; and one (1) belong in the 'keep up the good work' quadrant (Figure 2).

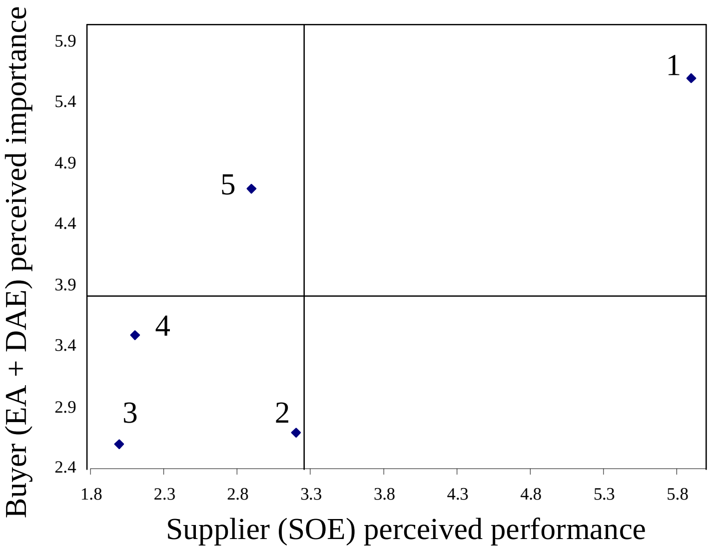

Figure 2: IPM for Economic criteria

Reliability Category assessment

Within the reliability category, buyers viewed 'timely delivery' criterion (mean = 5.3) as the most important criterion. This is followed by 'regularly meets quality specifications' (mean = 5.0), 'reliability in quality' (mean = 4.8), and 'has favourable financial position' (mean = 4.6). The least important criterion perceived is 'potential to expand capacity' (mean = 2.1). The suppliers also viewed 'timely delivery' as the most important criterion (mean = 4.6) and the least important is 'potential to expand capacity' (mean = 1.2). The difference between the means of importance and performance is significant for all criteria ($t > 2.0$); except for 'timely delivery', 'can deliver quickly', 'has favourable financial position', and 'guarantees price protection'.Figure 3 shows that three items (8, 10 and 12) fall into the 'low priority' quadrant; six items (7, 9, 11, 13, 15 and 17) fall into the ‘concentrate here’ quadrant; and three items (6, 14 and 16) fall into the ‘keep up the good work’ quadrant.

Familiarity Category assessment
Six items belong to the familiarity category of the supplier assessment instrument. Both category of respondents viewed the ‘reputation of supplier’ (buyers’ mean = 4.2; suppliers’ mean = 3.5) as the most important criterion within the familiarity category, followed by the ‘is a large firm’ criterion (buyers’ mean = 3.4; suppliers’ mean = 3.0). A *t*-test indicates that only the mean difference of criterion ‘helpful in providing special handling equipment’ is significantly different. IPM analysis indicates that one item (22) falls into the ‘low priority’ quadrant; two items (19 and 20) belong within the ‘possible overkill’ quadrant; one item falls in the ‘concentrate here’ quadrant, and two items (18, and 23) is in the ‘keep up the good work’ quadrant (see Figure 4).

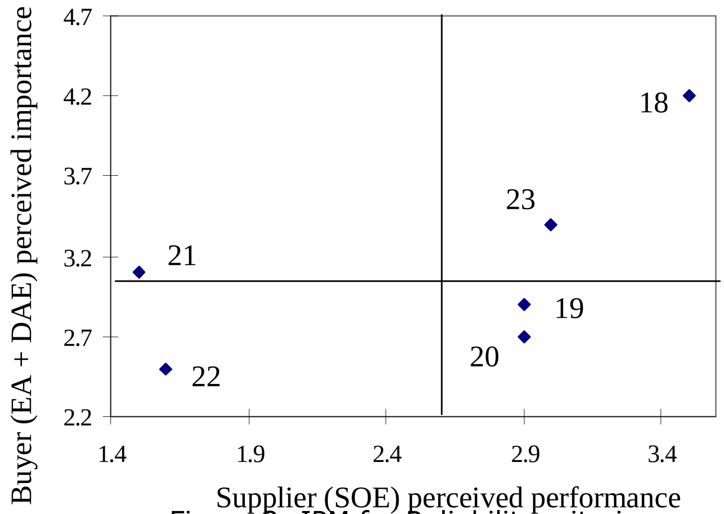

Figure 3: IPM for Reliability criteria

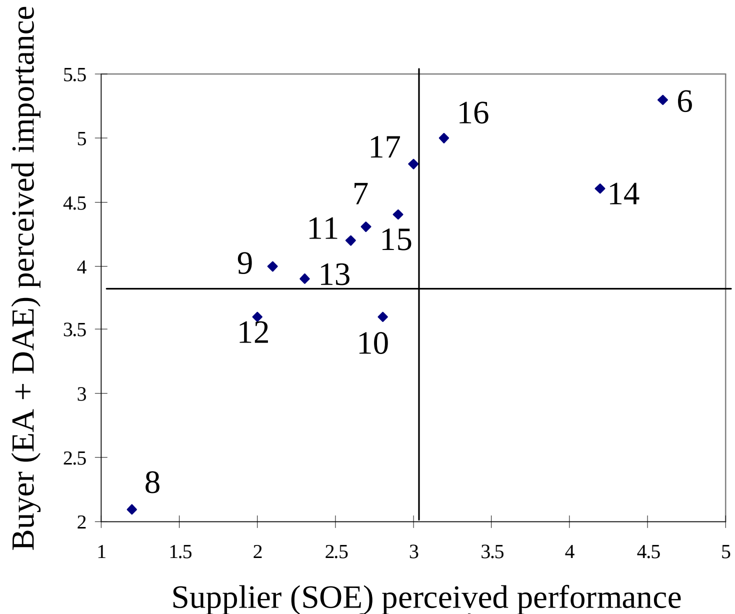

Figure 4: IPM for Familiarity criteria

Other capability Category assessment
Buyers considered the criterion ‘maintain technical services’ (mean = 4.3) as the most important assessment criterion within the other capability category, whereas, suppliers viewed ‘maintains repair service’ as the most important criterion. IMP analysis shows that two items (31 and 32) fall into the ‘low priority’ quadrant, one item (29) into the

'possible overkill' quadrant, and two items (27, 30) fall into the 'concentrate here' quadrant, and four items fall into the 'keep up the good work' quadrant.

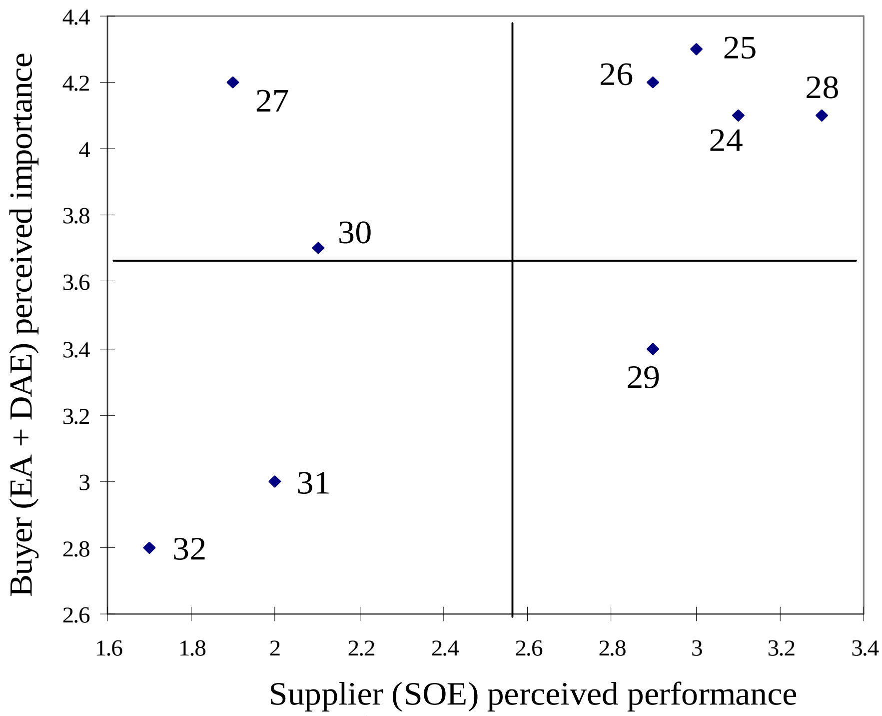

Figure 5: IPM for Other Capability criteria

CONCLUSION

This study provides an assessment on what is required by the buyers and what is provided by the suppliers when it comes to foreign-aid funded procurement in the context of Bangladesh. The results indicate that about 88% of the suppliers' performance ratings (28 out of 32 items) are lower than their corresponding buyers' importance ratings. The gap between performance and importance of a specific skill indicates its strength or weakness.

The analysis reveals that the scatter patterns of various skills in the IMP matrices are different (Figure 2 – 5). Overall, 28% of the assessment items fell in the 'low priority' quadrant, 9% in the 'possible overkiller' quadrant, and over 31% in 'concentrate here' and 'keep up the good work' quadrants (Table 1). The analysis also revealed that 60% of the assessment items where suppliers are required to improve belong to the reliability category (items 7, 9, 11, 13, 15, and 17). In order to provide better service suppliers it is essential that they assign knowledgeable sales personnel (item 30). They must provide better warranties (item 5) with well-known branded products (item 7) and at a reliable quality level (item 17). The supplier organistions must organize a high caliber management system (item 9) so that they are capable of providing services without constant follow-up by the buyers (item 11) and response to buyers enquiries promptly (item 13).

Quadrant in IPM	Item	Item description	Mean S-B	t-value
Low priority	2	Cash discount	0.5	-0.63
	3	Extended payment terms	-0.6	0.70
	4	Volume discount	-1.4	2.18*
	8	Potential to expand capacity	-0.9	2.27*
	10	Can deliver quickly	-0.8	1.12
	12	Guarantees price protection	-1.6	1.86
	22	Recommended by other similar	-0.9	1.42
	31	Has research and development facilities	-1.0	1.40
	32	Maintains frequent sales calls	-1.1	2.41*
Possible overkiller	19	Current supplier	0.0	0.05
	20	Exhibits desire for business	0.2	0.27
	29	Supplies special report	-0.5	0.75
Concentrate here	5	Better warranties	-1.8	2.86*
	7	Well-known brands and/or products	-1.6	2.69*
	9	High calibre management	-1.9	2.66*
	11	Delivers without constant follow-up	-1.6	2.02*
	13	Answers all communication promptly	-1.6	2.33*
	15	Handles rejections (of goods) promptly	-1.5	2.01*
	17	Reliable in quality	-1.8	2.28*
	21	Helpful in providing special handling	-1.6	2.94*
	27	Makes available test or demonstration	-2.3	4.01*
	30	Has knowledgeable sales people	-1.6	2.78*
Keep up the good work	1	Price	0.3	-0.54
	6	Timely delivery	-0.7	1.15
	14	Has favourable financial position	-0.4	0.60
	16	Regularly meets quality specifications	-1.8	2.01*
	18	Reputation of supplier	-0.7	0.96
	23	Is a large firm	-0.4	0.60
	24	Has technical ability and knowledge	-1.0	1.24
	25	Maintains technical service	-1.3	1.77
	26	Makes sales people available as needed	-1.3	1.88
	28	Maintains repair service	-0.8	1.08

Table 1: Distribution of supplier assessment items in the IPM matrix (* sign. at 0.05; Mean S-B – difference of mean of supplier and buyer)

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SECTION 4 – Risk and Visibility

VULNERABILITY IN UK FOOD SUPPLY NETWORKS: THE IMPACT OF GLOBAL EFFECTS

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ABSTRACT
UK food supply chains are increasingly exposed to global effects and trends. While these external factors have the potential to create new sources of risk and uncertainty, there have been very few studies in this area. As part of a project commissioned by Chatham House, this study examines the likely impacts of global uncertainties on the UK wheat and dairy supply networks. It concludes that future resource constraints, concerns over sustainability, global market volatility, higher input prices and increased exposure to crisis-led events are potential future points of vulnerability, particularly for the dairy sector. Questions over system capability and resilience in light of these uncertainties raise future implications for supply chain risk management.

INTRODUCTION
Food supply chains have seen a rise in disruptions in recent years and the UK agri-food system is no exception, experiencing a number of well publicised crises over the last decade. These include the outbreak of BSE during the 1990s, the occurrence of foot and mouth disease in 2001 and food contamination scares (e.g. Sudan 1). The network has also seen wide-spread disruption from seemingly unconnected events such as the fuel protests strikes in 2000, the Buncefield oil depot fire in 2005 and the floods of 2007. These crises served to underline how interconnected UK agri-food chains are and their vulnerability to both shock type risks, both external and internal to the food chain (e.g. disease, terrorism, natural disasters) but also the concept of 'creeping' systemic crises (e.g. fuel protests) where one small event can filter through and escalated throughout the whole system (Peck, 2005).

As food supply systems become more globally interconnected, this in turn creates increasing exposure to complex political, social and economic effects. Recent years have seen renewed concerns over the longer term ability of food production to meet rising global demand for food, in light of potential resource constraints and the effects of climate change (Evans, 2009). Global events and externalities to the system have the potential to create longer-term, systemic risks and uncertainties for food supply. The effect of global events was keenly demonstrated by the recent price shocks experienced in global food commodities between 2006 and 2008. The FAO price index reached a record 219 points in June 2008, 51% higher than seen over the previous year. Between August 2005 and August 2008 the price of US hard wheat rose by 120%, the price of whole milk powder by 69%, butter by 74% and chicken by 62% (FAO, 2008). While these rises had devastating effects on developing countries, developed countries were affected too. In the UK, the rise in prices flowed though to the retail shelf; food price inflation peaked at 12.8% in August 2008 (ONS, 2008). Consumers in the UK, as well as agri-food businesses saw a sudden reversal in a 26-year trend of year on year price reductions, challenging expectations of sources of ever-cheaper food. Retails, suppliers and producers alike were caught by surprise by the sudden price rises. The events triggered wide-spread concerns over the global interdependency of modern food supply chains and demonstrated the political and social importance of affordable food.

In the UK, recent years have seen a shift in government policy to be more 'hands-off' in relation to food markets. Food-based organisations are expected to act to prevent or mitigate against loss of supply. While certain types of 'shock' based crisis are increasingly being catered for, organisations tend to focus on internally based disruption, often ignoring more externally based factors, particularly from a macro-network perspective (Peck, 2006).

Research into externally generated risks, particularly those of a global, long- term nature is also limited; previous studies have focused on short term supply risks (predominately shocks) within the immediate supply chain.

The Chatham House project 'UK food Supply in the 21st Century: the New Dynamic' is a £395,000, 2 year collaborative study, established to help bridge this research gap and examine how global effects could impact the UK food system. The project revolved around the development of four global scenarios which explored the potential outcomes of a range of global trends and uncertainties on food supply. Part of this project focused on the resultant vulnerability for the food system. This paper presents initial findings from this portion of the study, focusing on the outcomes of a series of scenario-based workshops. The paper presents findings which outline the potential impacts of each of the scenarios on the UK dairy and wheat supply networks, along with initial thoughts on the key themes which have significance for the ongoing resilience of the networks.

LITERATURE REVIEW

The last decade has seen an increasing body of literature focusing on the concepts and management of risk applied to supply chains. However, despite this, supply chain risk is considered to be in its infancy (Juttner, 2005) and there remains some debate as to the definition and scope of risks in the context of the supply chain. In the main, research has focused on risk management within the inbound supply chain (Hallikas et al., 2004); (Zsidisin and Ellram, 2003) with little research in risk across the end to end supply chain or networks ((Harland et al., 2003, Juttner, 2005). Research has also tended to narrowly focus on the outcomes of known risk (Zsidisin et al., 2005, Zsidisin and Smith, 2005). However, there is a growing body of opinion that the more uncertain aspects of risk should be given more consideration (Sheffi and Rice, 2005, Zsidisin et al., 2005), particularly those arising from the external political, social and economic environment (Kleindorfer and Saad, 2005). A small body of research has emerged to build on these concepts; supply chain vulnerability was first proposed by Svensson (2002) and subsequently developed by Juttner (2005) and (Peck, 2005). It is defined as 'an exposure to serious disturbance arising from supply chain risks and affecting the supply chain's ability to effectively serve the end customer market' (p. 124, Juttner 2005). Studies in supply chain vulnerability have been based on this wider concept of risk and uncertainty, with risk sources emanating from both the internal and external supply chain environment (Peck, 2005).

Previous studies in understanding risk in food supply chains have generally been single-issue led, majoring on either the environmental aspects (e.g. Vasileiou and Morris, 2006, Manning, 2008) or food safety risks (e.g. Manning et al., 2007, Roth et al., 2008). A few studies have examined the impacts of global, external factors but these again are pre-dominantly single-issue in focus (e.g. Manning et al., 2007), with a heavy bias towards animal disease and food safety issues. Post 2006, this has started to change with a number of organisations undertaking scenario-led research looking at how external factors could shape the future of food (Forum for the Future, 2007, Steedman and Schultz, 2009). However, these reports do not take a supply chain risk perspective and are mainly concerned with the sustainable and ethical development of the food system. There have also have been a number of government based reports and discussion documents produced over the last year (Cabinet Office, 2008, DEFRA, 2008). While these studies have considered in some part the effect of global factors, they are policy based and as such have no examination of implications for agri-food supply chains. It would seem only the study undertaken by Peck (2006) has examined the nature of risk across the wider food supply system. However, this study does not encompass the whole of the chain (it did not examine the agricultural base) and set out to explore principally evidence for contingency strategies to counter crisis or disaster-based events. The lack of previous studies examining longer-term global, exogenous factors and their implications for food supply vulnerability from either a systemic or network-based perspective is therefore perceived as a significant gap.

METHODOLOGY

The research was based on a primarily inductive approach(Easterby-Smith et al., 2002) using case studies(Yin, 1994). The use of case studies, when predominately using qualitative methods, are considered be more aligned to inductive-based, theory building research (Yin, 1994). The supply of wheat and dairy to the UK market were selected as two comparative cases (Bryman and Bell, 2003). The UK dairy and wheat industries equate to 12% and 13% respectively of the total household food market (DEFRA, 2007) The two sectors were chosen for their contrasting characteristics. The wheat sector is a net-exporter, with exports averaging around 2.5 million tonnes(FAOSTAT, 2008). The dairy sector is self-sufficient in the supply of fresh milk but there is a net imbalance in the trade of dairy products such as cheese, butter and milk powders (FAOSTAT, 2008). Wheat production is characterised by intensive, large scale farming, dairy has a larger tail of small-scale, family owned farms. Relationships within the wheat chain are predominately transactional based, based on trading/price agreements while the dairy sector has seen as rise in contracts and direct retail relationships.

The use of scenarios underpinned the research strategy. Scenarios are narrative-based tools, used to organise and systemise possible future consequences of current trends and uncertainties. Their aim is to not to create an accurate forecast of the future but to help inform better decision-making based on a range of possible future outcomes (Schwartz, 1998). Four scenarios were developed from an extensive phase of research, including both primary and secondary data collection, examining a wide range of global trends and uncertainties related to food production and supply. The four scenarios (shown in summary in figure 1) are described in outline below:-

- Scenario 1: 'Just a Blip' – high food prices prove to be a temporary blip and soon return to the long-term trend-line. There is a possibility, however, that if food prices fall back sharply, financial speculation in commodities will operate in reverse and lead to exaggerated food price volatility.

- Scenario 2: 'Food Inflation' – food prices stay high for a protracted period. They contribute significantly to inflation, but the economy adapts and the existing food system copes.

- Scenario 3: 'Into a New Era' – input prices initially stay high as per capita production falls steadily. In response, the system of food production is required to shift dramatically so that increased yields are delivered efficiently through 'regenerative' rather than purely 'extractive' uses of resources.

- Scenario 4: 'Food in Crisis' – multiple shocks disrupt food production and supply. Prices skyrocket as stocks plummet, triggering food shortages, famine and civil panic

In common with Peck (2005), the research study took a network approach and incorporated data collection from multiple organisations across the UK wheat and dairy networks. A series of workshops were built around the scenarios, designed to illicit perceptions and reactions from actors as to the potential impacts of global factors on UK supply systems. Participants were senior representatives from the dairy and wheat supply networks including producers, producer organisations, processors, food manufacturers, logistics and packaging organisations, retailers along with national and local government. Participants were taken through a series of structured questions to generate discussions as to the likely impacts of the scenarios plus any potential breakpoints, strategy failures or general concerns.

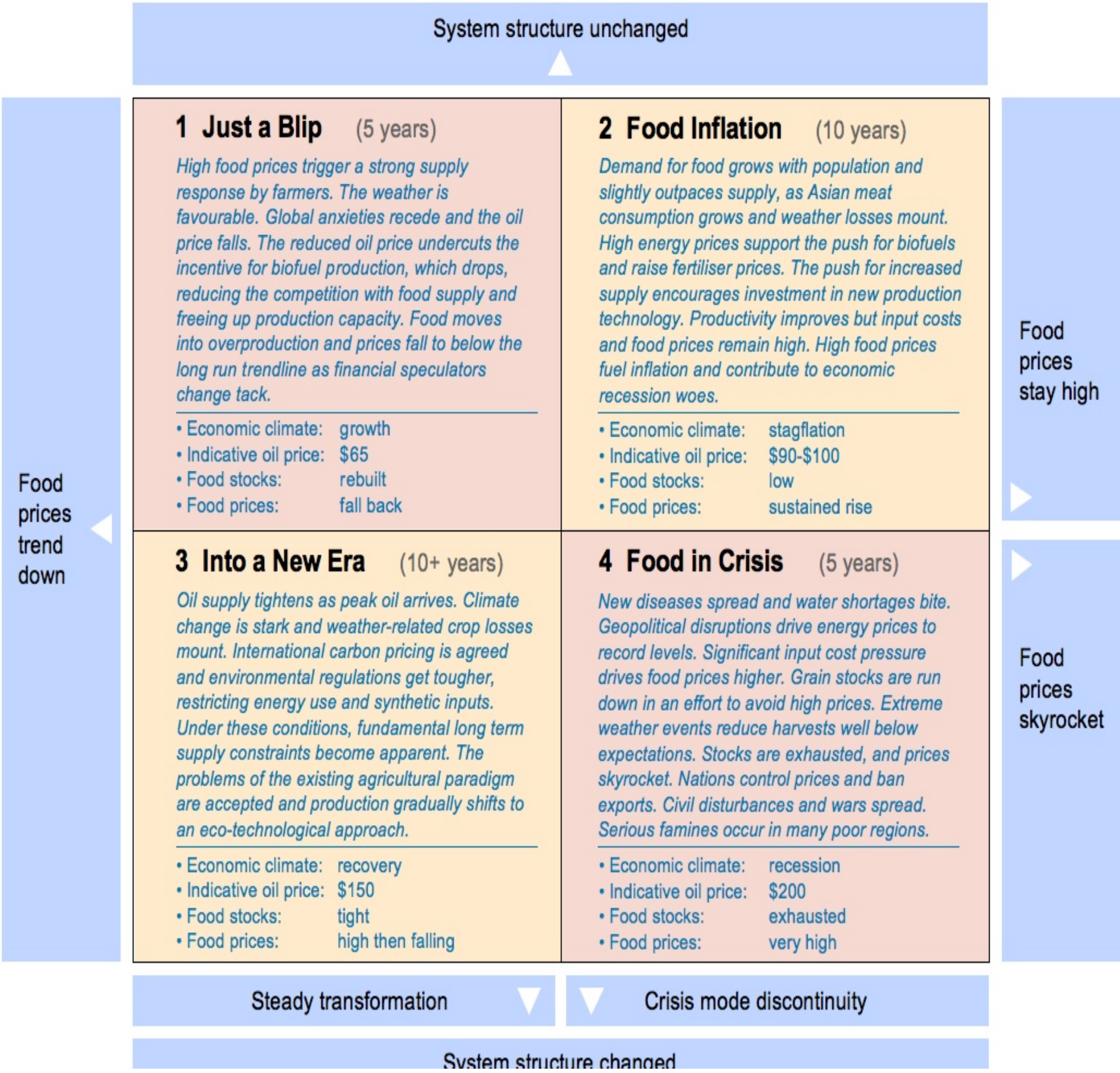

Figure 1: The four scenarios

FINDINGS

Just a Blip: This scenario is in effect 'business as usual' for the overall food supply system. For the wheat sector, a dip in prices would not cause many concerns as long as there were corresponding dips in input costs. However, in relation to dairy there are serious concerns that a fall in prices could accelerate the number of dairy exiting from the industry, significantly reducing the overall availability of milk. Price volatility is seen as a major characteristic of this scenario (post the 'blip' phase). This uncertainty combined with lower prices may promote shorter term strategies and dis-incentivise long term investment. This may weaken the capability of the system to respond to future supply imbalances.

Food Inflation: For many, 'food inflation' reflected the conditions experienced during the price rises in 2007/2008. Sustained inflation could see a reversal for consumers of the trend for decreasing spend on food as a percentage of overall income, putting pressure on disposable incomes. This could create some stagnation in the food market, slowing both the growth of premium foods, but also the growth in organic, free trade and higher welfare products as price becomes the overriding purchasing factor. This scenario presents challenging business conditions for industry with the need to manage rising input costs offset against continued competition between retailers to maintain low prices for consumers. Strategies to reduce costs are likely to drive further intensification of both the wheat and dairy sectors and further moves towards EU and global sourcing. While higher prices may encourage some level of increased investment, agriculture may still be vulnerable to low-investment patterns as the wheat and dairy sectors see margins curtailed by rising input costs, including fertilisers, energy and animal feed. For dairy the combination of these factors may prompt further contraction of milk production, forcing the national processing sector to become more focused on liquid milk rather than processed products. A perhaps unforeseen consequence of a period of continued inflationary effects is the ability of the situation to tip into crisis; if the supply chain is unable to continue to absorb rising input costs this could trigger severe price spikes.

*Into a New Era:*The Into a New Era represents a truly transformational scenario for the UK supply system, one which would require a switch from the traditional, resource intensive and predominately exhaustive models to a new, more regenerative approach. The eco-technological approach described in this scenario is a result of intense debate as to how agriculture in particular needed to be transformed. This debate was characterized by tensions between current intensive systems, favoured by industry, versus the agro-ecological approaches including organic based systems favoured more by ecological and environmental interest groups. Within the industry, while there is acceptance that the current model of farming was not ultimately sustainable, there is widespread rejection of the ability of agro-ecological approaches to deliver sufficient yields to meet growing global demand. This debate reflects the conflicting views as to the shape of a sustainable food supply system and whether the adaptation of current model will be sufficient or whether there needs to be complete structural change.

Independently of this, the transformation described in this scenario would rest on the development of a new competitive model; based on higher environmental, welfare and ethical standards. The retailers hold the key to driving forward these standards through the food system. This implies the development of a 'framework of integrity' across individual supply chains, requiring the development of new collaborative models from farm through to retail shelf. Higher oil prices and freight costs in this scenario may start to reign in any increase in global sourcing, further emphasizing EU self-sufficiency. This, along with consumer preferences for local sourcing, may start to drive some pressure for larger, multi-national firms to re-organise in order to provide more regionally based sourcing.

A further axis of debate is the extent to which consumers are likely to drive this transformation. Consumers in this scenario are expected to become more aware of the environmental impact of food as global climate change becomes starker, triggering incidences of global food shortages. However, the extent to which this would drive a significant shift in purchasing behaviour, particularly in light of higher prices, is difficult to determine. The pace of change could become a key factor here and it is thought that government will need to take a significant role in both helping to shaping changing consumer response, with the option of increased legislation to help drive for higher product standards. The need to develop standardized systems of measuring environmental impacts such as carbon foot-printing will also need to be considered.

Food in Crisis: A food crisis in the UK is viewed as highly plausible. This could develop through some form of external 'shock' based effect, such as animal or crop disease or through severe price rise caused by the inability of the food system to continually absorb sustained inflationary pressures (as mentioned earlier). The response of agriculture is very dependent on the crisis trigger. For the dairy sector, a widespread outbreak of disease (such as blue tongue or Foot and Mouth) would create a real problem for the industry, particularly if the disease is unable to be contained. Any significant herd loss could result in a mass exodus of farmers due to possible shortage of replacements. The UK cereals sector is felt to be slightly more robust in the event of crop disease, although even a contained outbreak would lead to drops in yields and therefore the output produced. In an inflationary driven crisis, farming output may also fall temporarily due to acute costs of inputs and the inability of farmers to manage the necessary increased cash flow requirements.

The management of any crisis would likely fall to industry first, although initial responses are likely to focus on protecting the ongoing viability of individual businesses. The success or failure of businesses will be highly dependent on their ability to secure supplies and access cash, calling on the strength of their trading partnerships. Product ranges would be severely rationalized and reformulated, potentially with lower quality ingredients, with a focus on basic, staple foods. Shortages in raw materials could lead to increased stock holding and hoarding, further exacerbating the situation. The contraction of global and to some extent the EU provision would switch emphasis to more UK based sourcing. Any restrictions in transport fuel or access to raw materials could drive even more contraction of the network to focus on local sourcing. Organizations with regionally based processing or distribution networks may be best placed to command significant competitive advantage, while those with more multi-nationally based logistics systems may find it more difficult to adapt.

There is a danger that if responses are not well thought through or well co-ordinated across the supply network as a whole, the crisis could escalate and government would be forced to intervene with increasingly draconian measures. However the nature of the intervention itself could serve also to exacerbate the situation. This creates a set of difficult decisions for government over when, how and far to intervene. To ensure that any interventions are effective, there is a need for more partnerships approaches, both within supply chains but also in conjunction with government, to effectively plan and co-ordinate appropriate responses.

DISCUSSION

Initial grounded analysis of the data, identify a number of key themes which were considered pertinent to the future resilience of dairy and wheat agri-food organisations and the supply networks as a whole.

Global market uncertainty: While further exposure to the global market would bring some benefits, tighter supply-demand conditions are likely to produce more market uncertainty.

Higher food prices and price volatility: Despite the recent dip in prices, future market uncertainty is likely to result in higher food prices. Along with increasing fuel and other input costs this could create a potentially difficult operating environment as pressures to keep retail prices as low as possible are set to continue. The dairy sector is more vulnerable to this squeeze on margins. Price volatility, particularly for the agricultural sector could prevent longer term investment, despite higher prices.

Resources constraints: Rising demand for agricultural products will intensify pressures on key resources such as water, oil and minerals. In addition, products with a narrow source base (e.g. non-GM soya, phosphorous based fertilisers) could become scarcer. Under these conditions, the ability to secure resources and assure the supply of raw materials will become a key competitive advantage. Supply chain behaviour will need to adapt as power may start to shift back down the chain.

Sustainability: The pressures to become more sustainable are only set to increase; either through regulatory requirements, consumer pressure or through the stark reality of climate change or supply/resource constraints. Any inability to adapt will create significant vulnerability for organisations. The need to increase or at least maintain UK agricultural productivity is seen as odds with the need to be sustainable, signalled by tensions between intensive-based systems and eco/organic based systems. How to reconcile this debate and develop network-wide low-carbon, resources efficient systems are seen as major future challenges. However, this also presents opportunities to create new competitive models and gain market advantage for those quick of the mark.

UK agricultural capability: The UK agricultural sector has seen a slow down in investment (DEFRA, 2007) and productivity has tailed off since 2002 (DEFRA, 2006). Dairy is vulnerable to cheaper imports, and continued under-investment could further hamper competitiveness. The loss of key agricultural skills or assets in the UK – prime agricultural land, animal herds – and a further slowdown in productivity/competiveness could have consequences for the resilience of the system as a whole. Shared capabilities and other systemic interdependencies between the different sectors will need to be better understood.

Consumer preferences: Consumer markets are likely to become more fragmented. Higher prices could signal stagnation in areas of the market focused on premium/niche foods, and values-based products (organic, free trade and higher welfare ranges). On the other hand, there is likely to be increasing pressure from consumers (aided by government regulation) for higher ecological, health and ethical standards.

System resilience: More systemic, network based approaches to resilience will be needed, including a better understanding of the inter-dependencies inherent in the dairy and wheat food supply systems, particularly those with a global dimension. The robustness of centralised systems will need further research, in addition to more analysis of the trade-offs between regional systems which, in some cases, may be more resilient. In addition, the longer term 'ecological' resilience of the system, in light of longer-term sustainability issues, will need to be considered.

Supply chain collaboration: The need for more collaborative practices is a strong theme. This includes mechanisms to ensure better traceability, measurement and transparency across the chain, strong trading partnerships to assure supply and counter potential disruption and collaborative-based contingency planning

CONCLUSIONS

Findings confirm that the concept of supply network vulnerability is under-researched there are very few studies of the effects of longer term external uncertainties on the UK food supply networks. Future global trends in food supply and demand will increasingly become significant sources of risk for UK wheat and dairy supply networks. Outcomes range from shock-based crisis to longer term questions over resource constraints and the 'ecological' resilience of the networks. The dairy sector in particular is vulnerable to the ranges of these effects. Further research is needed to examine particular points of vulnerability in these sectors, along with those of the wider food supply system. Questions of system resilience and capability will need to be examined along with implications for supply risk management and general supply management practices.

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DEVELOPMENT OF KNOWLEDGE BASED SYSTEM FOR RISK IDENTIFICATION FOR MULTI-PARTNER MANUFACTURING SUPPY CHAINS

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ABSTRACT

Nowadays Supply Chain (SC) networks are operating in an ever more complex and dynamic environments which is mainly due to the fast development in technology leading to the development of complex products and services, E-business and outsourcing practices. Tough business competition forces SC networks to implement several manufacturing approaches as an effort to operate in more efficient forms. As a result, supply chains have become more vulnerable to disruptions as SC network complexities and interdependencies increase the level of risks that organizations may get exposed to.

Supply chain risk management (SCRM) is aiming at reducing SC network susceptibility, with risk identification as its most important step. However, a specific tool is required to help organizations identify risks due to broader range of risk sources as the network gets more complex. This research aims to develop a model for assisting risk identification in a global manufacturing SC network by utilizing Knowledge Based System (KBS) approach. Accordingly, a Knowledge Based Supply Chain Risk Identification System (KB-SCRIS) is under development to support manufacturing organizations by giving recommendations about potential risks and their interactions with each other.

INTRODUCTION

Outsourcing, globalization, product /service complexity, reducing supplier and inventory practices are some reasons behind today's complex and highly interlinked business environment (Deleris & Erhun, 2005; Glickman & White, 2006; Khan, 2006). Rapid technology development especially in computer and communication allows firms reaching for overseas suppliers, global markets and offshore outsourcing / manufacturing. It also supports the efforts of organizations to operate more efficiently such as developing partnership with fewer/single suppliers or reducing inventory level. Thus, SC players are getting more geographically dispersed with larger vertical and/or horizontal network dimensions created in complicated environments. SC players should rely heavily on each other for synchronizing supplies with demands in such a complex network. As a result, SC network becomes more vulnerable to risks due to escalation of its complexity and interdependency and worsened by uncertain circumstances such as natural disasters, industrial accidents and political instability.

If supply chain potential risks within internal and external supply chain environment are not handled properly then it could lead to disruptions of resources and information in supply chain network. Disruption in one SC player could lower the entire SC network performances such as delivery time or quality problems which may trigger severe financial and goodwill losses and even business discontinuity (Chapman et.al, 2002; Griffy-Brown, 2003; Sheffi, 2005; Treece, 1997; Zsidisin et. al, 2005). Therefore, there is a need to manage supply chain risks in order to avoid ripple effects that could take place in any point of the supply chain network and its environment.

Risk identification is one the fundamental step in risk management process. However, identification of risks in the entire SC network is not a simple task due to broader range of risk sources as the network gets more complex and larger. Thus, there is a need a specific tool to assist organizations. Although a considerable number of research have been published on supply chain risk management, the development of a specific tool to support risk identification in a supply chain network is not yet available. Knowledge based system (KBS) has been known to have capability of providing problem solving features which is designed to emulate expert knowledge.

This research aims to develop a system for assisting risk identification in a supply chain network by utilizing KBS approach. The system which is called Knowledge Based Supply Chain Risk Identification System (KB-SCRIS) will assist organizations in risk identification process by suggesting potential risks and its interrelations in their SC network based on organization's internal and external conditions. This paper covers the preliminary part of the research which is knowledge structure and representation.

SUPPLY CHAIN RISK MANAGEMENT (SCRM)

Supply Chain Risk Management is defined by Chapman et al. (2002) as "the identification and management of risk within the supply chain and risks external to it through a coordinate approach amongst supply chain members to reduce supply chain vulnerability as a whole". Supply Chain Risk Management (SCRM) focuses on how to understand and avoid ripple effects by major or minor accident which could take place in one part of the supply network.

Several studies (Centre for Logistics and Supply Chain Management-Cranfield School of Management, 2003; Sinha et al., 2004 Hallikas et al., 2004; Deleris and Erhun, 2005; Khan and Burnes, 2007; Kleindorfer and Saad, 2005; Kiser and Cantrell, 2006) suggest similar Risk Management steps as in Standards such as AS/NZS 4360, which are: risk identification, risk analysis, risk evaluation, and risk mitigation. Risk identification is the most critical phase as this is the foundation of risk management process (Kayis et al, 2007;Hallikas et. al, 2004).

There are considerable number of research on identifying risks in supply chain however, there are fewer studies that discuss interactions between risks in supply chain (Hallikas et al.,2002, Hallikas et al.;2004). Each risk in supply chain should not be only identified as an isolated event since interrelationships between these risks are important for gaining a more complete picture of potential supply chain risks impact on organizations and its supply chain network.

Therefore to develop a comprehensive risk mitigation strategy, most (if not all) of the potential risks and interrelationships of these risks with other risks in organizations and throughout their SC network should be identified.

KNOWLEDGE BASED SYSTEM AND ITS APLICATIONS

Figure 1 summarizes the structure of the KBS developed in this study which is mainly comprised of:

a) Knowledge base is the main part of KBS where expert's knowledge (from knowledge acquisition) in the form of facts and rules are structured for solving a specific problem.

b) Inference engine makes decision/suggestion as needed by user based on information in knowledge base and working memory.

c) Working memory contains problem specific facts from consultation session with user and also stores the new facts in collaboration with inference engine.

d) User interface is a means of communication between KBS and user.

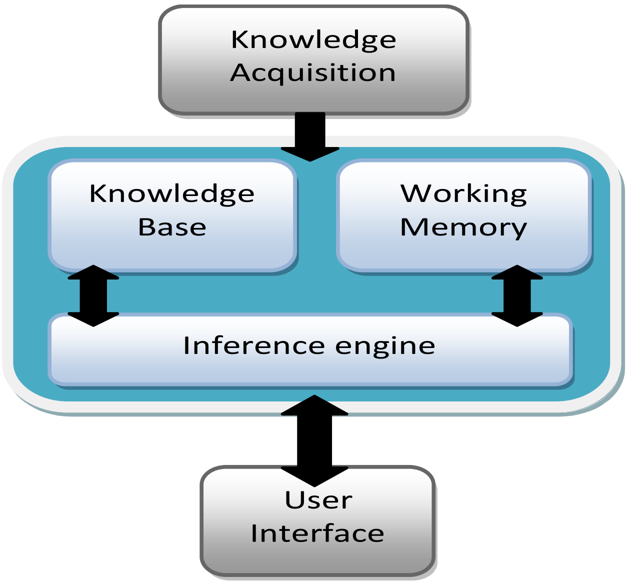

Figure 1: Knowledge Based System elements

KBS has been applied in various areas of supply chain network environments. Cheung et al.(2004), Yan et al. (2003), Yigin et al. (2007) utilized it for suppliers/vendors/logistic providers evaluation and selection. Also Cheung et al. (2004) developed an agent oriented and knowledge based system (AOKBS) to support knowledge acquisition, online bidding, and supplier evaluation in an e-procurement environment. AOKBS consists of a knowledge repository, autonomous agents, an RFQ advisor, an online bidding module, a tender evaluation module, and a supplier evaluation module. Lau et al. (2005) proposed a KBS comprised of neural network and online analytical processing (OLAP) to choose the suitable vendor.

Yan et al. (2003) proposed a model to support third party logistics (3PL) evaluation and selection based on past experiences. By using case based reasoning (CBR), this model utilizes company's requirements, 3PL conditions, and decision maker's preferences. Yigin et al. (2007) utilized rule based approach to select supplier based on supplier performance evaluation in automotive industries. KBS gives information and recommendations regarding suppliers ranking, alternative suppliers, and underperforming suppliers in accordance with multi criteria selection criteria and performance measurement indicators. Moreover, there are other areas of SCM that has utilized KBS approach. Chan et al. (2006) suggested a knowledge based simulation platform (KBSP) which can simulate SC operation before implementation of supply chain strategy, and predict SC performance. Case based reasoning (CBR) is utilized in KBS component to reuse past knowledge, capture new

knowledge and generate solutions/suggestions to assist employees and especially new staff to deal with their suppliers and retailers in SC environment. Udin et al. (2006) proposed Knowledge Based Collaborative Supply Chain Management (KBCSCM) system which incorporates GAP analysis technique within the rule based structure to assist organizations in implementing Collaborative SCM strategy in collaborative commerce era. Zarandi & Saghiri (2006) utilized fuzzy expert system (FES) with rule based approach to model supply chain based on case study of an automotive firm.

Since KBS is seen as an appropriate tool for ensuring project successfulness by maintaining, transferring and learning knowledge from the past project, it has been extensively used in project risk management. ConSERV (Concurrent Simultaneous Engineering Resource View) is a knowledge based risk management system which may be used in multidisciplinary design intensive capital projects where the knowledge base is acquired from user/s opinion (Conroy & Soltan, 1998). Caillaud, et. al (1999) utilized Case Based Reasoning and expert system to manage knowledge from similar past projects. This knowledge is employed and adapted to identify and analyze potential risks and their causes together with related risk actions whereas the outcome of this approach is completely dependent on the similarity of past projects with the ongoing project. Kayis et. al (2007) developed a risk management tool called IRMAS (Intelligent Risk Mapping and Assessment System) which has "knowledge warehouse" as a knowledge gathering and sharing tool from past experiences to be utilized in managing current risks.

DEVELOPMENT OF A FRAMEWORK FOR RISK IDENTIFICATION IN SUPPLY CHAIN NETWORK

In this stage, problem to be solved using knowledge based system approach is identified. As mentioned in the previous section, identification of risks in the entire supply chain network is not a simple task since it operates in a complex and significant network size, dynamic, and uncertain environments. Therefore this research aims to develop a Knowledge Based Supply Chain Risk Identification System (KB-SCRIS) for assisting manufacturing organizations in identifying potential risks which could arise in the entire SC network.

ESTABLISHING A STRUCTURE

Knowledge acquisition

Analyzing of domain knowledge to determine scope of knowledge that will be acquired and stored in the knowledge base is covered in this stage. There are two basic types of knowledge acquisition (Kumbakonam et al., 2002), which are:

1. Knowledge acquisition directly from the human expert (non deterministic knowledge)
2. Knowledge acquisitions thorough previous cases, relations, look up tables (deterministic knowledge).

In this research, deterministic knowledge is acquired through extensive literature survey covering case studies, fieldwork findings, and expert opinions/experiences in risk management, SCM and SCRM.

As this system is aimed to support decision-makers by recommendations on potential risks and their interrelationships in supply chain network, the knowledge gathered are organised as follow:

a) Potential supply chain network risks, their interrelationships with each other and classification methods.
b) Manufacturing approaches used and their characteristics linked with several supply chain network risks. This research covers three main manufacturing systems (Make to Stock, Make to Order, and Engineering to Order).
c) Risks in supply chain network also vary according to different organisational structures and manufacturing management approaches used.

Knowledge structure

Based on previous stages, knowledge on potential risks in SC is structured according three main layers. First layer is SC process stages (Plan, Source, Make, Deliver, and Return). Second layer is, SC operation environment or risk source locations. Internal environment consists of manufacturing firm, its suppliers, supplier's suppliers, logistic providers, distributors, retailers and customers etc.

Knowledge representation

The next step is how to represent the knowledge into the knowledge base. There are several alternatives of knowledge representation which has been mentioned in previous sections. In this research, production rule (rule based) is utilized to represent the knowledge of risks in supply chain (cause effect relation) as it corresponds with if-then structure. When "If clause" is true, then some action is performed so when risk factor X is occurred then risk event A is happened. CLIPS software is utilised to develop the model of Knowledge Based Supply Chain Risk Identification System (KB-SCRIS).

RESULTS
This paper presented the preliminary part of the research conducted to develop a model for assisting risk identification in global manufacturing SC networks by utilizing Knowledge Based System (KBS) approach. Accordingly, a Knowledge Based Supply Chain Risk Identification System (KB-SCRIS) is under development to support manufacturing organizations by giving recommendations about potential risks they are exposed to and their interactions with each other.
The prototype of the system is currently being tested in industry followed by further improvements and further validations planned to be conducted.

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Table 1. Examples of internal and external organization SC network characteristics

Internal organization characteristics	• *Organization's manufacturing system* • Business/management approaches (ie. lean manufacturing, TQM, sole supplier, etc) • Product design newness • Product/parts specific characteristic • Number of plants/warehouses • Location of plants/warehouses • Level of equipment/machineries capability • Factory layout • Demand volume • Product variations • Number of product components • Configuration of operations and productions (John et.al, 1997, p.232)
Internal SC characteristics	• Members of SC network • Number of customers • Number of (main components) suppliers • Customer(s) location • Supplier (s) location • Number of supplier tiers • Number of customer tiers • Relationship level with (main component) supplier(s) • Relationship level with customer(s) • Relation term with supplier(s) • Relation term with customer(s) • Level of integration with supplier(s) • Level of integration with customer(s) • Level of logistic provider services
External SC characteristics	• Competitors of organization/ suppliers / customers • Complimentary product organization (if applicable) • Political / governmental issues at organization / suppliers / customers location • Nature related condition/activities at organization / suppliers / customers location • Macroeconomic condition at organization / suppliers / customers location • Socio - cultural condition at organization / suppliers /customers location

MANAGING RISK IN INTERNATIONAL INBOUND SUPPLY CHAINS

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ABSTRACT
Purpose of the paper
Managing risk has emerged as an issue of critical importance for today's globalised supply chains. In fact, in global sourcing contexts increased distances between sources of supply and final markets add uncertainty to supply continuity through longer and more variable lead times. Therefore, the aim of this paper is to study how a company can reduce its inbound supply risk, by employing specific strategies.

Methodology
A set of strategies, including both contingency plans and mitigation actions as well as operational buffers, are proposed in order to manage the areas of vulnerability of the inbound supply process. To compare these approaches we propose a simulation-based framework, able to estimate their expected impact on the supply lead time and the overall logistics cost. This framework has then been tested on a real case study.

Findings
This paper provides a useful identification of strategies able to lead to an improvement in the supply chain risk management process in global sourcing. Furthermore, the simulation-based framework contributes in assessing the efficiency and the effectiveness of the proposed strategies.

Research implications
The study attempts to support the quantification of the effectiveness and efficiency of possible risk management strategies, thus contributing in the research on the management of risk in global sourcing contexts.

Practical implications
Besides general managerial insights, this paper provides supply chain managers with a tool that could be used to perform an economic evaluation of different strategies for managing risk in their specific business context.

Originality
The paper addresses an identified gap in the literature for supply risk related to the transportation process which, to date, is the most neglected phase in the global supply process. Moreover it consider the integrated adoption of different risk-reduction strategies.

Keywords
Supply Chain Risk Management; Inbound Supply Risk; International transportation; Global sourcing.

Paper Type: Research paper

INTRODUCTION
Supply chain risk has recently gained considerable attention. This is mainly due to the fact that the more complex the relationships among the nodes of the supply network, the more prone modern global supply chains are to disruptions. Although it is not a brand new problem, these days, due to higher competitiveness levels in the economic context and increased interconnections between businesses, companies are affected by a

wider exposure to risk sources than before (Sheffi, 2005). Despite increasing awareness of this topic among both academics and practitioners, most of the existing research has addressed the sources of risk in the supply chain from a general perspective (Blackhurst et al., 2005) whilst few systematic approaches for their evaluation are actually available.

The objective of supply chain risk management is the protection of business from adverse events. A first approach to reach this aim is represented by the introduction of operational buffers along the supply chain (e.g. excess inventory or productive capacity, backup sourcing, multiple sourcing) (Chopra and Sodhi, 2004). Other two risk management approaches move towards the reduction of risk by addressing its probability (mitigation actions) and its direct impact (contingency plans) (Faisal et al., 2006): the former approach is based on the analysis of the processes with the aim of reducing the likelihood of occurrence (Zsidisin, 2004; Christopher and Lee, 2004; Sheffi, 2005), while the latter "provides alternative modes of operation for those activities or business processes which, if interrupted, might bring a damaging or loss to the supply chain"(Norrman and Jansson, 2004).

An effective risk management strategy should consider all the aforementioned approaches, taking into account the respective activation cost as well.

We focus on one of the main sources of vulnerability studied in the literature: supply lead time variability. Supply chain processes, and in particular transportation one, are often measured against time (Christopher and Rutherford, 2004). For this reason supply lead time (SLT) and its variability are often recognised as the main vulnerability areas in inbound logistics, especially in a global sourcing context (Goetschalckx et al., 2002; Manuj and Mentzer, 2008; Wu, 2008).

Therefore, the aim of this research is to analyse how alternative strategies can be applied for managing risk in inbound supply chains, with reference to the global sourcing process. Furthermore it provides supply chain managers with a framework that could be used to assess the efficiency of different risk-reduction strategies.

IDENTIFICATION OF STRATEGIES FOR MANAGING SUPPLY CHAIN RISK

The present research refers to a supply process of a European company (manufacturer or retailer) with suppliers located in the Far East and shipping product by means of FCL (Full Container Load). We assumed EXW (Ex-Works) as Incoterm trade term, thus allowing the sourcing company to have full control of the process and the related supply risks (Dallari et al., 2006). We refer to a Hub & Spoke network as the base transportation case, usually resulting as the less expensive one to ship goods from supplier's plant to the European warehouse.

Such a complex process presents several areas of vulnerability (Svensson, 2000), each of them characterised by high or low level of impact and likelihood of occurrence. A set of contingency plans and mitigation actions validated with freight forwarders, are herein proposed.

Contingency plans provide alternative ways of transport to be utilised when the SLT might result longer than expected. Four contingency plans are proposed (sorted by increasing cost and decreasing lead time):

- C1. Use of multi-port calling, i.e. shipping containerised goods from port of origin to port of destination without changing vessel in the transhipment hub.
- C2. Bypass the local feeder service in the Mediterranean Sea, by means of road haulage from the transhipment hub to the final destination.
- C3. Use of sea/air service, i.e. a mix of sea and air freight, where the initial phase is represented by sea shipping. During the ocean shipping leg, the container can be unloaded at one of the scheduled ports of call in the Middle East (e.g. Dubai) where the goods are transferred onto an aircraft flying to the airport nearest to the final destination.

- C4. Use of air freight, i.e. shipping non-containerised goods by means of a direct flight leaving from the airport nearest to the supplier's plant.

Mitigation actions, as opposed to contingency plans, are risk management approaches that need to be put in place beforehand, without waiting for unpredicted events to happen. Their role is to reduce the likelihood of a negative event. The main mitigation actions are:

- M1. Pre-booking containers as soon as possible (in order to have scheduled departures).
- M2. Bonded warehouse, shifting the customs inspections from the port of destination directly to the European warehouse, with the supervision of custom authorities on site.
- M3. Agreements with shipping companies or freight forwarders on loading priorities at ports.

Based on these approaches and consistent with the literature review outcome, 5 strategies for risk management are identified:

- S1. Passive acceptance of risk, in which none of the approaches are applied.
- S2. Setting up a buffer safety stock at the company warehouse.
- S3. Adoption of contingency plans.
- S4. Adoption of mitigation approaches.
- S5. Adoption of both contingency plans and mitigation actions.

These 5 strategies differ both in terms of effectiveness (on SLT mean value and variability) and efficiency. To evaluate the performance of the proposed strategies, different cost items are taken into account: transportation costs, inventory carrying costs (at the company warehouse and in transit), stock-out costs. These cost are dependent on the duration and on the variability of SLT for each order.

THE MODEL: A SIMULATION-BASED FRAMEWORK

The effectiveness and the efficiency of the proposed strategies are herein evaluated according to a framework composed by 2 steps:

- Defining the input parameters required to calculate the logistics cost (LC).
- Simulating the physical logistics flows for a significant time horizon and calculating the related LC.

The main input parameters, common for all the 5 strategies, are:

- Demand characteristics: number of items, average item volume, product value density (ratio between item value and unit volume) and weekly demand (mean value and variability).
- Lead time components: duration of each activity in the FCL shipping process.
- Supplier performance: average lead time of the supplier and its variability.

According to the second step of the framework, the flow of goods between supplier's plant and company warehouse is simulated. For a given time horizon, the weekly demand according to Monte Carlo method is generated. Company warehouse operates with an (R, S) inventory control policy, where R indicates the review interval and S indicates the order-up-to level (Nahmias, 1997). S is updated at the beginning of each replenishment cycle to reflect the changes in demand patterns. The quantity ordered by the company warehouse depends on the demand of each item, on the inventory review interval, corresponding to the shipping frequency, and on the order batch size (depending on container volume constraints). The inventory control parameters are regularly updated including demand forecast (moving average of the last 12 weeks).

Therefore extending the target SLT leads to an increase in the forecasting horizon and to a reduction of forecast accuracy, thus increasing the occurrence of stock-outs. Out-of-stock could also occur when SLT results longer than expected. Unlike other approaches for assessing supply risk available in literature (e.g. Tomlin, 2006), our model considers lead time as a result of the simulation, depending on the adopted strategies for risk management, and not as an input parameter for the problem.

We propose to represent the supply process under consideration as a sequence of N single activities, each modelled by defining the best fitting time-frequency distribution. The proposed framework can be applied regardless of the time-frequency distributions, even though the type of distribution selected and its parameterisation affect its accuracy. It is important to underline that when mitigation actions are employed the sequence of activities in the supply process is the same of the base case, while some time-frequency distributions change. On the contrary, when contingency plans are put into action, the overall supply process varies.

As represented in Figure 1, there are few points in the process, called trigger points, in which contingency plans could be started, thus modifying the remaining process and its duration.
At each trigger point j, if the elapsed time up to that point (LT1) does not exceed a threshold value (TH), the supply process proceeds as planned. Otherwise the most suitable contingency plan is put into action.
Setting the threshold value TH_j at each trigger point j is critical. Therefore we define:
$TH_j = SLT^* - LT2_j$ (1)
Where:
SLT^* = target value of the SLT
$LT2_j$ = the expected duration of the remaining base process, from the trigger point j onwards

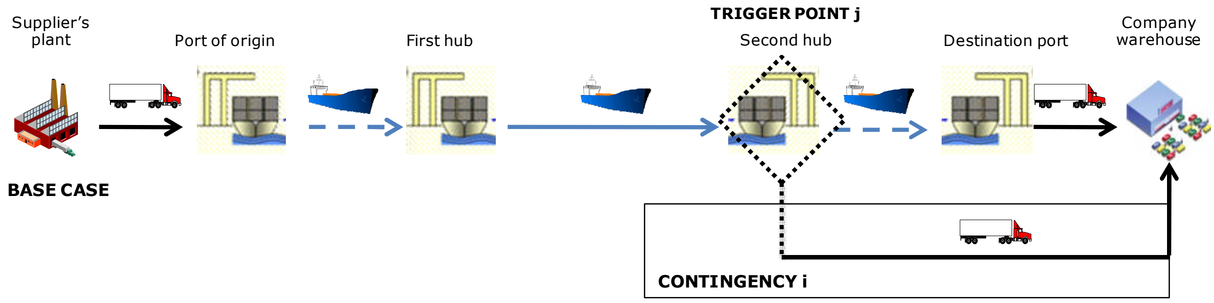

Figure 1. Exemplification of contingency plans in the supply process

For a given trigger point j, LT2 ranges from a minimum to a maximum value following its time-frequency distribution. Given that the aim of the present study is to reduce the overall supply process variability by activating contingency plans only when strictly required and cost efficient, we introduce a degree of safety (DS) corresponding to the likelihood of the SLT being less than or equal to the SLT* (i.e. the DS^{th} percentile of LT2 that determines a TH value such that in DS percent of cases a delay does not occur).
Therefore, following the proposed approach and for a given trigger point j, a contingency plan will be activated if:
$LT1_j > SLT^* - LT2_j\,(DS)$ (2)
Where:
$LT2_j\ (DS)$ = the DS^{th} percentile of time-frequency distribution of $LT2_j$ from the trigger point j onwards
In a given trigger point j it is possible to select a contingency plan k among a few alternatives (C1, C2, C3, C4), each with different impact on the SLT and implementation cost. Therefore it is necessary to put into action the fastest and most expensive contingency plan only if the accumulated delay cannot be recovered by other less expensive alternatives.
Similarly to the approach of contingency plan activation, the choice between different plans depends on a degree of safety corresponding to the likelihood of the SLT resulting from the activation of a contingency plan being less than or equal to the SLT^*. Defining DC as the degree of safety for all contingency plans, we identify the alternatives that assure a DC probability for the SLT^* of not being exceeded when the Eq. (3) is satisfied:
$LT2_{j,k}\,(DC) \leq SLT^* - LT1_j$ (3)
Where:

$LT2_{j,k}$ *(DC)* = the DC[th] percentile of time-frequency distribution of $LT2_{j,k}$ resulting from the activation of contingency plan k at trigger point j

This simulation-based framework gives an estimate of the SLT for each replenishment order and could be applied in different scenarios.

On the basis of the assumed unit costs and of simulation results (in terms of shipped volumes, lead time, and average inventory and stock out units), we derived the LC for each strategy.

CASE STUDY: MAIN DATA AND RESULTS

The analysis has been performed with respect to a case study, derived from a manufacturer of electrical appliances, operating in Western Europe, which has Chinese suppliers located in the Bejing area, whose identity has not been reported here for confidentially reasons. The analysis of the company's business environment allowed deriving the input parameters connected to the demand characteristics and to the logistics network model.

As considered by other authors (e.g. Tomlin 2006), we focused on the supply process of a single component for a family of appliances. This component is critical for the target SLT (86 days) and for its technological characteristics as well, which make it difficult to find alternative sources of supply. The stock out of this component can interrupt the production of the finished product and could also have an impact in terms of lost sales of the finished product.

The weekly demand of components is represented by a normal distribution, with a mean value (D) equal to 1,000 units/week and demand variability described by the coefficient of variation, i.e. the ratio between the standard deviation of the weekly demand and the relative mean value equal to 0.3. The unit volume is equal to 0.01 m^3 and the product value density equal to 3,000 €/m^3. According to other studies on global sourcing (e.g. Zeng and Rossetti, 2003), we have assumed fixed shipping frequency on a quarterly basis (R equal to 3 months).

As regards transportation we considered a door-to-door cost of 50 €/m^3 in the base case, assuming a FCL shipping via 40' container. For each contingency plan we assume an increase in transportation cost, ranging from +20% (C1) to 1000% (C4). This evaluation was derived from interviews with global freight forwarders. Furthermore we considered mitigation adoption cost equal to 200 € for each container and inventory holding cost (including cost of capital, space, insurance and depreciation) equal to 13% of inventory value on a yearly basis.

For all the 5 aforementioned strategies the type of time-frequency distribution for each activity has been set. With respect to S1 and S2, Table 1 summarises the time-frequency distribution and the parameters used for each activity in which the overall supply process has been broken down. An average SLT equal to 24 days was considered and a supplier's reliability (i.e. the ratio between the variability and the mean value) equal to 0.3.

Activity	**Time-frequency distribution**	**Min**	**Max**	**μ**	**Md 1**	**Md 2**	**σ**
Manufacturing	triangular	10	40	21.7	15	-	6.6
Road haulage to the loading port	normal	0.2	1.5	0.7	0.7	-	0.3
Customs and handling operations at loading port	bimodal	2	18	6.8	4	9.5	3.6
Feeder service to the first hub port	triangular	5	15	9.3	8	-	2.1
Transhipment from feeder to mainline vessel	bimodal	3	18	7.6	5	10.5	3.5

Main ocean route to the second hub port	triangular	13	19	15.7	15	-	1.25
Transhipment from mainline to feeder vessel	triangular	3	10	6	5	-	1.47
Feeder service to the port of destination	triangular	2	5	3.3	3	-	0.62
Handling and custom clearance at port	triangular	6	21	11.7	8	-	3.3
Road haulage to final destination	normal	0.7	2	1.2	1.2	-	0.3

*All values refers to durations in days
Legend:

Min	Minimum value	Md1	Mode value
Max	Maximum value	Md2	Second mode value, only for bimodal distributions
μ	Mean value	σ	Standard deviation value

Table 1. Frequency distributions assumed in the simulation model for the base case

For each strategy, replications were carried out using @RISK, the Monte Carlo simulation software for risk analysis, and processed by means of a spreadsheet, in order to obtain SLT value for each replenishment cycle. With these values it was possible to simulate, with Matlab software, the process and the related inventory level for a significant time horizon (2 years) and calculate the related logistics cost (LC) for the supply process. The resulting LC depends, in each simulation run, on the values of the items' weekly demand. In order to reduce the impact of random variations, the same random numbers have been used to simulate all the 5 strategies (thus generating the same weekly demand time series for all the configurations). In addition to this variance reduction technique, we performed 500 simulation runs to reach the stability of the system (Law and Kelton, 1997). Moreover, as far as S3 and S5 are concerned, the DC and DS values connected to the minimum expected LC value are used for the simulation. For S3, the minimum cost occurs, as shown in Figure 2, for DS equal to 0.5 and DC equal to 0.9 (i.e. using contingency plans only when significant delays occur and, in this case, recurring to the fastest alternatives). In S5 the optimal solution is both DS and DC equal to 0.9 (i.e. using as much as possible contingency plans in case of delays, recurring to the fastest alternatives).

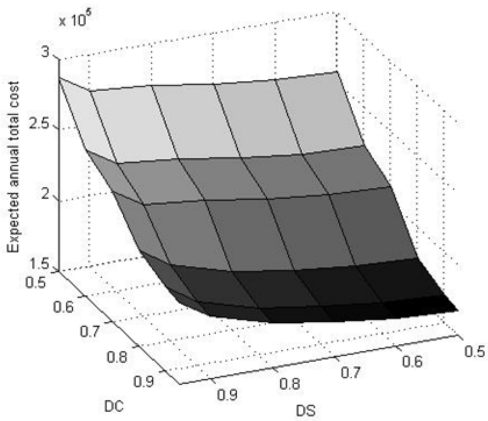

Figure 2. Impact of the DS and DC on the expected annual LC (Strategy 3).

The results of this case study, in terms of impact on SLT (Table 2) and expected annual logistics cost (Table 3), highlight:

- The joint use of mitigation actions and contingency plans (Strategy 5) allows for a reduction in SLT variability of 44%.
- For the examined case study, improving the performance of SLT results in an improvement of the total logistics cost, making the strategy typically used (buffer safety stock) less convenient.

- The use of mitigation actions (Strategy 4), compared to Strategy 3, has a minor effect on stock out cost.
- The efficiency of strategy 3, 4 and 5 are similar in this case study.

Strategy	Min[a]	Max[a]	μ[a]	σ[a]	% reduction μ	% reduction σ
Strategy 1 and 2	62	122	86	9.4	-	-
Strategy 3	52.1	101	71.6	7.8	17%	17%
Strategy 4	56	105	75.1	7.9	13%	16%
Strategy 5	56	87	71.7	5.3	17%	44%

a All values refers to durations in days

Table 2. Impact of the proposed approaches on parameters of SLT

	S1	S2	S3	S4	S5
Transportation costs	22,22	22,22	27,95	23,82	25,74
Inventory holding costs	16,00	19,94	17,92	16,96	16,39
In-transit inventory costs	16,38	16,38	14,90	14,31	14,31
Out-of-stock cost	57,45	33,43	15,08	24,39	20,55
TOTAL	**112,05**	**91,97**	**75,85**	**79,21**	**76,71**

Table 3. Expected annual costs for each scenario (€*1000/year)

CONCLUSIONS

This paper sought to address one of the areas of vulnerability that emerged reviewing the literature: supply lead time in a global sourcing context. A framework for Supply Chain Risk Management has been then developed. The goal of this was twofold: to evaluate the proposed approaches and to offer a model to support manufacturing or retail companies in the implementation of strategies intended to reduce their supply chain risk. The results on a case study confirm the effectiveness and efficiency of the proposed approaches to supply chain risk management on one hand and highlight the relevance of their correct use by setting detailed rules and procedures on the other. Finally, the supply process improvement obtained in this case study, related to a reduction of the total expected logistics cost, does not necessarily entail an absolute efficiency of the proposed solutions, which we do not claim to be exhaustive. In fact, within some specific business contexts it might be more cost-effective to assess and implement other risk-reduction strategies.

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FRAMEWORK FOR DESIGNING ROBUST SUPPLY CHAINS

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ABSTRACT
After years of emphasis on leanness and responsiveness businesses are now experiencing their vulnerability to supply chain disturbances. Although more literature is appearing on this subject, there is a need for a framework to support the analysis and design of robust supply chains. In this paper we present such a framework. We define the concept of robustness, classify sources of (food) supply chain vulnerability, define supply chain disturbances, and classify adequate redesign strategies to achieve robust supply chain performances. We conclude with preliminary findings of a case study in the meat supply chain.

INTRODUCTION
Today's business environment and harsh competitiveness force companies and entire supply chains to increase their efficiency as much as possible. As a consequence, supply chains have become highly sensitive to disruptions and less tolerant to deviations in operations, i.e. supply chains have become more vulnerable (cf. Kleindorfer and Saad, 2005). Vulnerability of supply chains may result in less consistent supply chain performances and consequently, their competitive power in the market may diminish. In order to maintain stability of supply chain performances, it is necessary to design robust supply chains. Robust supply chains should be able to continue to function well in the event of a disruption as well as in the normal business environment (cf. Dong, 2006; Tang, 2006; Waters, 2007). Generally, robustness of the supply chain depends on its capability to respond adequately to different kinds of risks of disturbances. Recently, supply chain vulnerability and robustness has become a hot research topic, and as such, it is still in its infancy. With this paper, we aim to contribute to the existing knowledge in these areas.

RESEARCH MODEL
Our research model consists of four research variables: supply chain scenario, sources of vulnerability, redesign strategies, supply chain disturbances and supply chain performances (Figure 1).

A *supply chain scenario* is an internally consistent view of a possible instance of the logistics supply chain concept, i.e. the managed, managing, and information systems and organization structure in the supply chain (van der Vorst, 2000). *Managed* system refers to the physical design of the network and facility and all other elements that perform the execution of logistic activities (such as equipment, vehicles, and people), as well as product characteristics (element in transformation). *Managing* system (control concept) refers to planning, control and co-ordination of logistic processes in the supply chain while aiming at realizing logistical objectives within the restrictions set by the supply chain configuration and strategic SC objectives. It also considers relevant contextual factors (i.e. specific characteristics of food supply chains such as product quality requirements, as well as requirements that come from specific product–market combinations). *Information* system refers to decision making support within each of the decision layers of the managing system, as well as the IT infrastructure needed. *Organization* structure refers to tasks, authorities and responsibilities of the departments and executives within the organization and supply chain.

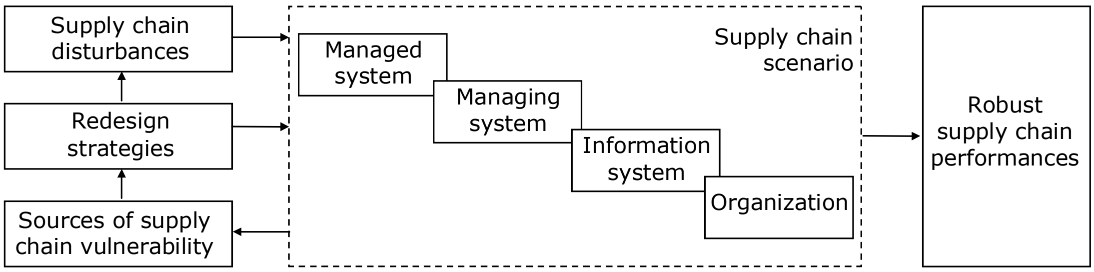

Figure 1. Research model for robust supply chain design

The design of the supply chain scenario results in higher or smaller susceptibility of a supply chain to disturbances, i.e. supply chain vulnerability. According to Waters (2007, p.99): "supply chain vulnerability is the exposure of a supply chain to disruption arising from the risks to operations within each organization, to interactions within the supply chain, and from the external environment". In this paper, we focus on supply chain vulnerability from the aspect of disturbances[1] (more about that in the section about supply chain disturbances and vulnerability).

In order to sustain competitiveness in today's highly dynamic environment, it is necessary to maintain robust performances and supply chain resilience (c.f. Dong and Chen, 2007). The degree of performance robustness depends on level of supply chain flexibility (c.f. Barad and Sapir, 2003) and the flexibility in performance requirements. Therefore, the selection of the best supply chain scenario that will enable robust supply chain performances requires:

- An analysis of supply chain vulnerability sources;
- An analysis of supply chain disturbances and their estimated impact on relevant supply chain performance indicators (KPIs);
- An identification of appropriate supply chain redesign strategies (that consequently change the supply chain scenario) per source of vulnerability;
- Modelling and quantification of supply chain performances for alternative supply chain scenarios subject to different disturbances.

Focus of this paper is on classification of supply chain vulnerability sources, disturbance characteristics and classification of supply chain redesign strategies.

SUPPLY CHAIN ROBUSTNESS CONCEPT

In the supply chain literature robustness is mainly defined in a broad, conceptual level as the ability of the system to continue to function well in all circumstances (see Vlajic et al., 2008 for an extended review). According to Dong and Chen (2007), extensive literature exists on the measurement of supply chain performance, but little of this work has focused on measuring supply chain's robustness, i.e., its ability to cope with disturbances (deviation, disruptions and complete failures). According to (Waters, 2007, p.159), a traditional way in business specifies an acceptable range for specifications, and performance is considered acceptable if it stays within this range. This effect can be describes as 'loss function', which gives a notional cost of missing the target. Therefore, we can conclude that a supply chain (scenario) is robust if values of its KPIs are sustained between minimal required values and target or norm values for a defined period, in normal as well as disrupted regime of work. Here, it is necessary to consider that target (or norm) values as well as minimal required values are case dependent as the selection of KPIs and their values depend on company objectives and problem

[1] In the supply chain literature, disruptions and disturbances are interchangeably used; however, in most of the papers term "disruption" is associated with high consequences and less frequent unexpected events, while disturbances usually cover wider area (low and high consequences, more and less frequent unexpected events)

characteristics (i.e. strategic versus operational problems) and KPI's might not be equally important.

By developing a tool for measuring supply chain robustness, such as the robustness index (e.g. see Gupta and Rosenhead, 1968; Dong, 2006; Dong and Chen 2007; Vlajic et al., 2008), one can get insight to the current state of supply chain vulnerability as well as to the potential of the supply chain to overcome different kinds of disturbances.

SUPPLY CHAIN DISTURBANCES AND SUPPLY CHAIN VULNERABILITY

In order to better understand supply chain vulnerability, it is necessary to get insight into the sources of vulnerability (i.e. what is causing the vulnerability), and to distinguish levels of disturbance magnitude and related impacts on performance. In the literature, there are several approaches to classification of *sources of vulnerability* (from this aspect, classification of sources of supply chain vulnerability are complementary with sources of disturbances, risk and uncertainty). Based on the reviewed literature (e.g. Mason-Jones and Towill, 1998; Asbjørnslett and Rausand, 1999; Svensson, 2000; Van der Vorst and Beulens, 2002; Waters, 2007; Simchi-Levi et al., 2008; Asbjørnslett, 2009) we distinguish two basic levels of vulnerability sources: internal and external (Figure 3).

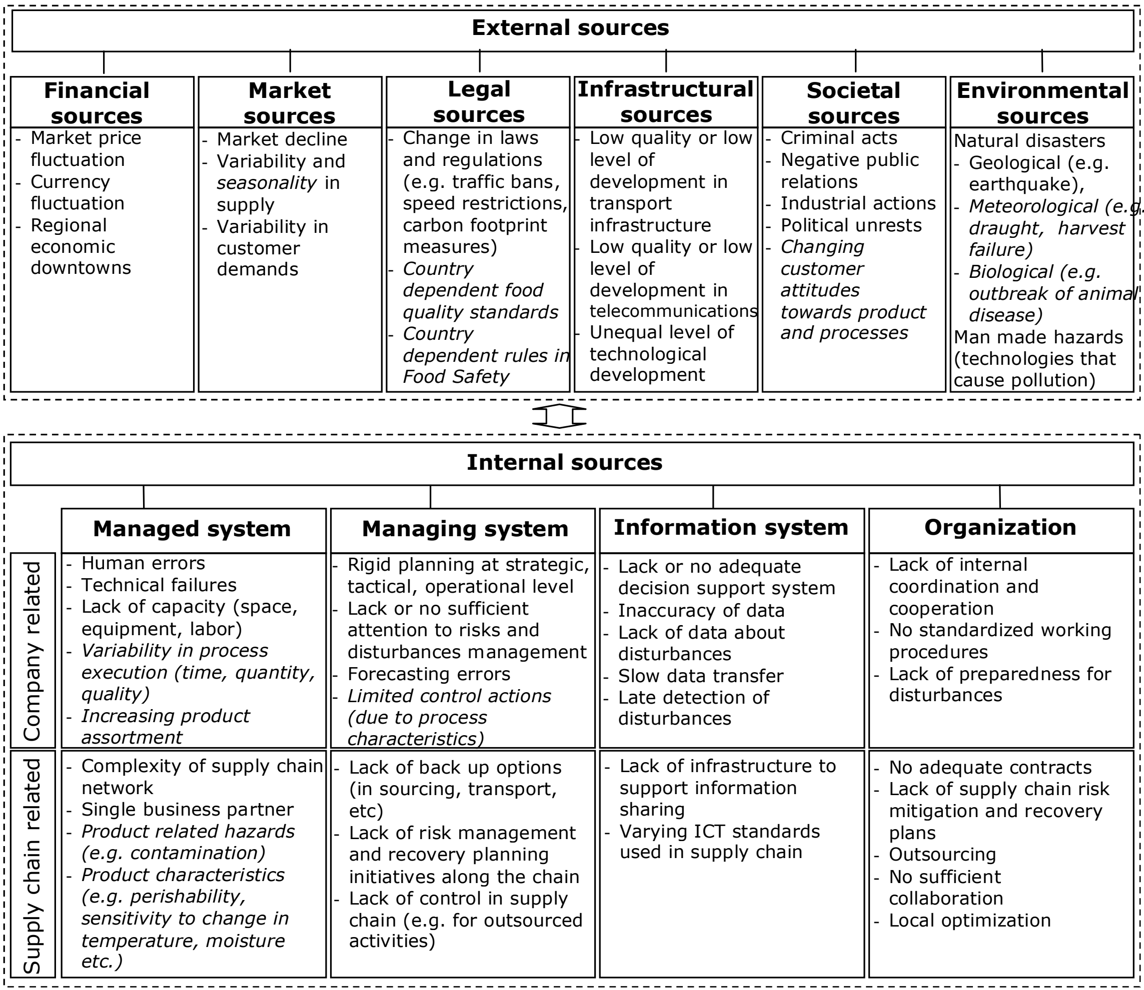

Figure 3. Preliminary list of sources of supply chain vulnerability (*italic* letters denote specific sources related to food supply chains)

Roots of internal sources of supply chain vulnerability lie within the logistics concept of the supply chain, i.e. within the elements of the supply chain scenario: managing, managed, information system and organization. However, from the company perspective, these internal sources are more or less controllable (c.f. Simchi-Levi et al., 2008, p. 316) and they have two levels: the company level and the supply chain level. Roots of external sources of supply chain vulnerability lie in the environment; some of them are controllable to some extent (e.g. market or financial sources), others are not (mostly environmental sources) – c.f. Simchi-Levi et al. (2008, p. 316). We base our classification of external sources on the work of Asbjørnslett and Rausand (1999). Additionally, it has to be taken into account that sources of vulnerability are interconnected with each other, both within each level and across the levels (Asbjørnslett and Rausand, 1999; Peck, 2005).

We define the *magnitude of a disturbance* by the impact it has on the KPIs; i.e. the variation in process KPIs in a defined time period. In principle, the level of variation has to be considered in the context of the norms and requirements on the KPIs. Melnyk et al. (2009) proposed "quantity loss" as measure of magnitude (quantity dimension), but other KPIs have to be considered as well (e.g. time and quality dimensions of KPIs - Van der Vorst and Beulens, 2002). A similar categorization is given by Viswanadham and Gaonkar (2007) who categorized uncertainty manifestations to deviations, disruptions and disasters. In line with the thoughts of Vorst and Beulens (2002) and Viswanadham and Gaonkar (2007), we categorize disturbances in supply chain processes as deviation, disruption or complete failure of process execution expressed in loss of value of relevant KPIs (Table 1). Minor KPI deviations from the norm represent small disturbances, i.e. acceptable variation in process outcome and it can be considered as part of business as usual. High KPI deviations represent disruptions in process outcomes, i.e. the process outcome is much below the norm. Extreme values of process KPIs represent a failure of the process execution, i.e. there is no process outcome at all (e.g. due the burndown of a production plant).

Magnitude/KPI	Quantity dimension	Quality dimension	Time dimension
	Loss of material during transport	Number of products damaged in transport	Transport time
Deviation	Few product lost	Few product damaged	Slight delay
Disruption	Shipment partially received	Significant part of the shipment damaged	Significant delay
Failure	Complete loss	All products damaged	Inability to perform delivery in required time window

Table 1. Example of classification of disturbances in delivery process

Another aspect that is relevant is the impact that disturbance has on performance. *Impact of disturbances* on other processes within the company, supply chain or even environment is particularly important due to the fact that disturbance in one process can have a domino effect to other processes (c.f. Waters, 2007). In principle, the impact of a disturbance depends on the flexibility and responsiveness of the system to adapt to the new situation caused by a particular, accidental event. Therefore, the impact of a disturbance can be local (e.g. delivery failure can have local impact on transport performance, but it will not jeopardize production process if there is enough inventory or if a backup delivery option exists) or system wide (e.g. harvest failure or animal diseases outbreak can cause lack of raw material which effects will be transmitted through the whole chain). According to Wu et al. (2007), perturbations originating in a localized point of a supply chain have the potential to be passed onto subsequent tiers or branches of the supply chain, with possible amplification effects. Therefore, the Bullwhip effect can be also seen as a system wide impact of disturbances in demand along the chain (Wagner and Bode, 2006).

CATEGORIZATION OF REDESIGN STRATEGIES

In the literature there are many concepts related to responses to uncertainty (Van der Vorst, 2000; Lee, 2002; Shimchi-Levi et al., 2002; van der Vorst and Beulens, 2002; Simangunsong et al., 2008), and recently – more focused to disturbance and risk (e.g. Zsidisin et al., 2000; Tang, 2006, 2006a; Tomlin, 2006; Waters, 2007; Hopp, 2008; Macdonald, 2008; Shimchi-Levi et al., 2008; Dani, 2009). In general, response concepts are based on three elements: when to plan and act, what is the frequency of the disturbance and, what is the consequence of the disturbance. The time perspective refers to the moment when to make a plan and when to execute it. In principle, the right choice depends on the probability and consequences of disturbances (c.f. Hopp, 2008), (Table 2).

		Consequences (i.e. business impact)		
		Light	**Medium**	**Severe**
Frequency	**Low**	**Ignore risk** **Plan – ignore** **Act – no**	**Contingency planning** **Plan – before it happens** **Act – after it happens**	**Crises management** **Plan – while it is happening or after** **Act – while it is happening or after**
	Medium	**Ignore risk** **Plan – ignore** **Act - no**	**Contingency planning** **Plan – before it happens** **Act – after it happens**	**Contingency planning** **Plan – before it happens** **Act – after it happens**
	High	**Buffering or pooling** **Plan – before it happens** **Act – before it happens**	**Buffering or pooling** **Plan – before it happens** **Act – before it happens**	**Buffering of pooling** **Plan – before it happens** **Act – before it happens**

Table 2. Categorization of responses to disturbances from the aspect of time, frequency and consequences (colored part is focus of this paper).

In this paper, we focus on disturbances that are characterized by medium to high frequency and light to severe consequences. These kind of disturbances usually come from market, financial, infrastructural and legal sources of vulnerability, as well as from internal sources and they are more or less predictable and controllable (c.f. Shimchi-Levi et al., 2008, p. 316). In general, responses to these kinds of risks and disturbances are *planned in advance*, and it can be seen as a *mitigation concept* (c.f. Macdonald, 2008). However, within this concept there are two approaches:

- Based on the moment of the response itself, i.e. moment when plan is executed – before disturbances happen (e.g. buffering and pooling concepts, Hoop, 2008) or after that (contingency concept - Tomlin, 2006; Waters, 2007, p.156; Hoop, 2008). According to Hopp (2008), buffering denotes maintenance of excess resources (inventory, capacity, time) to cover for fluctuations in supply or demand. Pooling denotes buffers sharing in order to cover multiple sources of variability. Contingency planning implies the establishment of a preset course of action for an anticipated scenario;
- Based on the purpose of the response – prevent the disturbance or reduce its impact (Waters, 2007). Disturbance prevention implies reduction of disturbance frequency, i.e. acting in advance in order to eliminate, control or avoid direct cause of disturbances. Reduction of the impact of disturbance mostly implies passive protection, i.e. building in redundancy, but other concept may be appropriate as well.

In line with the work of van der Vorst and Beulens (2002), we classified redesign strategies using the second type of approach. Therefore, we classified redesign strategies that can be used to reduce the impact of disturbance (Table 3) and redesign strategies that can be used to prevent disturbances (Table 4). Here, we have to mention that some of these strategies can be used for both purposes (especially in the part related to information system and organization).

	Redesign strategies – to reduce impact of a disturbances
Managed system	Adjust the structure of the supply chain **(e.g. Zsidisin et al., 2000; Snyder et al., 2006; Tang, 2006; Tomlin, 2006; Waters, 2007)** - Increase the width of the supply chain - Use multiple modes of transportation Buffering in capacity and inventory **(e.g. Zsidisin et al., 2000; de Neufville, 2004; Snyder et al., 2006; Tomlin, 2006; Waters, 2007; Hopp, 2008; Simangunsong et al., 2008; Simchi-Levi et al., 2008)** - Increase number of equipment, vehicles or workers - Increase capacity of equipment, vehicles or space - Make strategic (safety) stocks - Make well stocked supply pipeline Increase flexibility of the supply chain **(e.g. Tang, 2006; Tomlin, 2006; Waters, 2007; Hopp, 2008; Simangunsong et al., 2008)** - Use multiple modes of transportation - Use flexible automation - Use temporary workers - Use multiple purpose resources (e.g. standardized equipment, vehicles, cross-trained employees) Use product management **(e.g. Tang, 2006/a; Waters, 2007;Hopp, 2008;Simangunsong et al., 2008)** - Use possibilities of product substitution, e.g. silent product rollover - Use product postponement
Managing system	Hedging **(e.g. Tang, 2006; Tomlin, 2006; Waters, 2007; Hopp, 2008)** - Using business disruption insurance - Diversifying operations across multiple markets - Produce certain products in-house and outsource other products Make back up options **(e.g. Snyder et al., 2006; Tang, 2006; Tomlin, 2006; Waters, 2007; Hopp, 2008, Simchi-Levi et al., 2008)** - Use alternative suppliers - Use a flexible supply contracts for non strategic components, such as: Long term contracts (forward or fixed commitments contracts), Flexible or Option contract, or Spot purchase - Make alternative transport routes Increase flexibility of planning and control **(e.g. van der Vorst, 2000; Tang, 2006, 2006a; Waters, 2007; Hopp, 2008)** - Increase manufacturing flexibility, e.g. use flexible receipts, coordinate and redesign policies - Use postponement - Do tasks parallel instead sequential - Allow time and capacity buffering in plans and operations Use lead time management **(e.g. van der Vorst, 2000; Tang, 2006; Waters, 2007; Simangunsong et al., 2008)**
Information system	Use IT to increase speed of disturbance detection and support decision making **(e.g. Zsidisin et al., 2000; Shukla and Naim, 2007)** Create support for information transparency in the chain **(e.g. van der Vorst, 2000; Zsidisin et al., 2000; Lee, 2004; Waters, 2007; Hopp, 2008; Simchi-Levi et al., 2008; Simangunsong et al., 2008)** - Implement real-time information systems - Enable continuous data exchange with partners in the supply chain - Insure infrastructure to enable information exchange and sharing
Organization	Increase preparedness to disturbances **(e.g. Hopp, 2008)** - Enable empowerment (authorization of employees to make independent decisions) - Build awareness for crises situations Increase collaboration in chain **(e.g. Zsidisin et al., 2000; Tang, 2006; Simchi-Levi et al., 2008)** - Establish strategic alliances Create an adaptive supply chain community **(e.g. Tang, 2006; Simchi-Levi et al., 2008)** - Establishment recovery planning systems along the chain **Make back up options** (e.g. Tang, 2006, 2006a; Simchi-Levi et al., 2008; Hopp, 2008) – use risk sharing supply contracts for strategic components, such as: - Revenue sharing contracts - Back-up (advance purchase) contracts - Quantity flexibility contracts - Wholesale price contracts - Sales rebate contracts - Capacity reservation contracts - Cost sharing contracts - Buy-back contracts

Table 3. Redesign strategies that can be used to reduce impact of disturbances by acting to elements of logistic concept

	Redesign strategies – to prevent disturbances
Managed system	Adjust the structure of the supply chain **(e.g. van der Vorst, 2000; Waters, 2007)** - Reduce the length of the supply chain - Change the location of facilities Use product management **(e.g. Waters, 2007)** - Avoid risky products - Rationalize the product range
Managing system	Carefully plan investment **(e.g. Tang, 2006)** - Regular replenishment of equipment, vehicles - Economic supply incentives to cultivate additional suppliers - Innovations (e.g. to packaging, information system, etc.) - Increase capacity Control variability **(e.g. Zsidisin et al., 2000; Tang, 2006a; Waters, 2007; Hopp, 2008, Simangunsong et al., 2008; Simchi-Levi et al., 2008; Dani, 2009)** - Careful supplier selection process by using vendor rating techniques; supplier audits and quality certification programs - Use (virtual) pooling: centralization of decisions - Increase price stability - Use standardized work (procedures) - Use procedures and techniques to improve quality control, as well as industry standards - Develop proactive maintenance) - Use demand postponement strategy Use revenue management strategies **(e.g. Tang, 2006; Simchi-Levi et al., 2008)** - Use dynamic pricing (convenient for perishable products) - Use promotion Decrease lead time and use short term forecasts or aggregate forecasts **(e.g. Waters, 2007)**
Information system	Use IT to increase data accuracy and speed and support decision making **(e.g. van der Vorst, 2000; Hopp, 2008; Simchi-Levi et al., 2008; Simangunsong et al., 2008)** - Implement real-time information systems - Use the same information standards - Use Tracking and Tracing system Create support for information transparency in the supply chain **(e.g. van der Vorst, 2000; Zsidisin et al., 2000; Waters, 2007; Hopp, 2008)** - Insure infrastructure to enable information exchange and sharing Collect relevant data about disturbances **(e.g. Hopp, 2008)** - MTTF (mean time to failure), MTTR (mean time to repair), Lead times
Organization	Increase collaboration in supply chain **(e.g. Zsidisin et al., 2000; Tang, 2006; Waters, 2007; Simchi-Levi et al., 2008; Hopp, 2008)** - Use information sharing - Joint forecasts and planning - Establishment of strategic alliances, such as transport alliances, VMI, etc Increase cooperation and coordination between departments **(e.g. Waters, 2007)** - Closer cooperation between people who are doing planning and people who execute plans Create an adaptive supply chain community **(e.g. van der Vorst, 2000; Zsidisin et al., 2000; Waters, 2007; Simchi-Levi et al., 2008)** - Establishment of risk mitigation plans together with suppliers - Align objectives and define KPIs

Table 4. Redesign strategies that can be used to prevent disturbances by acting to elements of logistic concept

CASE STUDY

In order to test our framework we performed a case study in a company that processes meat. Data was collected from September 2008 to February 2009 based on interviews with company managers, as well as on the observation of researcher who spent six months in the company. The supply chain consists of suppliers (slaughter houses), transport, warehousing, production and customers (processing companies). Our research was focused on production and production related processes. Preliminary data analyze showed that disturbances in production are: *disruptions in the production process* (e.g. half day closure of production lines) caused by variability in supply (in quantity, quality and time); *deviations in planned daily production outcome* caused by variability in quality of supplied raw material, technical failures of production line, rigid planning of incoming shipments, lack of decision support system (DSS) for production planning and scheduling, late detection of low quality material and human errors (in quality control, production and data entry and processing). For the identified sources of disturbances, we proposed the following redesign strategies (Table 5) using our framework.

Our current work is related to the selection of the most appropriate redesign strategies. That requires: 1) a deeper analyses of the sources of vulnerability and disturbances itself (e.g. duration, time of detection frequency), 2) modeling and quantification of supply chain KPIs for alternative supply chain scenarios (i.e. use of alternative redesign strategies) and disturbance levels.

Sources of vulnerability	Redesign strategies – to prevent disturbances	Redesign strategies – to reduce impact of a disturbances
Variability in supply (in quantity, quality and time)	- Control variability by careful supplier selection process - Increase collaboration in supply chain by establishing strategic alliances - Create an adaptive supply chain community by aligning objectives and mutual definition of KPIs - Use quality certification programs	- Adjust the structure of the supply chain by increasing the width of the supply chain - Buffering in inventory (make strategic stock) - Make back up options by use of alternative suppliers and risk sharing supply contracts for strategic components - Increase collaboration in supply chain by establishing strategic alliances
Technical failures	- Control variability by using standardized work (procedures) and proactive maintenance	- Increase flexibility of the supply chain by using flexible automation or by using resource to serve multiple purposes
Rigid planning of incoming shipments	- Decrease lead time - Use IT to increase data accuracy and speed - Increase cooperation and coordination between departments	- Increase flexibility by allowing time buffering in plans and operations
Lack of DSS	- Use IT to support decision making - Collect relevant data about disturbances	- Use IT to increase data accuracy, speed and to support decision making
Late detection of disturbance	- Control variability by using procedures and techniques to improve quality control	- Use IT to increase data accuracy, speed and to support decision making
Human mistakes	- Control variability by using standardized work procedures and IT to increase data accuracy and support decision making	- Use IT to increase data accuracy and speed and support decision making

Table 5. Redesign strategies that could be used to prevent disturbances or its consequences

CONCLUSION

In order to sustain competitiveness in today's highly dynamic environment, it is necessary to maintain robust performances. The degree of robustness, i.e. what will be the impact of disturbances on business/chain performances, depends on the flexibility of the system itself (e.g. how much system can adapt to new situation caused by accidental event and how fast it can respond to it) and the flexibility of performance requirements (e.g. how flexible are customer demands or industry standards). This paper presented a preliminary framework that aims to support companies in designing robust (food) supply chains. More research is needed to extend and validate the categorizations of redesign strategies and sources of vulnerability.

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SUPPLY CHAIN RISK MANAGEMENT: A NETWORK PERSPECTIVE

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ABSTRACT
Purpose of this paper.
The aim of this paper is to undertake a network perspective for supply chain risk management (SCRM) by reviewing the existing literature on supply chain risk and locating it within the general literature on networks.

Design/methodology/approach
Existing research suggests the SCRM to be an integrated process among the supply chains: the literature on networks provides the needed theoretical support for a better understanding of this integration and points out ways of reaping the higher benefits of it.

Findings.
The findings suggest that a small network, with a low level of density and a high degree of centrality, is the configuration with the higher level of risk. We posit that a more decentralised network could present lower risks in several regards, such as technological, supply chain, process, demand, and risks of exposition. Firms can, then, consciously manage their networks in order to lower the overall risk level, by using both formal (e.g. control) and informal mechanisms (e.g. emergence). In order to measure the relevant metrics, Social Network Analysis represents one of the several tools that can be used.

Research limitations/implications:
This is a conceptual paper, whose findings need to be tested empirically. For instance, longitudinal research could investigate the direct influence of logistics knowledge flows on overall supply chain performance.

The original/value of paper.
The value of this paper is to adopt a network perspective to answer the need to integrate risk management along the supply chain, suggesting a tool able to measure network's social dimensions.

RISK AND VULNERABILITY ALONG SUPPLY CHAINS: A NETWORK PERSPECTIVE
A higher awareness related to arising risks along supply chains has been due to the spread trend of outsourcing activities and processes. Vulnerability along the supply chain can be defined as '*an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain*' (Cranfield University, 2002).
Several logistics tools and techniques have been used in the recent years in order to lower costs and to reduce revenues and assets: they can strongly contribute in environments where there is a significant stability from the demand side. However, they can cause a higher level of vulnerability in those environments where there is high unpredictability (White, 2007; Berger and Zeng, 2006; Paulsson, 2007; Manuj, Dittman and Gaudenzi, 2007; Ritchie, Brindley C, 2007; Khan, Burnes, 2007).

The relevance of this issue is well established, both among the academics and the practitioners: nevertheless, a common framework has not been agreed, yet. It should be clarified, that a very detailed common tool, able to work according to sectors' differences, couldn't be developed. This variety should be embraced in a general tool, able to be replicated in every condition.

A reasonable approach seems to be the one that remains as general as possible but that gives the opportunity to be declined according to the sector investigated.
For this reason, this research considers as valid the approach, which follows the next steps:

1. Risk identification: the objective is to determine all the feasible sources of risks;
2. Risk analysis and assess: this phase aims to evaluate the probability and the possible impact of the events listed;
3. Response evaluation: it is required to design the appropriate responses in order to deal with the different ranks of risks evaluated.

Then, Supply Chain Risk Management process is the 'identification and management of risks within the supply chain and risks external to it through a co-ordinated approach amongst supply chain members in order to reduce supply chain vulnerability as a whole' (Cranfield, 2002; Paulsson, 2007).

ASSUMING THE NETWORK AS UNIT OF ANALYSIS

'In recent years, the nature of competition has increasingly shifted toward 'supply chain vs. supply chain struggles' (Hult, Ketchen and Arrfelt, 2007; Gomes-Casseres, 1994). A supply chain is made up from components and linkages: as we mentioned before, we can read a supply chain through the Viable System Approach, pointing our attention on both physical and relational perspectives. The former point of view is connected to the 'total cost of ownership'; the latter to communication and knowledge flows (Cavinato, 2004; Harland, Zheng, Johensen and Lamming, 2004; Fugate, Stank and Mentzer, 2009), able to influence network's performances. Harland et al. (2004) define "knowledge capture" according to the following aspects: organizational learning, collective entrepreneurship, shared learning, exchange of tacit and proprietary know-how, learning in buyer-supplier relationships, learning networks and knowledge-sharing routines. Moreover, Resource Based View has been adopted in order to read networks specific competencies: 'Knowledge sharing between supply chain members has only just begun, and the organizations that lead the way in implementing this tool will have a significant competitive advantage' (Birou, 2006). It seems tautological to consider Supply chain risk management an integrated process among the organisations involved: it is not evident, though, that it is actually run in an orchestrated way (Ritchie and Brindley, 2007). According to Waters (2007):

'There are different levels of integration for supply chain risk management:

1. No significant risk management is done anywhere in the supply chain;
2. Some basic risk management is done within the separate activities of logistics within separate organization;
3. Risk management is done for the broad logistics function, but is contained within separate organizations;
4. Risk management is extended and coordinated along the supply chain to include first-tier suppliers and customers;
5. Risk management is extended to the broader supply chain.

Obviously, many factors can suggest that complete integration is unlikely to be achieved: it could be interesting to find new tools to manage the risk in the whole network.' Even if, then, a certain level of awareness about the need to assume a network perspective is shown along the literature on supply chain risk management, it is difficult to find tools able to ensure the fluency of these flows. According to Harland, Brenchley and Walzer (2003): "Risk and benefit sharing is relevant to joint product/service design, process design and supply chain innovation. The uncertain nature of these activities requires an open dialogue between parties to assess risk and benefits and agree on their theoretical allocation across the supply network. A mutually agreed measurement system is required to measure actual realization of risk, consequential losses. Despite the fact that this is recognized as increasingly important, there is relatively little empirically based knowledge to guide managers on how to do this."

As a matter of fact, the structure of networks may influence networking processes, depending on coordination mechanism implemented, product complexity, information exchanged and knowledge shared. 'Network position can influence access to resources of other network members, reputation and expectations, and may need to be considered in assessing and managing risk' (Harland, Brenchley and Walzer, 2003).

The Social Network Analysis (SNA) is a methodological tool that can measure structural measurements of a network, starting from the dyadic dimension. Social network analysis can be defined as follow: 'Given a collection of actors, social network analysis can be used to study the structural variables measured on actors in the set. The relational structure of a group or lager social system consists of the pattern of relationships among the collection of actors. The concept of a network emphasizes the fact that each individual has ties to other individuals, each of whom in turn is tied to a few, some, or many others, and so on. The phrase "social network" refers to the set of actors and the ties among them. The network analyst would seek to model these relationships to depict the structure of a group. One could then study the impact of this structure on the functioning of the group and/or influence of this structure on individuals within the group.' (Wasserman and Faust, 2004)

The typical metrics used in SNA are:

- Distance: degrees of separation (also referred to as the diameter of a network);
- Ties: in-ties and out-ties represent the number of connections, or ties, to and from a person;
- Centrality: the extent to which a network is organized around one or more central people;
- Density: the percentage of connections that exist out of the total possible that could exist.

SNA quantitative metrics analyse the structural dimension, while the qualitative ones monitor the strength of the relations and the eventual positions of influence and the existing network specific resources.

The core is that: both of these dimensions are crucial to the evolution of the dynamics of the logistics system aiming to excellence. In fact they could be a vital support to the decision making process, to guarantee an adequate profitability.
As profitability is a function of risk**,** we can see a new research path, which considers SNA a possible risk mitigation tool.

RISK MANAGEMENT PROCESS IN THE SUPPLY CHAINS OF BUSINESSES PRODUCING HIGH-TECH GOODS.

High-tech sector are characterised by creation and use of state-of-the-art technology: they are relevant to the economic general trend. Companies involved in a high-tech good project and creation should share their competencies and knowledge, through collaborative relations that bring the shape of a vertical linkage: this is related to the very high amount of money to be invested and to the continuous technology evolution. Design and creation of a high-tech product need a huge amount of investments, and time to do the proper research: hence, it seems reasonable to assume the Project Management perspective, in order to cover those gaps, existing in the supply chain literature. It would be unfair to hide the difficulty to integrate supply chain risk management process along the supply chain: several oppositions arise from the companies to disclose some reserved information. The first step toward this direction is to map the supply chain, in order to discover, at least, the critical path. Aligning practices from both project management and supply chain management perspectives, a risk management process is proposed.

Identifying areas of vulnerability

The existing literature in Project and Supply chain risk management makes mention of several sources of vulnerability, according to the specific field of research carried on.

Integrating all these different points of view, 13 areas of vulnerability arise: Supply chain e.g. on-time performance, average lateness, degree of inconsistency, financial health problems of suppliers, reliability of suppliers; Demand chain e.g. forecasting errors, irregular orders, exceeding needs of the customer, inability to make volume and mix requirements changes; Technology e.g. technology changes in industry or inability to adapt to product design changes; Processes e.g. product process design or product flow supporting system; Control e.g. degree of flexibility of control processes; Operations e.g. machine breakdown, shortage or detective of raw material, labour productivity; Industry e.g. assets and infrastructure, legal liabilities; Financial and economic risk e.g. unavailability of funds, inflation; Contractual and legal risk e.g. delay in solving disputes, change order negotiation; Safety and social risk e.g. accidents, pollution and safety rules; Design risk e.g. design change, scope of work definition; Force majeure risk e.g. war, fire and theft; Network Structure e.g. lack of a shared strategy, paradox of embeddedness, exposition risk, and opportunistic behaviour (Chen and Paulraj, 2004; Christopher, 2005; Zsidisin, 2006; Manuj, Dittman and Gaudenzi, 2007; Paulsson, 2007; Juttner, Peck and Christopher, 2005; Waters, 2007, Cranfield University, 2002; Ghosh and Jintanapakanont, 2004; Samaddar, Nargundkar and Daley, 2006; Kothamaki Vesalainen, Varamaki and Vuorinen, 2006; Carter, Ellrma, Tate, 2007; Gadde, Huemer, Hakansson, 2003; Muthusamy, White and carr, 2007; Kale, Singh and Perlmutter, 2000; Todeva and Knoke , 2005).

Assessing risks' probability and impact
The objective is to rank selected risk sources according to their probability of disruption and impact. In order to carry out this task, Project management perspective suggests the well-known 'Probability-impact matrix': it categorises risks sources according to their relevance.
Ranking the risks could not be enough. There are two other actions that can help:

1. Differentiating a matrix for each objective: cost, time, efficiency, and flexibility,
2. Putting the selected sources of risk on the supply chain design to discover the critical path.

Supply chain objectives are cost, time, efficiency and flexibility: differentiating probability/effect matrix could represent a way to better clarify risk sources' relevance according to priorities, in order to balance sought performances.
Once ranked all the feasible sources of risks, according to the Project Management perspective, it might be useful to locate all the indicators on the supply chain map, in order to: 1. Define the critical path; 2. Discover where are the most vulnerable nodes.
As mentioned before, statistical tools cannot offer a comprehensive analysis: scenario methods are proposed in order to reach a higher accuracy.

Response strategies
Once defined the priorities, response strategies are developed. They could be listed as follows:

- Ignore or accept the risk;
- Reduce the probability of the risk;
- Reduce or limit the consequences;
- Transfer, share or deflect the risk;
- Make contingency plans;
- Adapt to it;
- Oppose a change;
- Move to another environment.

It should be mentioned that Project management approach does not exclude the chance that something not planned, but with a positive meaning, can happen.

The following list summarises some of the contributions relating to mitigations strategies, as mentioned by authors. The reader could recognise some conflicting suggested measures: unfortunately, it is not possible to indicate unambiguous answers to each single situation, since each sector, or network observed, has different characteristics (Berger and Zeng, 2006; Christopher and Lee, 2004), requiring specific actions:

- Flexible Sourcing Strategies, Supply chain visibility, Flexible transportation, Postponement strategy, Economic Supply Incentives, Pooling Resources, Stockpiling, Strategic Stock, Dynamic pricing and promotion, Assortment planning, Product rollover (Tsiakkour and Ward, 2007);
- Insurance, Information sharing, Relationship development, Agreed performance standards, Regular joint reviews, Joint training and development programmes, Joint proactive assessment and planning exercise, Developing risk management awareness and skills, Joint strategies, Inter-partnership structures, Relationship marketing initiatives, Enablers of risk mitigation (Ritchie and Brindley, 2007);
- Adjust the design of the supply chain, Reduce variability, Keep more stock and add spare capacity, Increase agility, Improve forecasting and planning, Increase collaboration, Vendor rating, Make to order, Outsourcing, Binding contracts and using insurance (Waters, 2007);
- Diversification, Stockpiling, Redundancy, Insurance, Supplier selection, Supplier development, Contractual obligations, Collaborative initiatives, Rationalisation of product ranges, Localised sourcing (Cranfield University, 2002);
- Supply Chain Design (Khan, 2006).

A following remark concerns information and data sharing in order to manage risk along the supply chain. It is acknowledged that sharing information is a crucial activity to carry on: it is not clear, yet, the linkage between the level of information shared and the level of integration in implementing supply chain risk management. It should be recognized, though, that it is not an unimportant aspect: moreover, some more efforts in order to define the terms "information" and "knowledge" should be paid (Fugate, Stank and Mentzer, 2009).

The Kralijc matrix, as recently re-edited by Cavinato (2004), represents a very useful tool to focus the attention on both physical flows and knowledge flows along the supply chains. Response strategies can be divides into two categories, according to Kralijc original version, in order to face risks mentioned in the matrix itself. The former is aiming at assuring the continuity of physical flows, thus modifying the physical structure; the latter is turning into guaranteeing proper actions on relational structure.

SOCIAL NETWORK ANALYSIS AS A TOOL TO MITIGATE RISKS

Social network analysis is a sociology branch aiming at studying connections among individuals, using principles coming from the graph theory (Mueller et al, 2007). A network perspective is strictly related to a holistic point of view, rather than a partial one: this is perfectly aligned to the kind of relationships established with strategic suppliers, e.g. vertical linkages, as developed in the Viable System Approach (Golinelli, 2005; Massaroni, 2007; Choi, Dooley and Rungtusanatham, 2001).

Each of the following contributions are related, more or less admittedly, to a network perspective and to a structural dimension of a network. As Carter, Ellram and Tate (2007) hypothesise and test 'The centrality of the position of an actor within the organizational network is positively related to the actor's influence in informal logistics projects'. Samaddar, Nargundkar and Daley (2006) mention and relate information sharing to network metrics, such as the degree of centralization, able to 'affect the nature and the amount of information that gets shared across the network. Similarly, the degree to which the partner firms perceive a match in their goals may impact the nature and amount of information they are willing to share with each other. (…) Although the potential exists for opportunistic behaviour, governance mechanisms such as goal congruence can mitigate this type of behaviour and lead to superior performance that is mutually beneficial.'

Choi, Dooley and Rungtusanatham (2001) relate connectivity degree to the potential for chain reaction: 'If no connections exist, then agents will behave independently and the aggregate response will be unstructured and random.' Other authors investigate the nature of the relationship existing along the supply chains, according to concepts as power, control, authority, social mechanisms or social patterns. Capaldo (2007) investigates on strong and weak ties according to innovative attitude of the network: according to his results, the configuration, which promote the highest level of innovativeness is a dual network architecture 'by promoting a vicious circle in which growing numbers of contacts and increasing network diversity reinforce each other, resulting in a large, diverse, and open network.' Batt and Purchase (2004) correlate a high level of power of control to an inadequate effectiveness and innovativeness: 'The more a single firm seeks to control the network, the less effective and innovative the network will become.' Kothamaki Vesalainen, Varamaki and Vuorinen (2006) usefully differentiate relationships based on the strong use of authority from ties governed by social mechanisms, depicting the effects they can have: 'the use of authority leads to negative experiences, (…) strong use of only the social mechanism leads to an actor having positive and reasonable experiences of the governance of the customer when the supplier is dependent on the customer and the actor is committed to the relationship (…). It is here suggested that customers should govern its supplier by developing a shared strategy that covers these issues instead of using only strong authority, which often causes distrust.' Choi and Krause (2006) relate supply base complexity to the level of differentiation and supply risks. Chen and Paulraj (2004) characterise supply networks according to non power-based relationships: 'In line with the existing research, this study characterizes supply network structure to emphasize non-power based relationships and inter-firm coordination as well as the informal social systems that are linked through a network of relations.'

Ketchen and Giunipiero (2004) describe supply chains as social patterns, i.e. a 'middle round between market and hierarchies'. Those who belong to a supply chain defined as above, contribute with their own resources in order to reach a common objective, throughout share information and coordinate activities. Analysing the risk according to a network perspective let some areas of vulnerability arising: these can be faced manipulating network dimensions in order to lower the overall amount of risk. The clearer remark is connected to the awareness that a small network, with a low level of density and described by a high degree of centrality, is the configuration with the higher level of risk. Starting from the quotations mentioned, we could posit that a more decentralised network could be lower several sources of risks, such as technological, supply chain, process, demand, and risks of exposition. Firms can, then, consciously manage their networks in order to lower the overall risk level: it can happen by using both formal (e.g. control) and informal mechanisms (e.g. emergence (Choi, Dooley and Rungtusanatham, 2001). SNA could, then, represents a network of companies by defining some metrics, rundown of both formal and informal social exchanges. Manipulating formal and informal exchanges can then represent a useful tool to lower the probability of occurrence of some risk sources.

FIRST EMPIRICAL REMARKS IN THE UK AEROSPACE SECTOR.

The aerospace sector seems to be highly affected by vulnerability across the supply chains: as a result, it is very easy to run into delays, quality problems, low cost performances. The supply chain complexity is very high and each organization can influence other companies about innovation through knowledge and information exchange. Supply chain delivering complex products are characterised by a highly complex and long upstream and by a very short downstream. Several modules, each of them independent from the others, compose the product: they are designed and produced by different companies, specialised on a core activity, then (Silvestrelli, 2003).
A leader company, who is responsible for the project, assembles those modules. This pyramid configuration governs labour division, and knowledge and information flows. Developing vertical linkages is a need due to the complexity of the product, in these

terms: firstly, economies of scale can be achieved; secondly, they allow sharing the risks related to the high technological and assets intensity (Giuri, Tomasi and Dosi, 2007). Giuri (2003) investigated the evolution of the aerospace sector using network analysis in order to show the changing configuration through the transformation of the vertical linkages. The results from a sector perspective were very interesting and give us a further confirmation about assuming a single supply chain point of view using network analysis, as a proposition for further research. In order to corroborate the soundness of this proposition of research, an analysis of secondary and primary data related to the Uk market have been carried on.

A research developed at Cranfield University (Haywood, 2002; Haywood and Peck, 2004) offers interesting insights: the project was aiming at disclosing best practices related to Supply chain risk management in one project belonging to the British Aerospace Society. Some considerations about feasible further tools to manage risks are the most relevant understanding for our research. The author asked to supply chain responsible from all the components suppliers involved in a project, who were attending a meeting, which was the level of integration reached in that supply chain. The answer was that the continued process of managing risks involved only first tier suppliers.

Three possible solutions were proposed in order to move around this obstacle:
- Independent activity of identifying risks sources along the supply chain.
- Collaborative effort from all the members of the supply chain, assuming the same code;
- Collaborative effort from all the members of the supply chain, sharing data related to supply chain risk management among all the companies belonging to the supply chain.

The third solution has gained the major support from the panel, even if a certain amount of unwillingness of revealing sensible information has been mentioned.

In order to have confirmation about the need to monitor and manage knowledge and relational supply chain flows, several academics and practitioners have been get through to. In particular, one interview will be briefly summarised. These comments cannot be considered enough to validate our approach, but they offer some interesting remarks. The company is one of the most relevant actors in the global aerospace sector. Their supply chain is aiming at '*delivering both customer focus solutions on products as well as services doing that in an efficient manner*' and according to an end-to-end management of supply chain, implemented by a high exchange of information among the supply chain. Beside product and information consideration, the manager stated: '*And the third dimension is probably knowledge in terms of how we establish best practices in supply chain management's tool and techniques and through our production system, of which supply chain management is a key part of that. We have internal mechanism to share that knowledge with our partners and suppliers*.'

Supply chain risk management process follows the three mentioned steps and the involvement of partners in it is limited to the strategy development based to a dyadic perspective. Their approach in developing relationships with all the level of suppliers and partners is based on the following sentence: '*Poor relationship, poor performance*.'

Assuming a network perspective has been recognised as a possible improvement in supply chain risk management, in order to ameliorate the integration along the supply chain. A tool to understand the dynamics in a network has been identified as a useful step forward.

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AN INTEGRATED APPROACH TO MANAGE RISKS IN THE FAST MOVING CUSTOMER GOODS SUPPLY CHAIN

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ABSTRACT

Purpose: This paper presents an approach for a semi-quantitative assessment of supply chains chain risks in the Fast Moving Customer Goods (FMCG) supply chain and for the identification of risk mitigation strategies.

Design/methodology/approach: The approach developed is based on a hybrid methodology, combining Dysfunction Mode and Effects Analysis (DMEA) and Quality Function Deployment (QFD) tools. In particular, the DMEA method is first used to identify possible risks and dysfunctions of the supply chain, and to prioritise them based on an estimated expected failure cost. Hence, the customer requirement planning matrix, also known as House of Quality (HoQ), is used to correlate the supply chain risks identified with possible mitigation strategies.

Findings: The presented methodology enables to examine the impact of mitigation strategies, such as technological innovations, process improvements or organizational changes, on different particular supply chain risks and to identify the strategies to be preferred for implementation.

Research limitations/implications: A further task is the validation of the approach through to a real case example, with the aim to assess its applicability. A practical application will also make it possible to adjust specific parameters of the approach and will enable to integrate all levels of Supply Chain Risk Management, namely the operational, tactical and strategic level.

What is original/value of paper: The approach developed serves at least for two main problems of supply chain management. First, it can be used to identify and rank possible risks and dysfunctions related to a given company or supply chain. Second, the methodology serves as a decision making tool to prioritise possible countermeasures for supply chain risks previously identified.

Paper type: Research paper

INTRODUCTION

Supply Chain Management (SCM) describes various approaches to handle the challenges of a logistic network, in which a product or service moves from its first genesis to the end customer. Typical SCM goals include, among others, matching supply and demand, reconfiguring supply chain based on changing market requirements, avoiding out-of-stock situations, reducing the bullwhip effect (Christopher, 2004) and managing supply chain risks (Juttner et al., 2003).

Recently, the interest in Supply Chain Risk Management (SCRM) has increased in purchasing, logistics and SCM research (Lindroth & Norrman, 2001; Johnson, 2001;

Christopher, 2004). Risks, also referred to as "vulnerability", "disturbances" or "uncertainty", affecting an entity anywhere in the supply chain have a direct effect on a corporation's ability to continue operations, get finished goods to market or provide critical services to customers (Juttner et al., 2003). Hence, such risks should be considered in the strategic design and management of a supply chain, and mitigation strategies should be undertaken to reduce them (Peck, 2003; Christopher & Peck, 2004; Jüttner, 2005).

In this paper, a new approach is presented to manage risks in the Fast Moving Consumer Goods (FMCG) supply chain. The proposed approach subsequently exploits Dysfunction Mode and Effects Analysis (DMEA) and Quality Function Deployment (QFD) techniques, respectively to identify risks and dysfunctions of the supply chain and to link them with possible mitigation strategies.

The remainder of the paper is organized as follows. In the next section, an overview of the FMCG supply chain and related processes is provided. Then, the potential risks of the supply chain and the corresponding risk management tools are detailed. The approach developed is proposed in section 4. Concluding remarks and future research directions are finally presented.

OVERVIEW OF THE FMCG SUPPLY CHAIN

FMCGs constitute a large part of consumers' budget in all countries. FMCG supply chains deal with the production and distribution of products that are sold quickly at relatively low cost and in large quantities (e.g., food packaged products and drinks, toiletries, cosmetics, health and beauty care, etc).

For a better understanding of risks in the FMCG context, an overview of the FMCG supply chain should be first sketched. The FMCG supply chain is a complex and dynamic network of producers, distributors, retailer and customers whose behaviour has dramatically changed, due to increased globalization, importing of special products from foreign regions and increasing pricing pressure, which led to the need of shortening stocks, and saturation of the domestic markets (Eastham et al., 2001). Consequently, companies in the FMCG field moved to affiliations and fusions, to start international expansions. In addition, the development of collaboration and partnership strategies between entities made supply chain management more complex in the FMCG context (Walker, 1994). In this regard, complexity and dynamics led to higher uncertainty and enhanced risk to process vulnerabilities in the last decade.

According to Simchi-Levi et al., (2000), a typical FMCG supply chain is build of three levels, namely the suppliers of raw materials, the manufacturer's production site and distribution centre, as well as the retailer's distribution centre and the corresponding stores. Manufacturers receive raw material from suppliers, for instance from the agriculture sector or the chemical industry. After production, goods are stored in the manufacture's warehouse to be distributed to the retailer's distribution centre and finally to the retail stores to fulfil customer's demand.

To describe the typical processes of the FMCG supply chain, several reference models can be exploited. In particular, the four stages of the Metz model (Metz, 1997), namely "receive", "manufacture", "distribute" and "deliver", provide a framework to fully detail the supply chain or network structure, to correlate the logistics processes within an entity, as well as to describe links between entities. Based on the analysis of each step of the Metz model, the typical processes of a single FMCG supply chain player can be described as per Figure 1. As can be seen from the figure, processes listed are general in nature; however, in most practical cases, supply chain processes could be very specific and thus have to be examined carefully with respect to the case study considered. A detailed process analysis is required to punctually identify possible risks factors of the supply chain.

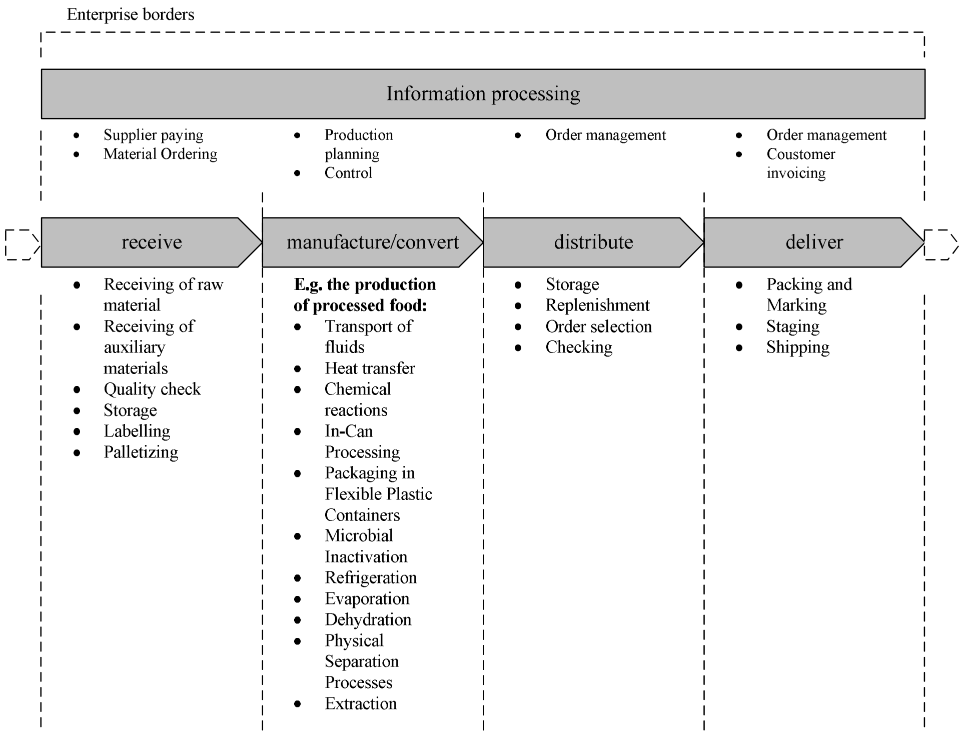

Figure 1: Typical logistic processes for FMCG manufacturer (adapted from Metz 1997).

POTENTIAL RISKS OF FMCG SUPPLY CHAINS

The proper management of a supply chain is affected by several issues and risks, virtually related to all levels of an organization. General issues to be faced in managing a supply chain or an entity include, for instance, configuration and strategic orientation of the distribution network, inventory control or integration and partnering with suppliers (Christopher, 2004). From a more tactical and operational level, the process reliability highly depends on the manageability of specific issues, including problems, uncertainties, disturbances and risks threatening the enterprise; such problems or disturbances may came both from internal processes and from the external environment.

A first step towards the analysis and management of supply chain risks is a classification based on their origin. Peck, (2003), presents a popular taxonomy, suggesting vulnerability to depend upon external and internal risks. The external risks, in particular, can be classified as related to "demand", "environment" and "supply". The site of internal risks focuses in detail on the "process", "control" and "mitigation/contingency" fields. Besides this classification, other possible taxonomies of risks can be found in literature. Different classifications suggest risks to be grouped based on the time or space where they could occur (Jüttner, 2005; Jüttner et al., 2003; Wu et al., 2006a,b). Otherwise, classifications available could focus on strategic aspects of risks. Hallikas et al., (2004), presents a classification based on two main dimensions of risks, referred to as "probability" and "impact"; both dimensions are evaluated on a scale ranging from low to high. While this approach can be useful to prioritize different risks, it does not enable to distinguish the source of a risk occurrence.

Further relevant information can be obtained by examining risks from the perspective of their degree of manageability. Such an analysis allows distinguishing between uncertainties, that could be managed and mitigated, and natural catastrophes, which could not be prevented. For instance, uncertainties include risks associated with demand, production and delivery. A well known consequence of such uncertainties is the bullwhip effect, which describes the increase in orders variability due to a time delay in information and material flows, as well as to a batch ordering attitude. In this regard, several mitigation strategies can be found in literature, to make uncertainty manageable (Hwarng & Xie, 2008). Conversely, risks such as accidents, natural catastrophes or political instability are substantially more difficult to be managed and almost impossible to be forecasted (Christopher & Peck, 2004; Wu et al., 2006a). Nonetheless, the possibility to mitigate them is desirable, and should be based on prevention possibilities or the creation of emergency plans in the case the risk occurs.

THE PROPOSED APPROACH FOR SUPPLY CHAIN RISK MANAGEMENT

The methodology developed in this paper strives to analyse and to prioritise risks and disturbances in the FMCG supply chain and to quantify the impact of mitigation strategies on risk factors.

To achieve the aims detailed above, the methodology exploits the combined application of Dysfunction Mode and Effects Analysis (DMEA) and Quality Function Deployment (QFD) tools. An overview of the approach and of the corresponding steps (from 1 to 5) is presented in Figure 2.

As the starting point (Step 1), the typical processes of a regarded enterprise are identified and listed on the basis of a hierarchical process model (i.e., process, sub-process, phase/operation). This step is usually based on a comprehensive analysis of processes of a real enterprise. The approach developed by Bertolini et al., (2006b), could be followed to this extent. Otherwise, as the tool proposed is particularly conceived for the management of risks in the supply chain, several companies can be examined at this step. As a result, a detailed list of processes to be included in the analysis is provided.

In Step 2, the potential disruptions and dysfunctions of each process previously listed are examined. Risks can be identified either based on the analysis of the literature or on the investigation of a case study. In this latter case, site visits and direct interviews with company's managers could be helpful to refine the risks definition.

To assess and prioritize the potential risks, the DMEA method is exploited. This method is based on the Failure Mode And Effects Analysis (FMEA) approach (Department of Defense, 1980), which was originally developed and used in reliability and maintenance activities (Bevilacqua et al., 2000) and whose application is standardized in many industries. The approach has been transferred into the field of FMCG and food processes (Bertolini et al., 2006a; Scipioni et al., 2002). When applied to the SCM context, DMEA allows, among others, to identify potential causes of dysfunctions and errors within a company, as well as to prioritise them based on the importance of potential dysfunctions.

The DMEA methodology presented in this paper is essentially the result of two sequential phases. First, each elementary activity of the regarded processes is analysed and potential failure modes (i.e., dysfunctions) are identified. Based on those input data, the second phase, i.e. Criticality Analysis, aims to evaluate the priorities of each potential risk, to create a classification. This is done according to criticality parameters, which are failure probability, severity of the consequences and detection probability. By gathering these parameters, the key indicator, called risk priority number (RPN), provides an estimate of the criticality of a given dysfunction mode, according to the following formula:

RPN = probability × severity × detection *(1)*

It is useful to modify the traditional approach of Criticality Analysis by introducing a cost-based evaluation (Rhee & Ishii, 2003). Accordingly, the computation of the RPN is replaced with the analysis of the expected failure costs (EFC) occurring in the case a given risk is observed. Thus, EFC result as the product of the probability of a particular dysfunction (p) and the costs associated with it (c). This indicator is particularly useful, as costs are a language that is understood by business administrators as well as engineers, and highly improves the assessment itself and the comparisons of results. The computation of EFC_j takes into account different cost components (or drivers) involved in the risk considered (e.g., cost of manpower, material or product); they are referred to as $c_{1j},\ldots c_{nj}$. Hence, for a given dysfunction mode D_j (j=1,…m) the computation of the EFC_j results from the equation below:

$$ESC_j = p_j \sum_{i=1}^{n} c_{ij} \qquad (2)$$

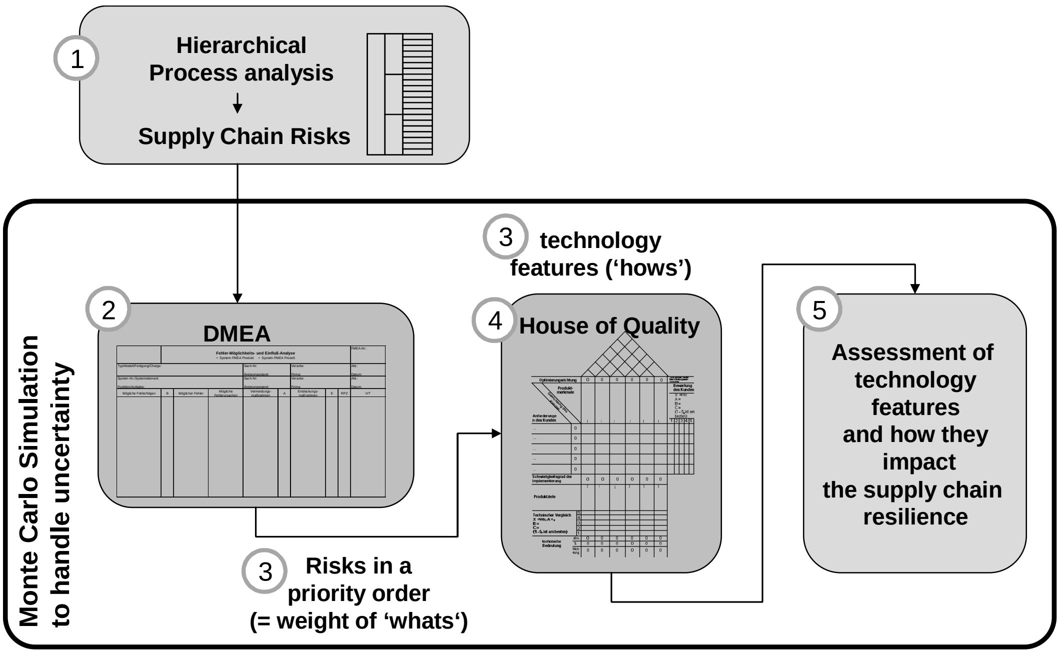

Figure 2: scheme of the methodology proposed for risks management and of the corresponding steps.

The result of this phase is the prioritization of dysfunction modes based on the resulting EFC (Step 2).

As a third step, possible mitigation strategies concerning the risks previously listed should be collected and figured out. To identify such strategies, a preliminary analysis of the literature may be beneficial; moreover, results from the literature could be integrated with information collected from interviews with managers of the company or supply chain examined. To find and quantify correlations between the risks identified and the possibilities to handle them with a particular mitigation strategy, the QFD method is chosen. QFD was first used in the 1970's in Japanese firms to improve the quality of their products and has been first adopted in product development processes with a special focus on customer' voice (Akao, 1990). It has subsequently been transferred in other business areas and application fields (e.g., Bottani & Rizzi, 2006).

The suggested application of QFD in the context of SCRM is based on the four-phase model described for instance by Bouchereau and Rowlands, (2000). In this paper, we exploit the customer requirement planning matrix, also called the House of Quality (HoQ). When applying the HoQ in the proposed methodology, the customer requirements are replaced by possible risks and dysfunctions of the supply chain examined; they are listed in rows in the HoQ (i.e., as "whats"). Risks and dysfunctions to be considered are taken from the results of the previous DMEA. Similarly, the relative importance of dysfunctions is directly available from the EFC previously computed, which is used as the "weight" of "whats". The engineering characteristics are replaced by specific mitigation strategies, which are listed in column (i.e., as "hows") in the HoQ (Step 3).

Step 4 consists in completing the HoQ with the remaining parameters. The core element of the HoQ is the "relationships matrix", which expresses the relationship between "whats" and "hows". The relationships quantify how and to what extent each characteristic meets each requirement, and are expressed on three degrees of strength (i.e., weak, medium, or strong). For computational purpose, the relationship can be translated into numerical values based on an appropriate scale (see, for instance, Bottani & Rizzi, 2006). To complete this part of the HoQ, the possibility to mitigate a given risk with a particular strategy should be assessed. This could be done either based on the available literature or on direct interviews with managers of the company examined.

Moreover, the roof of the HoQ, called the "correlations matrix", should be filled, by evaluating whether, and to what extent, risk mitigation strategies affect one another. Following the traditional QFD, correlations are expressed on a 4-point linguistic scale, from strong positive to strong negative. A positive relationship indicates that two mitigation strategies can improve each other, while a negative one suggests that tradeoffs are required. Absence of symbols denotes that "hows" are not correlated. Correlations are translated into appropriate numerical values for computational purpose. Again, the definition of correlations is usually grounded on interviews with managers of the company examined (Step 4).

Finally, a target measure for each mitigation strategy in the matrix has to be calculated (Step 5). The target measure translates the ability to reduce possible risks into numerical values, in order to quantify the performances of certain strategies to mitigate the identified risks. The final result is thus an overall score indicating which mitigation strategy has the greatest impact on risks identified. This is reported in the lower part of the HoQ, and allows identifying the strategies to be privileged for implementation. The structure of the resulting HoQ is shown in Figure 3.

The evaluation process described would benefit from quantitative values, in order to provide an objective ranking of risk mitigation strategies. However, in practical cases, the assessment of costs, probability, relationships and correlations could be based on estimations and experts' know-how or opinions. Hence, the resulting values are often subjective, and characterised by a certain degree of uncertainty. For that reason, methodologies like Fuzzy Logic (Zadeh, 1965) or Monte Carlo could be successfully integrated in the model presented for the assessment of EFC and of relationships and correlations in the HoQ.

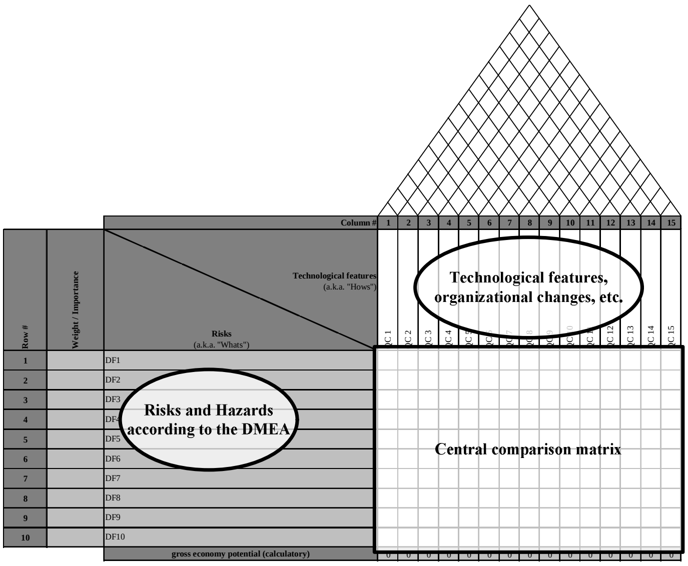

Figure 3: Structure of the adapted House of Quality for risk management.

CONCLUSION AND FURTHER TASKS

In this paper, we have presented a methodology to assess and manage supply chain risks and dysfunctions. The approach developed serves at least for two main problems of supply chain management. First, it can be used to identify and rank possible risks and dysfunctions related to a given company or supply chain. Second, the methodology serves as a decision making tool to prioritise possible countermeasures for supply chain risks previously identified. The final result of the methodology is the indication of the mitigation strategies that should be privileged to reduce risks and dysfunctions. Hence, we believe that both practitioners and researchers would benefit from the methodology developed.

A further task is the validation of the approach through to a real case example, with the aim to assess its applicability. A practical application will also make it possible to adjust specific parameters of the approach and will enable to integrate all levels of SCRM, namely the operational, tactical and strategic one. The superior aim should be the creation of an integrated framework of methodologies and tools which serves as a standard for risk considerations in SCM.

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RESILIENCE IN THE FOOD SERVICE SECTOR SUPPLY NETWORKS

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ABSTRACT
This paper reports on the findings of a study of resilience in the food services as a system, looking at individual organisations, the sector and its supply chain networks, and dependencies between the food supply and other aspects of the UK's critical national infrastructure. The aim of the study was to ascertain the current state of continuity planning for national emergency planning purposes. Themes for the study included the scope, extent and limitations of continuity planning within and between individual organisations; and the likely impact throughout the sector of widespread potentially disruptive events such as a human flu pandemic; national/international energy or fuel shortages and longer-term questions of sustainability.

INTRODUCTION
The food supply is vital to us all. The supply chains that feed us are complex and far reaching. They are, according to some well-used used definitions from supply chain management, networks of interdependent organisations formed to facilitate high performing business models, deliver competitive advantage and ultimately better value to shareholders, customers and consumers (***refs***). In reality they are much more, they are part of the fabric of society. They link organisations, industries and economies and intersect the established remits of business continuity management (BCM) and the civil contingencies agenda.

In some respects BCM's objectives chime with the commercial concerns of supply chain management. According to the Business Continuity Institute, BCM is "A holistic management process that identifies potential impacts that threaten an organisation and provides a framework for building resilience with the capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value creating activities" (***BCI Glossary***). However, whilst SCM embraces inter-organisational perspectives, best practice BCM has delineating itself from both SCM and the civil contingencies remit of emergency management by cultivating a single firm perspective. In 2003 the forerunner of the current British Standard (PAS %^) aligned BCM with the operational risk concerns of corporate governance, encouraging continuity managers to focus on 'quiet catastrophes' that only affect and individual organisation". The earliest drafts of the British Standard for Business Continuity (BS 25999****) drew an even clearer distinction, suggesting that "business continuity management pertains to activity that is conducted for the benefit of a single organisation" whilst emergency planning "pertains to activity that is conducted for the benefit of the public or society".
In the UK an event a situation that it poses a threat to human welfare, including a disruption to the supply of food constitutes an emergency under the Civil Contingencies Act (***ref). From a national security perspective, the supply of food is designated as one of nine elements of the critical national infrastructure (**Ref**). However the characteristics of the food supply are quite different from most of the other elements of the UK's critical infrastructure. The others are for the most part either in the public sector (e.g. health, government and emergency services); concentrated in public sector oligopolies (e.g. privatised utilities) or in the case of finance, dominated by relatively few regulated companies, currently positioned somewhere between private ownership and nationalisation (***Ref**). In contrast, the production and supply of food has always been a private sector endeavour, with hundred of thousands of businesses involved in its

production and distribution. Yet food has also been at the centre of some of the most memorable national emergencies of recent times. Long before 'toxic assets' brought the world financial system to the brink of collapse (****), food emergencies had demonstrated the need for a better understanding of systemic risk. It was 'creeping crises' caused by outbreaks of livestock diseases such as BSE and Foot and Mouth Disease and fears over disruptions to all elements of the critical national infrastructure during the fuel protests of 2000, together with increased incidence of flooding, which prompted a major revision of emergency planning policy in the UK (***ref**).

The purpose of this study was to inform evidence-based policy making within the UK government. The research builds on the limited body of literature into BCM in food service sector (Moor 2005; Rousaki and Alcott 2006). It complements an earlier study of the UK's grocery sector supply chains (Peck 2006) and included a review of other recent literature on food security from the perspectives of maintaining reliable sustainable supplies of food whether from a global markets or a national contingency planning policy perspective (e,g. Burns and Bu 2006; Chatham House 2006; 2007;). The literature review also covered concerns about over-reliance of the UK on food imports (NFU 2006; Defra 2006) and the vulnerability or otherwise of UK national food supplies to disruptions to transport (McKinnon ***life without lorries 2006). The work produced by Defra (2006 **b**) on the subject of food security was particularly relevant to this study. It took a robustly competitive free market stance, pointing out that many of the risks associated with the food supply can be dealt with by markets. Nevertheless it also recognised that systemic risks to food supply may not be adequately managed by markets, either for domestic or overseas produce. It conceded that these need to be correctly identified and appropriately targeted. From a policy development perspective the paper's authors stress that food security cannot be a single policy issue, but should be built on cross-cutting policies. These included "Promoting the development of business and contingency planning, together with relevant industry players; improving coordination and information flows across industry; contingency governance arrangements; and early warnings preparedness for the private sector".

METHODOLOGY

The research design aimed to replicate the sampling strategy used by Peck (2007) for the grocery sector, adjusted where necessary to reflect structural differences between the sectors and the concerns of national emergency planners.

In practice the food service sector is diverse and extremely complicated network of specialists businesses, performing many different functions and operating different business models. In value terms the food service industry is heavily weighted towards London and the South East of England (***), though opinions were sought from managers from all over Great Britain. A total of 41 managers from 26 organisations were interviewed over a 10 month period between September 2007 and June 2008. They included managers from some of the best known High Street chains; leading contract catering, facilities management and wholesale distribution companies; owner proprietors of a small sandwich bars and independent hotels; managers from a hospital trust, a city council and representatives of the armed forces, together with suppliers of fresh produce, meat, ready meals and a spokesperson for an industry association. Collectively the challenges they faced ranged from providing fine dining facilities in the City of London, to the provisioning of High Street sandwich and burger bars or the gas rigs of the North Sea, through to school meals for children made homeless by flooding in the summer of 2007 or feeding of the armed forces in the UK and on deployed operations in Afghanistan.

An interview schedule was used to provide a framework for discussions, with questions on the scope and purpose of BCM, actual disruptions experienced, near misses and known vulnerabilities. Given the characteristics of the food chain and the interests of the research sponsors the study advanced from a BCM perspective across the supply chains. In addition it included three specific scenarios: loss of people due to some form of life threatening infectious disease; loss of energy supplies and loss of fuel for road transport. The interviews averaged 2 hours each, all but three were conducted face-to-face at the interviewees' offices. Three were conducted over the telephone. The interviews were recorded in field notes which were returned to the interviewees for verification. Analysis proceeded through thematic coding of the responses.

FINDINGS

In common with the grocery sector, BCM in food services is being driven by a combination of compliance requirements; the fear of reputational damage and client pressure. Few of the companies involved in this study were Stock Exchange listed companies. Those that were tended to have well established, comprehensive BCM programme in place. However the vast majority of businesses in the industry (and in this study) are actually small or medium sized privately owned or private equity businesses. Here the EU's General Food Law Regulation makes its presence felt. Lessons have been learned from earlier food scares and under EU law all food has to be ultimately traceable from point of origin to final point of sale, to facilitate product withdrawals and recalls and should they be necessary. As a result traceability across the supply chain was recognised as important even in the smallest businesses. The larger and medium sized businesses had formal or ad hoc crisis management and recall procedures in place. The system as a whole was tested by the UK's Food Standards Agency in 2005, when contaminated Worcestershire source caused the recall of around 600 product lines. The recall affected thousands of food processors and retailers. The food manufactures not retailers or food service businesses bore the cost of that episode.

Across the food service sector dedicated specialist BCM managers are extremely rare and BS25999 was not widely used. Nevertheless organisations large and small were managing operational risk or intuitively taking steps to safeguard their own 'mission critical' assets and activities. However in an industry characterised by multiple levels of contracting and outsourced or franchised business models, the largest companies were protecting Head Offices and activities such as contract management, marketing and finance, rather than food preparation and service operations at consumer facing service outlets. The public sector organisations were required to ensure their own continuity management under all circumstances under the Civil Contingencies Act, as well as meeting emergency planning obligations. They too focused their efforts on maintaining their core activities i.e. the provision of health care, education or defence rather than ancillary activities like logistics, distribution, catering or facilities management, which were often outsourced or managed under contract. The contractors are increasingly often required to undertake BCM as a contractual requirement, but their planning tends to be based on maintaining operations under otherwise normal conditions, not for a prolonged or widespread emergency. Military ration packs provide a back-up option for the armed forces. For hospitals, schools and even emergency service workers, bought in sandwiches are usually assumed to be available as a default option.

In fact when it came to planning for and responses to localised events or those "quiet catastrophes" affecting only a single organisation, it was remarkable how infrequently intra-organisational solutions formed the basis of continuity management.

Single site small businesses were certainly vulnerable to major disruptions, such as a major fire, but the small business owners were embedded within their local business networks which routinely helped customers, suppliers and occasionally even competitors to overcome temporary difficulties. They were keen to be seen as contributing to the wellbeing of their local communities. Franchisees of major fast food chains were also found to be self organising with fellow franchisees with informal reciprocal arrangement in place to overcome localised disruptions the operational problems of everyday business life. Reciprocal arrangements could also be found in public sector and public-private partnerships organisations e.g. between local hospitals and prisons when kitchens were closed for refurbishment or after a fire. Local businesses and community based supply arrangements were the preferred option for facilities managers responsible for vulnerable populations in closed environments such as prisons and off-shore.

When fire struck a distribution centre supplying meat for the armed forces, intra-organisation cooperation again provided the solution as other members of the food supply contract consortium rushed to their partner's assistance. The explosion of the Buncefield fuel storage depot in December 2005 was anything but a quiet catastrophe. It compromised sites serving three of the four national High Street chains involved in this study. Their managers praised the efforts of suppliers who had rallied around to overcome the loss of access to their customers' distribution centres.

Higher up the supply chains, when a supplier of one food stuff lost a factory to fire, retail and wholesale customers found another supplier or substituted other products instead. The bigger franchised fast food and sandwich chains also relied on the robustness of their centralised purchasing arrangements and rigidly controlled first tier suppliers to provide switching options for both products and suppliers.

Whilst BS25999 was not widely used, awareness was spreading amongst the larger contract catering and facilities management companies, often because public sector clients such as the Ministry of Defence or National Health Service Trusts or financial service firms in the City of London had brought it to their attention. This was prompted by concerns over corporate governance and more recently, pandemic planning.

All but the tiniest businesses were aware of the natural hazard posed by a possible human flu pandemic on the scale on the 1918 Spanish Flu. Some of the contract caterers and facilities management companies, particularly those operating in closed environments had established contingency menus and protocols, some had asked their wholesale or distribution companies to prepare pandemic plans. Beyond that they were checking the World Health Organisation's website for advice, and looking to Government for further instruction. Other companies were hoping existing switching options, agency labour or even Government intervention would see them through, though the feasibility of these positions has not been worked through.

Food service is essentially a 'people business', anything affecting the availability of labour would have an impact on the sector as a whole. Throughout 2007 and 2008 interviewees had complained of shortages of skilled and unskilled workers in many parts of the food service industry. During a pandemic staff shortages were expected to intensify in all areas, including processing and distribution. Demand for food service was expected to fall in the most profitable areas such as High Street retailers providing 'grab and go' sandwiches for office workers, businesses involved in leisure and tourism and in-company dining. At the same time surge in demand is expected in other critical areas, including sections of the low-margin public sector contract catering services. The contract catering companies in particular raised some important unanswered questions about human resources management and their legal positions over duty of care. For example could they order staff to go to work in a hospital treating pandemic patients? The operators providing food services in secure environments and to vulnerable populations would also face particular problems in finding replacement staff quickly, because of the time delays involved in obtaining security clearance or Criminal Records Bureau (CRB) checks. In addition there were concerns that undermanned and overstretched public sector clients may not see paying suppliers as a priority activity as they struggled to meet their emergency management obligations.

The Department for Health and City firms had encouraged suppliers to engage in pandemic planning exercises during which some of these issues had come to light.

There were requests that similar direction and coordinated planning be given to food service companies supporting the off-shore industry and across the distribution sector.

The off-shore sector is key to the UK's energy supplies, a disruption to which formed the second of the three scenarios explored in this study. In terms of actual disruptions experienced, power cuts were a problem for all the small consumer-facing businesses. Their operations ground to a halt almost immediately. The same was true for the fast food franchises and sandwich chains who would be affected immediately at point of sale. The older department stores had generators but most sites would close almost immediately because of concerns over food safety. The large retailers, branded chains and contract caters all planned for localised short-term power cuts, which would close a small number of outlet for a limited time, but would not threaten the viability of the business. Across the sector there was an assumption that Head Office functions could be maintained by a combination of uninterruptable power supplies to support IT and staff working from home. Paper-based working was a possibility for some for a limited time assuming customers and suppliers were willing and able to trade on that basis, though opinions differed on the viability of email-based ordering and electronic payment systems. ***Traceability*****There were also concerns that even when customers and suppliers had agreed to proceed with paper-based working public sector clients would struggle to find the manpower to input data once normal systems were restored.

In public service locations back up power provision was usually better. Prisons, hospitals and some military bases had generators on site. Schools were unlikely to have their own alternative power, though some school catering arrangements used a centralised kitchen to prepare ready meals for distribution to others in the same area. The contract caterers relied entirely on clients' contingency planning arrangements, which varied greatly. One company had revised its contracts and added force majeure clauses for major events, another looked to skilled catering staff to provide work-around solutions if the power was lost. Some assumed that gas cookers could still be used, though one chef pointed out that fail-safe devices, fitted to meet Health & Safety requirements, automatically disabled the gas cookers if the supply of electricity was lost. Only those involved in catering in routinely austere environments (deployed military and off-shore) were confident that their own food service operations would be unaffected.

Moving back up the supply chains, some managers felt that their distribution centres and depots could survive for a limited time on generators, but the general feeling was that a widespread or prolonged power failure would soon bring the DCs to a stand-still. Even paper-based pick systems needed power to print instructions. One of the two largest distribution companies also confirmed that if the electricity supply was lost, the fuel pumps would be lost too. The food suppliers were all principally engaged in the import and/or preparation of chilled and frozen foodstuffs. Maintaining power to the cold stores was a priority. Production would grind to a halt. Like everyone else, the food suppliers' contingencies for were based on an assumption that power cuts would be localised, short-term events. Beyond that there was a misplaced belief that Government intervention, public sector clients or priority customer status would guarantee electricity supply and/or access to heavy duty generators. The expectations were very similar for disruptions to the supply of fuel for road transport.

The managers involved in this study reported very few problems associated with the 2000 fuel protests, other than staff in some areas experiencing difficulty getting to work or a drop in customer demand reported at county town hotel. However the industry profile as a whole had changed dramatically since 2000. The 'grab and go' food chains, contact catering and facilities management businesses had grown and developed significantly meaning direct comparisons could no longer be made. The grab and go retailers and fast-food restaurant chains assumed that their Just-in-Time supply chains would be maintained by their transport service suppliers' contingencies, or wrongly presumed that Government would somehow make fuel supplies available from national strategic reserve. On a more positive note, several companies, including catering and fast food chains reported that they were reducing their dependencies on conventional fuels and energy sources by running vehicles on recycled cooking fat and composting foods waste in green energy programmes.

The Ministry of Defence did have its own conventional fuel plans in place. The rest of the public sector organisations, their contract caterers and facilities management providers had no contingency plans because they too all presumed that the Government's priority user scheme would ensure supplies. The largest wholesale and distribution companies were holding limited fuel stocks, but they too looked to others for solutions, assuming that Government would guarantee supplies or customers' fuel stocks would be shared. Only the food producers and ready meals suppliers who used red diesel for other purposes or ran their own transport fleets actively had increased their stockholding of fuel in recent years. However their decisions were driven by rising fuel prices, rather than contingency planning. The stock holding costs were putting additional pressure on the margins of businesses already struggling to absorb rising food, fuel and energy prices.

2007-2008 had been difficult years for the industry as a whole. Managers in all of the organisations involved in this study reported exceptionally high incidences of supplier bankruptcies, including some long-established food production and supply companies. The remaining suppliers were refusing to enter into long-term supply arrangements and in some instances walking away from existing contracts unless terms were renegotiated. Successive shortages of foodstuffs and unfavourable exchange rates had all taken their toll. The staff shortages were exacerbated by changes in sterling/euro exchange rate prompting large numbers of Polish workers to return home.

Even the contract caterers' were feeling the pinch. Their high performing business models were designed to minimise financial risk, by minimising their fixed asset-base and working capital employed. They rely on takings from customers to pay and overdrafts to pay wages and supplier, as a result they are susceptible to cash flow problems, whether caused by late payment or rising costs and slowing demand. Loss-making contracts would render small companies bankrupt, larger ones are more likely to withdraw from loss-making contracts.

CONCLUSIONS, DISCUSSION AND FURTHER RESEARCH

The findings for this study of the food service sector revealed some similarities, but also some important differences in the contingency planning approaches in play across the supply chains.

From a single firm continuity management perspective, the food service sector is a relative late-comer to BCM, but starts from a higher base than its grocery industry counterparts.

BCM encourages a single firm focus but *** Intra-organisational, market or community-based contingencies were the norm ***but these only covered localised disruptions.

No proper provision for prolonged grid failures.

No adequate provision for fuel shortages.

**business models wobbly even before financial crisisi.

*BCM maturing**concur with Chatham House and BCI recent articles***

Further research ***BCI standard/best practice*

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SECTION 5 – Logistics, Planning and Control Models

TRUST AND CONTROL: DEFINING THE RIGHT LOGISTICAL MONITORING

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ABSTRACT
The operation of supply chains involves several firms in a shared process of value creation in the service of end-customers. A large number of academic works have now stressed the operational dimensions of logistical performance through the application of increasingly sophisticated management tools. Without questioning the pertinence of this type of approach, this paper wishes to indicate that an organizational perspective helps in understanding the operation of supply chains. Their efficiency is connected with the implementation of a climate of trust between partners, without excluding control. The issue of a balanced mix between trust and control is raised from an analysis of the literature and then from a quick application to VMI and CPFR.

INTRODUCTION
Supply chain management (SCM) is based on the building of relations between partners "who collectively convert a basic commodity (upstream) into a finished product (downstream) that is valued by end-customers" (Harrison and van Hoek, 2008:7). The literature on the management of supply chains states that efficiency and flexibility can be achieved only when partners fully trust one another. If trust cannot emerge, supply chain members find themselves in a situation of arm's-length relations where everyone's behavior will have to be strictly controlled so as to avoid opportunism from one or the other. This will increase costs significantly and engender major rigidities.

At the same time, another type of academic literature studying SCM tools has highlighted the numerous balanced scorecards and other control tools implemented along supply chains to pilot their operation. The approaches adopted by each type of literature may seem contradictory; common sense tends to consider that trust means doing without control and that control always expresses a degree of distrust. We would like to point out that this is not so, and that in the business world, trust and control are not incompatible but complement each other to improve logistical monitoring.

Inspired by the literature on interorganizational management, this paper tries to define the major modalities of the articulation between trust and control within buyer-seller relations in supply chains. It first defines the notions of trust and control in a way that stresses their complementarities. It then continues with an analysis of the positive, then the negative interactions that occur between trust and control, and points out that control does not disappear completely when trust reaches a very high level. Finally, examining the operation of VMI and CPFR in the light of these analyses, the paper concludes that supply chain members must learn to mix trust and control, including in collaborative practices where control now seems superfluous in the eyes of some observers.

COMPLEMENTARITY BETWEEN TRUST AND CONTROL
Trust is not a particular form of control. Trust is different in nature, as what makes it necessary are precisely the limits inherent to any control (Gambetta, 1988), the limits preserving the scope of freedom allowing a partner to default. Trust relies on a favorable anticipation of a partner's behavior based on an assessment of his capacities and motivations. Trust is manifested by the deliberate acceptation of a degree of vulnerability in relation with a partner whose behavior we think will be profitable to us although he retains his ability to act in his sole interest (Mayer *et al.*,

1995). A partner inspires trust when he shows himself competent, honest and benevolent, the last quality being indispensable for trust to improve. Trust develops progressively along with the steps in a relation (discovery, growth, maturity).

Establishing and reinforcing trust present significant advantages. Trust helps reducing transaction costs by avoiding the use of certain control processes associated with the assessment of the selected partner's profile beforehand and with the monitoring and assessment of his performances in a situation of information asymmetry later. Trust dispels the fears arising from a partner's possible opportunism –concealing data on the actual structure of his costs for example–, removes some inhibitions and helps to modify the division of labor by giving more autonomy to the partner and communicating sensitive information to him. This facilitates mutual adjustments, reinforces the flexibility of the buyer-seller dyad and increases the partner's creativity (Fenneteau and Naro, 2005).

Interorganizational control basically follows the same pattern as internal control within firms (Merchant, 1998). Control aims at influencing a partner so that his behaviors are consistent with the firm's objectives. Control must fulfill two complementary functions: (1) manage appropriation concerns by avoiding possible opportunistic behaviors, and (2) ensure the coordination of tasks (Dekker, 2004). Control relies mainly on contracts to supervise a partner's actions and on processes to monitor his performances or his behaviors (for example, balanced scorecards completed with corrective measures). Control may also be informal; in this case, it relies on the shared standards and references that develop within cross-organization teams.

Thus defined, trust and control appear complementary. They both help bringing a degree of safety to firms by giving them the assurance that partners will cooperate in a satisfactory manner. Das and Teng (1998), who were among the first authors to defend the theme of complementarity, call it *confidence*. They consider that this confidence is the result of the trust granted to the partner, whose motivations seem positive, and of the control the firm exercise over him. Control restricts the partner's freedom of action and directs his actions, and trust brings the conviction that the partner will not take unfair advantage of the latitude he enjoys.
Proportions may vary, but both elements must exist to guaranty a minimum efficiency: without any control, trust would be blind, and the efficiency of control would be limited if mistrust was the rule. Das and Teng (1998) stress that the same level of confidence may be achieved through different combinations of trust and control. They demonstrate that a firm wishing to benefit from greater confidence may either develop trust and control simultaneously, or privilege one of these elements.

The notion of complementarity between trust and control stresses the fact that both phenomena are always present at the same time, none of them completely superseding the other. It does not mean that trust and control always develop at the same time; it recognizes that they may also vary in the opposite direction, given certain circumstances, one taking the place of the other. Interactions between trust and control are complex and may be positive or negative depending on the context. The implementation of the right logistical monitoring first requires understanding both forms of interaction.

POSITIVE INTERACTIONS BETWEEN TRUST AND CONTROL

Positive interactions can explain how control can help in developing trust and inversely, how trust can make up the basis on which the forms of control reinforcing trust develop. Examining Tomkins's (2001) works, we can first consider that there is a positive relation between control and trust during the first stages of the relation. For trust to develop, the partner's actions must become predictable. This requires at first a monitoring of his results and behaviors. The information acquired from this monitoring gradually helps understand and anticipate the partner's action. When anticipations are positive, it becomes possible to have confidence in the partner, and trust develops.

This analysis is instructive, but does not take into account the power relationships maintained with the partner and does not reveal what makes him accept controls. When a partner is subjected to controls and remains distrustful because he considers he is being dominated, he shows reluctance and tends to keep information back. But controls are more efficient when trust is shared. Das and Teng (1998) show that trust has a positive moderating effect on the relation between control mechanisms and control level. Resorting to control mechanisms results in a more extensive control level when trust is strong than when trust is limited.

Woolthuis *et al.*'s (2005) research allows us to go further in the analysis of the positive effects of trust on control. These authors stress that contracts are not solely dedicated to the control of partners by reducing their latitude. They show that the meaning of contracts tends to change when they are drawn up in a context where partners have already succeeded in establishing a degree of mutual trust. In that case, contract designing is a process where partners learn to work together; they define the principles and the systems that will enable them to coordinate their actions by solving possible conflicts in a positive manner, and by facing together the possible disturbances in the business environment (Poppo and Zenger, 2002). Designed this way, contracts are signs of commitment; in agreeing to bind themselves by contract, both parties show their wish to commit themselves to a sustainable relationship.

Langfield-Smith and Smith (2003) combine those different approaches. Their analysis shows that positive interactions between trust and control can operate both ways. These authors studied the way various tools of formal control were developed within a buyer-seller relation, and pointed out that the outcomes of controls were accepted because they were introduced in a climate of mutual trust where each partner considered that the other was benevolent. The authors also show that the implementation of performance indicators favors the development of trust. This provides opportunities for exchanges that reinforce the partners' mutual knowledge. Each party may thus define their expectations in terms of performance and start a dialogue over these issues, by trying to find an agreement on the principles that must govern the sharing of the value obtained from collaborative practices.

Such analyses show that a virtuous circle, with positive interactions between trust and control, may gradually appear. They also define the conditions that must be combined for correct logistical monitoring taking advantage of these interactions. For us, the essential element seems to lie in the fact that controls are implemented as part of a dialog dispelling the fears of the weakest party, by proving to him that his partner is sufficiently benevolent to apply some limits to himself and see to not using his power in an unfair way (Dwyer *et al.*, 1987).

NEGATIVE INTERACTIONS BETWEEN TRUST AND CONTROL

There are also negative interactions between trust and control. When they occur, both elements tend to develop in opposite directions. Here too, several different views can be found. Das and Teng (1998) studied the question by rejecting the conventional approaches stating that the use of control mechanisms tends to sap trust in all circumstances and whatever their nature. They recommend the adoption of a contingent approach and establish a distinction between (1) formal control mechanisms, that have a negative impact on trust, and (2) informal social control, that tends to have the reverse effect. But the analyses above show that some formal controls developed in a climate of mutual trust can reinforce trust. It is therefore necessary to refine the contingent approach by identifying several forms of formal control and by including other explanatory factors.

Among the different forms of formal control, the control of behaviors (not of results) proves to be the least compatible with trust. The major effect of the trust given to a partner is in the extent of the autonomy it is granted. The formal control of behaviors is in contradiction with this autonomy. It can coexist with trust only when trust is at a very early stage; it is in fact incompatible with a high degree of trust. These different distinctions are useful, but they are insufficient for defining the negative interactions. Other paths have to be explored, particularly those stressing that the

intensity of control must be in proportion with the level of trust or mistrust specific to the relation, and those paths introducing the notion of threshold.
The intensity and dosing of formal controls applied to a partner are a significant explanatory factor. Vosselman and van der Meer-Kooistra (2009) distinguished two critical situations respectively characterized by a lack and an excess of control. In their analysis, the level of control becomes excessive when it over-compensates the legitimate mistrust coming from the framework in which the relation is established, particularly the institutional framework. Such an excess is considered as illegitimate by the partner subjected to it and this gives rise to negative reactions. What the partner feels as abusive pressure seems to him as a deviation from what should prevail within a partnership relation. As a consequence, he promotes his own self-interest to the detriment of cooperation. He is then suspected of opportunism and mutual trust tends to decrease. Excessive control does have a negative impact and weakens trust.

Tomkins (2001) also showed that the relation between control and trust reverses and becomes negative when trust exceeds a given threshold and reaches a relatively high level. Information acquired on the partner is then sufficient to trust him and reinforce cooperation, it is no longer necessary to try and get new information. It is even possible to limit supervision, as the firm members in relation with the partner have developed convictions on his reliability and these convictions no longer need be confirmed by a continuous flow of information. When this threshold is reached and exceeded, trust tends, at least partly, to take the place of control.

Dekker (2004) developed a similar analysis by stressing costs rather than the quantity of information required to assess the partner and to pilot the relation. This author reminds us that trust helps in reducing transaction costs and thinks that firms prefer this cheaper solution when a sufficient safety level is reached. The threshold varies, it depends on the nature of transactions and their inherent risks, but, whatever its level, when it is reached, firms tend to limit controls. Dekker (2004) went further and explained that trust has a negative moderating effect on the relation between control problems and use of control mechanisms. The need for control is translated by less monitoring among firms trusting their partners than among firms where trust is still being developed.

Additional lessons can be learned from the analysis of the negative interactions we suggest. The right logistical monitoring must take into account the fact that excessive control from a firm tends to be perceived by the partner experiencing it as a strong sign of distrust. It consequently generates negative effects weakening trust. In addition, one should not forget that trust development, beyond a given threshold, is accompanied by control reduction.

WHAT FORM OF CONTROL IN A SITUATION OF HIGH LEVEL OF TRUST?
Control does not disappear completely when trust becomes important. Some formal controls remain, others disappear and different, often informal, social control systems appear or develop. Whatever the form taken by the relation, it is always necessary to coordinate technical tasks and manage flows between partners. The development of trust and cooperation favors the implementation of shared routines and referentials that simplify exchanges. But some of the balanced scorecards and formal control tools implemented to pilot logistical operations or harmonize schedules remain useful even when trust reaches a high level.

Moreover, various informal controls resulting from the proximity established with partners tend to replace formal controls, such as audits, that are progressively abandoned or are scheduled less frequently, in a different spirit, with the desire to share experience. Trust favors further cooperation, and buyers and sellers now work together within cross-organization teams to perform some complex or strategic tasks. This leads each party to open the gates of their organization to the other more widely; the resulting transparency and increased information sharing highlight behaviors or resources that remained hidden and that formal controls could not detect. Control becomes more informal but still exists.

Reinforcing the trust granted to partners also leads to taking new risks by modifying the division of labor on which exchanges lie. To enable partners to take advantageous initiatives, firms may grant them further autonomy and delegate significant responsibilities (innovation piloting, development of working procedures used by all parties, etc.). Leifer and Mills (1996) studied this phenomenon in an intra-organizational context, but their analysis may be applied to relations between firms. It appears that the increased autonomy granted to a partner –although beneficial– is a loss of control reducing the safety level enjoyed by the firm.

When trust is strong but not unconditional, firms will at first try to maintain the achieved level of confidence with the implementation of new controls. These controls cannot involve the partners' behaviors, as that would be in contradiction with the desire to grant them more autonomy. They may focus on results, but this is difficult when the mission entrusted to partners consists in showing flexibility or creativity (performance ambiguity is then high). With these difficulties, the new controls are often applied to peripheral activities that reveal how far partners are willing to make efforts and conform to objectives defined by both parties. This may become particular attention given to the way partners agree to perform supplementary services or involve themselves in various social exchanges. The increase of trust goes together with the reinforcement of social relations and resulting informal controls.

In some cases, trust reaches an ultimate level where it becomes unconditional. There is no longer a direct supervision of partners and any new missions assigned are not associated with additional indirect control systems; but control does not disappear completely. Achrol (1997) showed that trust relies on an act of faith but together with the will not to be blind. For this author, when trust becomes unconditional, control tends to adopt the form of a self-regulated control based on standards promoting transparency, with spontaneous exchange of information on all the aspects of the relation. In brief, when trust is strong enough for some formal controls to be abandoned, the right logistical monitoring relies on a mix of trust and control; informal elements become more important, but trust and control never stop being complementary, including in collaborative approaches which seem like favoring trust only, like VMI and CPFR.

VMI AND CPFR: AN ORGANISATIONAL ILLUSTRATION

Vendor management inventory (VMI) is a logistical approach which, in a perspective of efficient consumer response (ECR), switches from a pushed flow, based on a more or less reliable forecast, to a flow pulled by the actual consumer demand. On a purely technical level, VMI "is a collaborative initiative where a downstream buyer shifts the ownership of inventories to its immediate upstream supplier and allows the supplier to access its demand information in return. In particular, a VMI process involves the following two steps: (1) a downstream buyer provides demand information to its immediate upstream supplier and leaves the stocking decisions to that supplier; and (2) the upstream supplier has the ownership of the inventories till the inventories are shipped to the buyer and bears the risk of demand uncertainty" (Yu *et al.*, 2009:274). For example, a large retailer forwards to his supplier all the information about products leaving stores, to enable the supplier to better schedule the large retailer's stock replenishing and, upstream of the supply chain, his own logistical activities.

An efficient implementation of VMI implies that the different players respect the rules favoring shared actions. A rigorous audit must first be conducted to formalize the architecture of both partners' supply chain, the number and location of their warehouses and platforms, and more generally their logistical facilities; as Duchessi and Chengalur-Smith (2008) note, this requires building strong trust through a cross-organizational management based on mixed teams. Then technical agreements for VMI operation must be clearly defined, together with the distribution of roles and the possible degree of freedom of each partner. The final delicate but indispensable step is to agree on the rules for sharing out gains and losses. For example, manufacturers and large retailers must state without ambiguity the amount of penalties in case of non-observance of the service rate. An *a posteriori* control is applied to check the service rate.

Since the implementation of the first VMI operations in the USA, then in Europe, it appears that this supply chain optimization approach meets with a fair level of enthusiasm linked with the generated financial and commercial advantages. The major advantages involve service rate and inventory levels. An improved knowledge of demand, through instant transmission of products leaving stores to manufacturers, increases reactivity with a stock-out rate becoming close to zero for convenience goods. At the same time and in the most spectacular instances, inventories in warehouses are reduced from 20 to 50%, thanks to a constant smoothing of product flows (Paché, 2005).

More recent in its applications than VMI, CPFR is an approach based on the principle of a single and shared forecast between manufacturers and large retailers. Its purpose is to obtain the maximum joint profit from the partnership, without weakening the competitive position of partners due to the confidential nature of the information exchanged. CPFR manages both offer and demand within the same transverse process inside a supply chain; on a technical level, it is an essential step for the emergence of collaborative logistics. This may be achieved only with a pluridisciplinary team made of representatives of the large retailer and the manufacturer, whose mission is to develop a shared business plan. CPFR includes a schedule of shared events (promotional operations) and concerted forecasts. This is the position of Langfield-Smith and Smith (2003) who stressed the importance of multiple mutual adjustments to improve supply chain monitoring.

Since CPFR operates on the basis of a single and shared forecast, built by the partners together, and "topped'' by a shared business plan, manufacturers and large retailers are automatically warned whenever their forecasts differ and in this case, they are invited to consult one another to formulate a shared forecast, guarantying the best management of logistical operations. One may conclude that CPFR is related to a data integration package aiming at improving interorganizational interfaces. Such a view is quite narrow as it underestimates the importance of absolute trust between partners, who do not hesitate a moment to divulge to third parties strategic information on their advertising-promotional plans. Formal control then tends to become superfluous as each firm has significant information on each of the other partners; they can trust one another by no longer applying permanent monitoring (Tomkins, 2001).

CONCLUSION

VMI and CPFR are difficult to implement because they require the conviction and will of top managers, who are sometimes little inclined to commit themselves to the building of cross-organizational teams threatening part of their autonomy. Decision makers' ulterior motives should not be neglected. The theory of organizations reminds us that the suspicion of opportunism remains permanent in business; each partner sees the other as a rational player looking after his own interests first, including by resorting to tricks or deception (Williamson, 1985). It is difficult to embark on ambitious collaborative practices (VMI and/or CPFR) before progressively building a good climate for cooperative relations. Beyond management tools, there remains a large field of investigation on organizational dimensions that allow collective projects to take shape and last in supply chains. Many factors have to be taken into account. One of them seems particularly decisive to us, the ability of supply chain members to define a judicious mix of trust and control to pilot exchanges.

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THE ROLE OF INTERMEDIATION IN ENHANCING THE FLEXIBILITY OF SUPPLY SYSTEMS

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ABSTRACT
The purpose of this paper is to critique and extend an existing risk/customer sensitivity model by assessing the role of mix and volume flexibility in increasing a supply system's risk alleviation capabilities and by considering the role of intermediaries in global supply networks. The paper introduces first a framework for supply systems flexibility and then a taxonomy that distinguishes between different supply sourcing strategies based on their flexibility requirements. Ultimately, the paper provides empirical evidence to highlight the fact that even though the existing supply chain management literature views intermediation as a barrier to supply chain transparency, intermediaries can have a beneficial effect in enhancing the flexibility of global supply systems and increasing their risk alleviation capabilities and customer sensitivity.

INTRODUCTION
As a result of the extensive use of outsourcing and the increasingly complex and global nature of today's supply chains, the likelihood of interruptions to product and information flows has increased significantly. As a result, identifying, mitigating and managing supply chain risk is now a critical requirement to ensure business continuity. One way in which external disturbances can be mitigated against is through the development of an appropriately resilient supply network strategy, which will allow businesses to take advantage of opportunities as they arise, while remaining in tune with their external environment. In the operations and supply chain management literature two main generic supply chain strategies are commonly referred to: 'lean' and 'agile', while a hybrid, 'leagile' strategy aims to reconcile the best of both worlds. As argued by Faisal et al. (2006), agile supply chains have greater risk alleviation and customer sensitivity characteristics than either mass production, lean or leagile systems. The purpose of this paper is to critique and extend the risk/customer sensitivity model of Faisal et al. (2007) by first developing a methodology through which the risk alleviation capability and customer sensitivity can be measured, and then considering the role of intermediaries/agents in achieving resilient global supply networks.

SUPPLY NETWORK FLEXIBILITY FOR LEAN, AGILE AND LEAGILE SYSTEMS
Generically, the flexibility of a supply system is 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 (Crowe, 1994; Morlok and Chang, 2004). Upton (1994), following Slack (1987), highlighted the fact that a system's flexibility is based on internal resources that can be used to achieve different types of internal flexibility (such as machine flexibility and routing flexibility), which in turn can support the system's ability to demonstrate external flexibility to its environment (such as 'mix flexibility', 'volume flexibility', 'product flexibility' and 'delivery flexibility'). In addition to these, Sanchez and Perez (2005) further define 'access flexibility' as the ability to provide extensive distribution coverage, facilitated by adequate coordination of internal and external downstream activities in the supply chain.

At a supply chain level, Tachizawa and Thomsen (2007) identified two main strategies that could be employed in order to increase the flexibility of a supply chain:

- Improved supplier responsiveness – the focus of this strategy is on the durability of relationships and the ability of a supply chain actor to support changes in product or service offering in response to changes in the business environment Gosain et al. (2005)
- *Sourcing Flexibility* – this practice involves the adoption of a large supplier base and constantly redesigning and reconfiguring the supply chain, known as adaptability (Easton and Rothschild, 1987).

As a result, the model developed by Purvis et al. (2008) highlights the fact that, at a network level, the external flexibility of a supply system (new product flexibility, volume flexibility, mix flexibility, delivery flexibility or access flexibility) will be determined by two internal sources of flexibility: the flexibility of individual nodes within the chain (*Vendor Flexibility*) and the ability of the focal firm to re-design (re-configure) and manage (coordinate) the supply chain (*Sourcing Flexibility*) (see Figure 1).

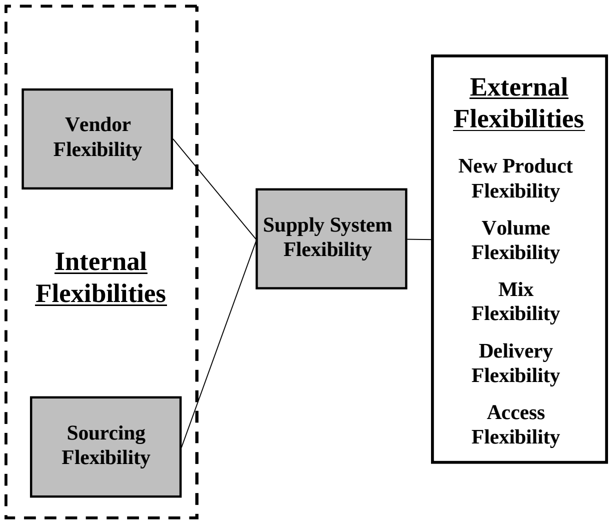

Figure 1. Supply Systems Flexibility Framework

Purvis et al. (2008) further highlighted the fact that a fundamental difference between lean, agile and leagile supply networks is that they have different requirements for different levels and types of flexibility. With a focus on mix and volume flexibility, the supply network taxonomy in Table 1 was proposed. The framework also introduced two different types of leagile pipelines: Leagile I, which uses agile vendors and lean sourcing strategies, and Leagile II, which uses lean vendors and lean sourcing strategies.

	Vendor Flexibility		Sourcing Flexibility	Supply System Strategy
	Mix Flexibility	Volume Flexibility		
Scenario A	Low	Low	Low	**LEAN**
	LEAN		LEAN	
Scenario B	High	High	Low	**TYPE I LEAGILE**
	AGILE		LEAN	
Scenario C	High	Low	High	**TYPE II LEAGILE**
	LEAN		AGILE	
Scenario D	High	High	Low	**AGILE**
	AGILE		AGILE	

Table 1. A lean, agile and leagile supply network taxonomy

The original model developed by Faisal et.al. (2006) did not offer a systematic approach to assess these two dimensions, neither did it consider different types of leagility that could be identified in practice. This paper will fill these gaps. The paper also discusses the role of sourcing agents in increasing the risk alleviation capabilities of supply networks.

METHOD

Using Purvis et al. (2008)'s supply network taxonomy, this present paper revisits the framework developed by Faisal et. al. (2006), which proposed that suitable supply chain strategies can be selected based on their customer sensitivity and risk alleviation competency. A case study research approach was chosen as the main research strategy. The supply chain of focus is a UK fashion retail chain. The retailer provides a broad line of products aimed at the 16 to 35 years old market, with various shelf lives, ranging from 2 weeks up till 12 to 18 months. These products are served by various parallel supply pipelines and are sourced both from the UK and abroad.

CASE STUDIES

Scenario A: Lean Vendor and Lean Sourcing Pipeline (Lean System)

The retailer's low fashion, 'functional' range had a long life cycle (ranging from one to three years) and very predictable demand. The design alterations were rare from one season to another. They were selling in large volumes, with small unit profit margins. This enabled sourcing to be committed up to one year in advance, and the search for low labour costs meant that global suppliers were always used, mostly located in the Far East, where close proximity among garment manufacturers, fabric suppliers and logistics providers was also an advantage. The high volumes and stable, predictable nature of demand, with long product life cycles, enabled economies of scale and this could facilitate the development of stable and ongoing partnerships.

This network exhibits the characteristics of lean supply systems (see Table 1). It requires low Vendor Flexibility, due to the low demand for variability in production (low volume flexibility) and low demand for variety of products (low mix flexibility). At the same time, the formation of long term partnerships agreements between supply chain partners renders Sourcing Flexibility to be low.

Scenario B: Agile Vendor and Lean Sourcing Pipeline (Type I Leagile System)

The retailer's 'knits' range was offered in lower volumes per stock-keeping-unit (SKU) due to demand for these products being variable in terms of the amount of the basic model that will need to be customised (volume flexibility). These products' life cycle would average 6 months, or one season, after which the line would be discontinued and any left-over stock would be marked down, incurring significant losses. These could be technically complex products which, in an effort to minimise waste and increase the design content, were woven in one piece by a UK based, capital intensive garment manufacturer. Demand for these products was continually monitored and daily analysis of point-of-sale data allowed the retailer to identify quickly changes in demand pattern. To minimise the risk of obsolescence, frequent orders would be placed and small volume frequent deliveries would be expected. This required a high level of volume and mix flexibility from their garment supplier.

In this type of network, the typical buyer-supplier relationship that is too often motivated by opportunism in the fashion industry (Fernie and Azuma, 2004) had transformed into a more collaborative partnership, where the retailer's objective was to develop the customer's business. The benefit to the vendor was the fact that they were treated as a preferred supplier. Cost benefits were being achieved through greater sharing of information and integrated logistics systems. Based on Table 1, this network is a Type I Leagile Supply System, in which agile vendors (characterised by high volume and high mix flexibility) and low sourcing flexibility are combined to achieve an adequate response to the market place.

Scenario C: Lean Vendor and Agile Sourcing Pipeline (Type II Leagile System)

The sourcing model for knitted garments illustrated above was, however, applied to a very small part of the retailer's product range, as knits accounted for just under 10% of its total annual stock-keeping-units. The remainder of the non-basic range was mainly made up of woven products, the manufacturing of which was a much more labour intensive process. A decision on the raw material (fabric) used for these products was made six months before each season would be due to start, once information from designers, fashion shows and trend annalists would be gathered. The six month design cycle was dictated by the long lead times imposed by the fabric suppliers.

With an increasing number of new products introduced each season and reduced volumes per stock-keeping-unit, the pool of skills required by the retailer for clothing manufacturing was becoming increasingly complex, requiring a larger network of suppliers every season. And due to the large local labour costs, combined with reduced local capacity availability, the supply networks used were almost exclusively global in nature. The suppliers used were characterised by high labour intensity, small average plant size and relatively unsophisticated technology used.

In order to reduce the complexities associated with global sourcing and due to the continuous need to restructure the supply network, we found that the common norm for sourcing these items was to make use of third party indirect sourcing import/export agents, so called intermediaries (Masson et al., 2007). Many of these were agents in the broadest sense, with no manufacturing, logistic resources or assets, but with a wide knowledge of the local supplier base. If and when the retailer's initial market trial seemed to indicate a market existed, the order for the new product in the relatively small quantities would be placed with the intermediary. The intermediary would then organise competitive auctions for garment manufacturing. However, the final design of the product would not be decided on till much closer to the season, which meant that the retailer had positioned the fabric and pre-booked capacity with the garment manufacturers, but still allowed for a high level of customisation in terms of the number of different product combinations (high mix flexibility). At the same time, due to long delivery times incurred mainly due to the employment of sea transportation, and in an effort to cut down costs, large volumes of one-off deliveries would be placed, which meant that the level of volume flexibility required from the garment manufacturers was low.

In these networks, establishing long-term partnerships with a small number of more flexible suppliers was perceived as likely to reduce the retailer's market-orientation capabilities to flexibly and responsively cater for a diverse, fast moving fashion market. It was, indeed, to risky to trade off the variety with a streamlined (lean) yet less flexible supply chain (Fernie and Azuma, 2004). These networks have been categorised as Type II Leagile Supply Systems (see Table 1). In these systems, lean suppliers, characterised by low levels of volume flexibility and high levels of mix flexibility (Naylor et al., 1999), and a high level of sourcing flexibility have been employed.

Scenario D: Agile Vendor and Agile Sourcing Pipeline (Agile System)
The retailer's seasonal product range offer would also have to allow for new product introductions designed as a response to shifts in popular culture, expected to occur anytime from anywhere and creating significant demand for a fashion style or trend. For these 'high fashion' items with very short shelf lives (averaging 3 to 6 weeks), forecasts were impossible to be made. As a result, the retailer had to be extremely agile in capturing emerging trends, designing new products once the new season has already started and quickly bringing them to the market. Even for these items, with a much shorter shelf life, the retailers preferred global sourcing to local producers. Some of the reasons for this were the lack of skilled manufacturers in the UK, the reduced local availability of fabrics and trims, high labour prices and very limited capacity still available. Eastern Europe and North Africa were the preferred sources of supply for these items, mainly due to their proximity to the UK market and hence short delivery lead times.

To minimise the risk of obsolescence, small volume deliveries were required on a frequent basis and this required high levels of both volume and mix flexibility from the manufacturer. The same sourcing practice of auctioning out production through trade intermediaries was used, allowing for quick redesign of the supply chain on an ad-hoc basis. The intermediaries' strategy of not owning any production facilities kept the supply chain flexible and adaptable, encouraging the constant search for flexible, quality-conscious and cost-effective producers. We categorise these pipelines as Agile Supply Systems, in which agile vendors (characterised by high volume and high mix flexibility) and high sourcing flexibility are combined to achieve a quick response to the market place.

RISK ALLEVIATION CAPABILITIES OF LEAN, AGILE AND LEAGILE SYSTEMS

The case studies presented above highlighted the fact that each pipeline exhibited different levels of customer sensitivity, with agile systems being able to bring a new product to the market place in 2 to 3 weeks, while the two types of leagile systems were able to deliver a new product to the market within an average of 6 months. Finally, the lean systems were the least responsive, taking an average one year to design, source and deliver a new product to the customer. Their ability to cope with demand uncertainty and hence alleviate risk, also varied. Lean systems were unable to cope with either mix or volume flexibility, hence their risk alleviation capability was perceived as low. Leagile II systems could cope with mix flexibility but not with volume flexibility, and as a result have been rated as exhibiting a medium risk alleviation capability while the Leagile I and Agile systems could cope with both mix and volume flexibility, and exhibited high risk alleviation capabilities, but within different time constraints. As a result, the framework presented in Table 2 shows how the level of Customer Sensitivity and Risk Alleviation Capabilities of the pipelines identified could be used to distinguish between Lean, Agile and Leagile Systems.

<table>
<tr><th rowspan="2">Pipeline Type</th><th colspan="2">Risk Alleviation Capabilities</th><th rowspan="2">Customer Sensitivity (Responsiveness)</th></tr>
<tr><th>Mix Flexibility</th><th>Volume Flexibility</th></tr>
<tr><td rowspan="2">Lean</td><td>Low</td><td>Low</td><td rowspan="2">LOW
(12 -18 months)</td></tr>
<tr><td colspan="2">LOW</td></tr>
<tr><td rowspan="2">Leagile I</td><td>High</td><td>High</td><td rowspan="2">MEDIUM
(6 months)</td></tr>
<tr><td colspan="2">HIGH</td></tr>
<tr><td rowspan="2">Leagile II</td><td>High</td><td>Low</td><td rowspan="2">MEDIUM
(6 months)</td></tr>
<tr><td colspan="2">MEDIUM</td></tr>
<tr><td rowspan="2">Agile</td><td>High</td><td>High</td><td rowspan="2">HIGH
(3- 4 weeks)</td></tr>
<tr><td colspan="2">HIGH</td></tr>
</table>

Table 2. Risk Alleviation and Customer Sensitivity Capabilities

This can be been further illustrated in the model presented in Figure 2, which could be used as a guideline for the selection of a suitable supply system strategy based on the risk alleviation capability and customer sensitivity dimensions.

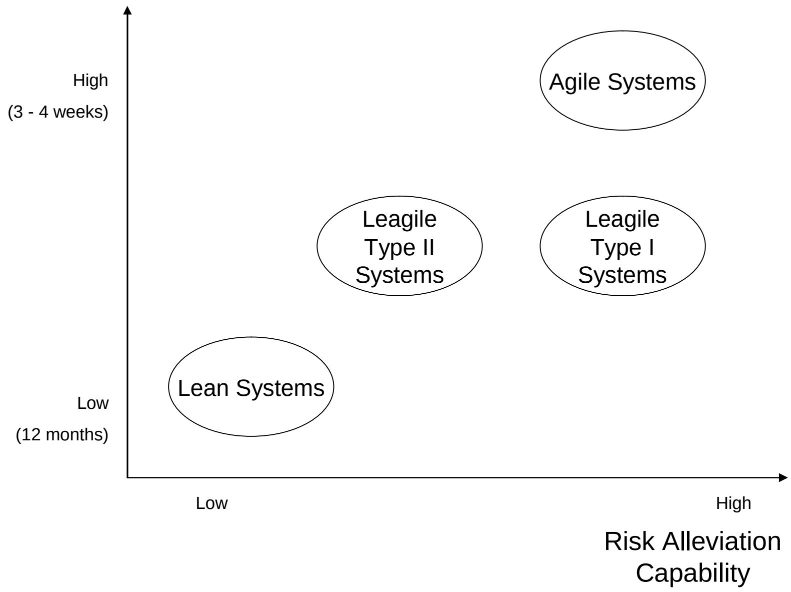

Figure 2. Mapping supply strategies on customer sensitivity and risk alleviation capabilities dimensions (adapted from Faisal et al., 2007)

THE ROLE OF SUPPLY CHAIN INTERMEDIARIES IN GLOBAL PIPELINES

Previous sections have highlighted the fact that, as demand for frequent new product introductions grows, the levels of responsiveness that companies operating in highly volatile environments need to exhibit needs to grow too. Furthermore, in an environment of global complexity, the importance of supply chain flexibility is even greater. Previous studies, such as the one conducted by Forrester Research in 2002, indicated that in global supply chains higher degrees of inflexibility can be expected, mainly generated by a firm's inability to transfer production from one plant to another and its inability to successfully respond when capacity is constrained. The study's authors stated that global manufacturers must be able to respond to "dynamic trade" which is defined as "the ability to satisfy current demand with customized response." Dynamic capacity includes the ability to add or reduce capacity at an existing facility, add or eliminate facilities, or source additional capacity at very short notice.

However, the case study findings presented in this paper revealed that in global networks that require high levels of customer sensitivity, retailers in the fashion supply chains strive to limit interdependence and retain the ability to easily switch partners in order to increase their responsiveness, allowing greater organizational flexibility. This flexibility will result in a more intensive capacity utilization resulted from industry-wide sharing, higher risk alleviation capabilities and higher levels of customer sensitivity.

The fashion retailer under study had previously taken a high-level decision to source a large proportion of its products from overseas suppliers in order to cut down costs and access a wider pool of manufacturing capabilities. For the retailer, the issue was not to carry out a thorough make-or-buy risk analysis in order to decide whether to outsource globally or not. Rather, it was to understand how to make the best of global sourcing in a very volatile market. As a result, a pool of global intermediaries was used, which enabled the retailer to interface with the market with a higher level of responsiveness and increased risk alleviation capabilities, factors which are now critical in a market subject to fluctuations in fashion. As a result, the level of complexity that the retailers had to manage in their supply networks was also hugely reduced, while fewer mark-downs and stock-outs were being achieved, and this ensured that gross margins were maintained and customer satisfaction was increased.

The sourcing flexibility of the supply pipelines employed was also highly enhanced, which increased the level of flexibility that these supply systems were ultimately able to exhibit. This was mainly done, as shown above, through sourcing capacity when and where required. For the intermediaries employed to be price and lead time competitive to support agile supply, the small, one off batches required by the retailers were auctioned in a traditional, and adversarial manner across those in the supplier network with capacity and capability to meet the requirements.

To enable a quick response to rapid changes in market trends through global sourcing, fashion retailers needed suppliers with the capability to manufacture the product required, but who were also able to provide the logistical know-how to find all the parts needed for the finished product and then deliver the finished product to the UK. Thus, they required more advanced full-package companies (intermediaries) who, in turn, may subcontract out these orders to other local firms. They would most frequently be involved in the product development process, purchase fabric and trims for their overseas contractors and participate in the quality control inspections for finished goods.

The product development process, for example, was the point at which the retailer would be able to address a number of factors, such as the choice of fabrics and trims, flexibility of delivery system required in order to match consumer demands, the size of batches to be processed to reduce risks, ways of bringing design and colouring decisions closer to the point of sale, ways of reducing the total cost impact of product development. The most time efficient method encountered in addressing these issues was through the employment of sourcing intermediaries. They would offer the fashion retailer assistance in bringing people with different areas of expertise together, including representatives from the retailer, the clothing manufacturer, the textile supplier, the dyer/printer and the yarn and fibre manufacturers. They would also source raw materials on behalf of the retailer and arrange delivery to the retailer's UK based distribution centres.

From the four types of pipelines employed by the retailer under study, intermediaries were used in Leagile II and Agile type pipelines, which were global in nature and required high levels of risk alleviation capabilities and a medium to high level of customer sensitivity. However, for Lean and Leagile I pipelines the use of agents was not required, mainly due to the low levels of sourcing flexibility which these networks needed to exhibit. The lean pipelines were global in nature and required low levels of customer sensitivity, and in an effort to reduce costs through economies of scale, strong partnerships were employed, rendering sourcing flexibility to be low. Leagile I pipelines employed the use of UK based capital intensive suppliers with which the retailer interviewed had built strong long term relationships, and as a result also required low levels of sourcing flexibility.

CONCLUSIONS

This paper shows that the global, flexible and responsive supply chain is not a myth or an unattainable goal anymore. Instead, it is becoming a necessity as customers become more demanding in terms of both service and cost. This has led to the retailers adopting several strategic responses that ultimately altered the content and scope of their global sourcing networks: they discontinued certain support functions and reassigned them to contractors. They were instructing the contractors where to obtain needed components, thus reducing their own purchase activities and reducing the complexity of activities that required direct management. They were shrinking their first tier supply base, mainly through using fewer but more capable contractors. In essence, fashion retailers recognised that overseas contractors have the capability to manage all aspects of the production and delivery process when high levels of responsiveness were required. This, however, also restricted their competitive edge, which was now focused towards the management of activities further down the supply chain.

Even though there has been a large amount of research on the topic of flexibility, the majority of it has been centred on manufacturing flexibility. What recent research has been done on supply chain flexibility has very much taken a static strategic perspective and ignored the implications that global sourcing can have on the management of these networks. Our paper extends the existing knowledge of supply chain flexibility. The paper suggests that the supply systems strategies identified can be differentiated based on their risk alleviation capabilities and the level of customer sensitivity they each exhibit. Ultimately, the paper provides empirical evidence to highlight the fact that even though the existing supply chain management literature views intermediation as a barrier to supply chain transparency, the role of supply intermediaries in enhancing the flexibility of global supply systems is paramount.

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A FLEXIBLE COMMUNICATION CONCEPT FOR INTEGRATED SUPPLY CHAIN PLANNING CONCERNING ASPECTS OF TRUST

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ABSTRACT

The purpose of this paper is to discuss the requirements for inter-company communication in co-operative supply chains concerning aspects of trust. The way trust building processes between supply chain partners are supported by implementing appropriate components of information and communication technologies (ICT) is analysed. Existing ICT concepts, such as information encapsulation, information encryption, user authentication and other authorisation techniques suitable for coupling heterogeneous systems are reviewed and evaluated. Finally, the question of whether using innovative ICT for data exchange purposes can affect the trust building process is raised.

The prototype presented here is based on the premises of a trusting co-operation between two supply chain partners: a manufacturing company and a third party logistics provider.

INTRODUCTION

Globalisation of production processes, accompanied by increasing competition as regards costs and service, is forcing companies to improve efficiency (Nooteboom 1997, pp. 308). Process costs and quality, lead times and service levels are key performance indicators measuring the operating success of not only individual companies' supply chain, but also supply chains in general. Supply chain management software, consisting of collaborative interaction tools, helps companies' endeavours to match supply with demand. The use of innovative ERP systems and their add-on components allows companies to advance successfully while enabling effective and efficient supply chain planning and controlling.

The *European e-Business Report 2008* ascertains that, depending on the specific business segment (steel, furniture, as well as chemicals, rubber, plastics), 70 to 80% of large (with upwards of 250 employees) manufacturing companies surveyed use ERP systems. The proportion in large retail and transport businesses is only half that. By comparison, the penetration rate in small and mid-sized companies is significantly lower (Selhofer et al., 2008, p. 27). Common ICT technologies for interaction and data exchange are proprietary standards, EDI, XML-based standards and Web Services. The family of EDI-based standards is, according to the study from 2007 (Selhofer et al. 2006, pp. 47), still one of the most commonly used standards for electronic data exchange. Regarding the use of these techniques, the *European e-Business Report 2008* shows that only about 50% of the large companies use EDI concepts. The corresponding value for mid-sized companies is approximately 30% (Selhofer et al. 2008, p. 77). It could be stated that there is significant room for improvement regarding both the usage of ERP systems and the interaction techniques.

Analysing the reasons for this situation the following obstacles can be identified: high costs of investment and the lack of experience and expertise in using these technologies, and also trust issues regarding information sharing in the supplier-customer relationship. This paper focuses on this aspect of data exchange processes and technologies.
Trust and confidentiality can be considered as key factors for the functioning of competitive supply chain co-operation (Li/Zhang et al. 2008). In this paper *trust* is defined as a willingness to rely on a partner in whom one has confidence, for exchange purposes (Moorman et al. 1993, p. 82, Moberg et al. 2002, p. 759). Existing information sharing and ICT concepts for coupling heterogeneous systems are reviewed and evaluated based on trust. A model of how ICT is suitable for supporting and/or enabling supply chain management across companies is presented in Figure 1, and a prototype composition model is presented in Figure 2.

EXISTING WORK

Christopher identifies co-operation and trust as main constituents within supply chain relationships (Christopher 1998, pp. 18). A review of different supply chain co-operation studies is given by e.g. Kaipia (Kaipia 2007, pp. 15). An important prerequisite for the successful launching and operation of co-operation models are information sharing concepts (Li/Zhang 2008, Li/Wang 2008). These can be differentiated into two classes: upstream, and downstream information sharing concepts (Kaipia 2007, pp. 27).

Process optimisation within and among companies, alongside outsourcing and other concepts, has become an urgent matter. A trend towards inclusion and collaboration instead of so-called arm's-length agreements has been identified between suppliers and customers, resulting in an ongoing development towards information sharing. Different types of B2B applications for data exchange are being used, e.g. proprietary standards, EDI, XML-based EDI standards, Web Services (Robson 1994, Lithicum 2000, Alonso 2004, Chappell/Hendrickson 2004, Yee 2008).

These innovative opportunities for working together present new challenges. The division of work within partnerships requires a collaboration of trust, which is a major success factor. A position of intentional vulnerability is accepted, matched by positive expectations of the intentions of another (Rousseau 1996, pp. 395). Trust is seen as "capital", which increases in value by use (Coleman 1990, p. 302). Factors affecting trust, such as a company's reputation, asset specificity or technical assistance, are versatile (Dan et al 2006, pp. 2267). There are various methods which can be employed to deal with the evaluation and selection of qualified business partners according to aspects of trust (Laaksonen/Kulmala 2006, Camarinha-Mato/Afsarmanesh 2008).

Using ICT for data exchange purposes means supporting co-operation processes across companies. The objective is to find appropriate solutions, designed according to different requirements, e.g. flexibility, future trustworthiness and cost efficiency. This paper now raises and discusses the following question:

Can improvements in ICT also have an impact on trust building within co-operations?
The model of understanding presented describes an indirect way of influencing trusting co-operation, achieved by transparency, correctness and value of data exchanged through the appropriate use of ICT.

RESEARCH APPROACH AND METHODOLOGY

As shown, the need for businesses to co-operate, the ability to share information using technology to connect businesses, and trust between the business partners are contentious issues. The question remaining is whether, and how, ICT influence a trust-based relationship.

Concentrating on different levels of trust, we adopt the model introduced by Rousseau et al., (Rousseau et al. 1998, p. 401) as shown in Figure 1. Within the framework, a distinction is drawn between calculus-based, relational, and institutional trust. The first is based on rational choice – characteristic of interactions based upon economic exchange. To facilitate this, credible information about the trustee may be provided by others. Relational trust derives from repeated personal interactions over time between truster and trustee. Institutional trust is a control mechanism, or a form of trust support given by laws or contracts (Rousseau et al. 1998, pp. 398).

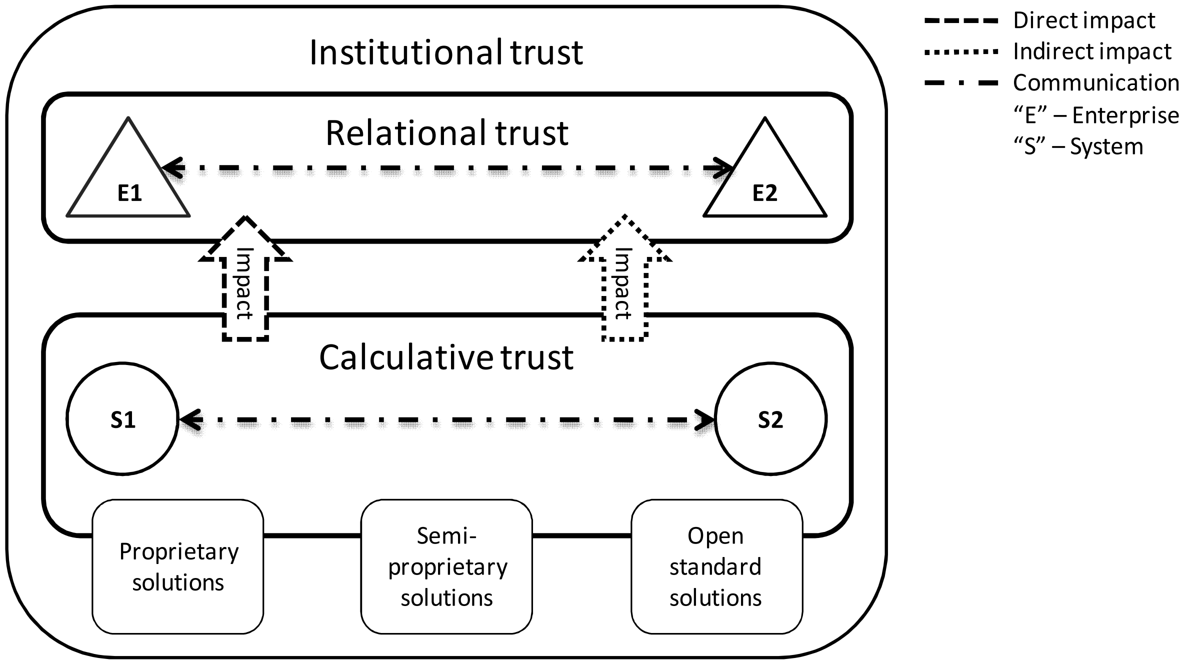

Figure 1: flexible, trust-based communication concept

Auditioning the trustee can increase trustworthiness in a relationship. Information sharing can be classified as a part of calculative trust: In this case the trustee may have to prove confidentiality in any information sharing. Assuming that information sharing influences trustworthiness, the aim of the next steps would be to discuss whether any impact is direct or indirect, what the estimated implications are, and which software solution provides the best assistance in different situations and kinds of co-operation.

The following functions should be included into any supply chain system in order to improve trust relationships:

- Logging, evaluation and rating of providing services in order to define estimation functions for trust. The estimation functions depend on the type of cooperation and exchanged application data (e.g. punctuality of responses, correctness and quality of data).
- User authentication and authorisation in order to provide traceability of user actions.
- Means to provide confidentiality of data in order to avoid misuse by third parties.

In order to realise a flexible concept, the solution developed considers different kinds of software implementations. Proprietary, semi proprietary and open source solutions can be itemised as follows:

- Proprietary solutions: In-house solutions, where the rights belong to a single software producer. Typically, there are no source code insights and very restricted possibilities for personal adjustments. For instance, SAP uses SAP Intermediate Documents (IDocs) for data exchange between systems.
- Semi proprietary solutions: Open standard solution, which is enhanced with special functions from a single software producer. Typically, there is insight into the source

code possible, as well as personal implementation. The HTML (Hyper Text Markup Language) standard is enhanced by different software companies. Microsoft in particular, with its earlier versions of the Internet Explorer (IE), implemented additional features.

- Open source solutions: Open standard solution, which is not enhanced by special functions. The source code is discretionary. Typically, pervasive adoptions are controlled by an open interest board. The United Nations Electronic Data Interchange For Administration, Commerce and Transport (UN/EDIFACT) standard, for example, is hosted by the United Nations. The SOAP standard, used for data interchange between Web Services, is hosted by the World Wide Web Consortium (W3C).
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First experience of application of the considered functions for trust improvement on proprietary, semi-proprietary and open source implementations shows that open source based XML-based solutions are very well suited for trust building, far better than proprietary or semi-proprietary implementations. This is due to XML standards (issued by the W3C) and tools for

- XML query languages (XQuery, XPath) which eases the extraction of data for trust estimation functions,
- XML signature that permits exact user authentication, and
- XML encryption for privacy of data and to keep information confidential.

PROTOTYPE

Testing different solutions requires implementation of a prototype with different settings, accounting for the diversity of trust aspects. Figure 2 shows the implementation of co-operation between a manufacturer and a logistics service provider.

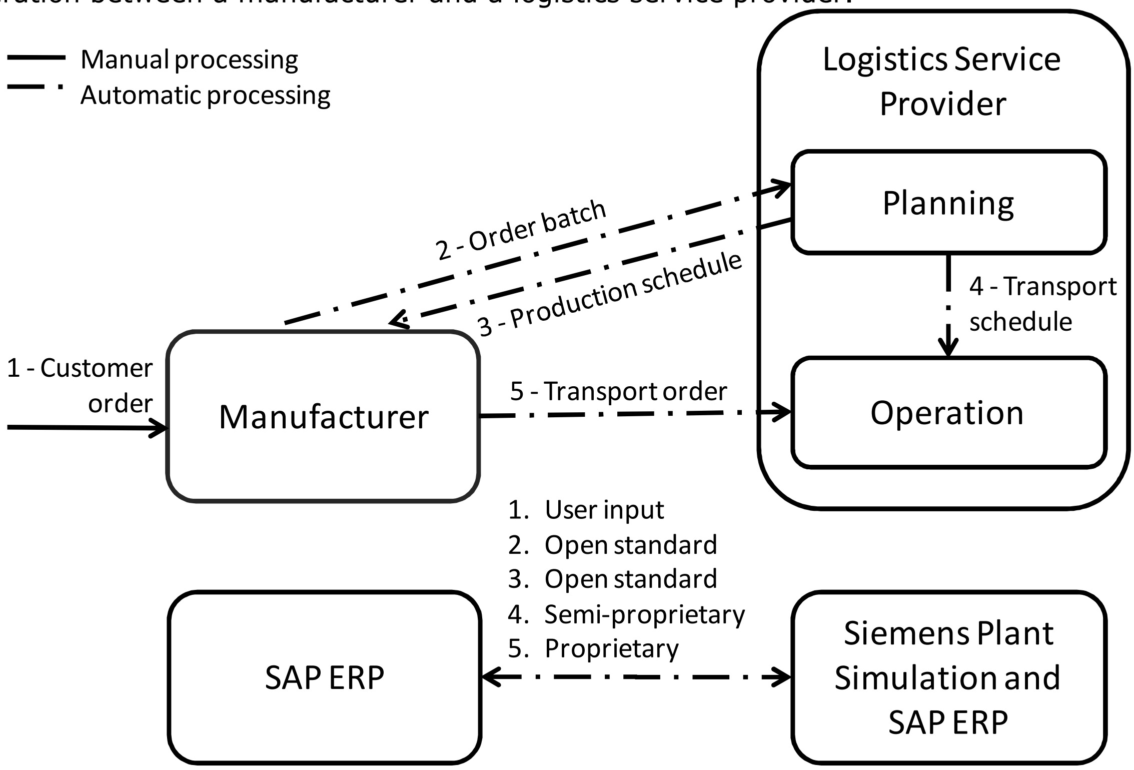

Figure 2: prototype

Depending on the level of trust, and the number of available alternatives, Laaksonen and Kulmala (Laaksonen and Kulmala 2006, p. 192) developed a framework to determine what kind of cooperation is workable. Depicted in the above scenario is strategic co-operation, based on a high trust factor with few alternatives. Communication inside the logistics service provider, from scheduling to transport, is based on a low need for trust.

Whether, and to what extent, software solutions support techniques such as the application of information encapsulation, information encryption, user authentication, and authorisation concepts will now be explored. After that, the direct or indirect effect on the trustworthiness among business partners will be looked at. Finally, we will answer the question of whether and how the software solutions offer useful implementation concerning the influencing factors and their impacts on trust. Putting the research into practice will result in a rating of these solutions in supporting or building trust.

As a first step, implementation of trust-based communication with different technologies is realised. Figure 2 shows the solutions for the different steps:

- User input (step 1): Customer orders are entered manually. Trust factors for this procedure are not considered.
- Open standard solution for steps 2 and 3: Based on a Web Service communication with SOAP, the focus is on on Web Service standards such as Web Service Security.
- Semi proprietary solution for step 4: Internal communication is based on a self-adopted XML communication protocol.
- Proprietary solution for step 5: The native communication capabilities of the SAP ERP-system will be used.

CONCLUSION

According to the EU Report on e-Business, further room for enhancements regarding interaction processes and technologies between companies can be identified. In particular, this concerns small and medium-sized companies, but for large companies a significant demand can also be stated. A key requirement is trust between business partners for impeccable data exchange between companies. Target-oriented investments in appropriate ICT are able to achieve improvements in terms of cost, time and quality of the considered supply chain organization, leading to successful business. Future research activities will target the analysis of causal relationships between ICT and trust factors. The objective is to design a framework to select the appropriate concept and technology, focusing on the requirements concerning flexibility, costs and trust.

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AGENT BASED SUPPLY CHAIN RISK MANAGEMENT: A CONCEPTUAL FRAMEWORK

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ABSTRACT:
The area of supply chain management has attracted the interest of organizations over the past twenty years. However, the uncertainty that exists in both the demand and supply of resources (especially in economic downturns) is recognized as a limiting factor in achieving its objective for coordinated supply chains. In this respect, modern decision support systems incorporate the management of disruptions along the supply chain. In this paper, an agent based framework it is proposed to manage disruptions in manufacturing supply chains. The framework is an adaptation of a framework suggested by Bansal et *al.* (2005) for refinery supply chains, to the reality of manufacturing supply chains.

Keywords: supply chain management, disruption management, multi agent technology, uncertainty

INTRODUCTION

In recent years, companies have shifted from a regime of mass production to one of mass customization of products. As a consequence, they strive to achieve the ideal objective of "*one unique product per customer*" (Zerenler and Özilhan, 2007). A new epoch of competition has emerged characterized by the shortening of product life cycles and the consolidation of both manufacturing and supply chain complexity (Christopher and Lee, 2004). In the current business environment, many successful global organizations have aligned to a collaborative concept of cooperation, seeking to achieve through a high level of supply chain complexity, an analogically high level of supply chain agility (Christopher and Towill, 2000).

However, a wide range of risks along the supply chain operate as a limiting factor for their global operations, imposing negative implications upon their overall level of performance (Wilding 1998). As a result there is an increasing need of organizations to manage risks and disruptions so as to achieve a high level of agility, that directly corresponds to a higher level of organizational performance (Christopher and Towill, 2000a).

The concept of collaboration among business partners in supply chains is vital to achieve responsiveness, agility and to offer a high customer service level. The use of Information and Communication Technology tools is perceived as a paramount facilitator for the realization of this collaborative perception, offering the capabilities of information sharing, customer sensitivity and process integration. Conventional Information Technology however has proved to be a limiting factor to the fruitfulness of this collaborative concept, due to the fact that it does lacks real-time adaptability in supply chains and it focuses on dyadic contexts of collaboration rather than collaboration amongst a plethora of partners.

Multi-Agent modelling (a sub category of Artificial intelligence) is considered as a promising alternative decision making tool for the design and synchronisation of supply chains (Stone and Veloso, 2000). Multi-agent systems (MAS) can demonstrate efficiently the proactive and autonomous behaviour of the participating agents in mitigating risks and rectifying supply chain disruptions in real time (Im et *al.*2007, Lu and Wang, 2007) and can promote high level of cross organizational collaboration under a computational and cost efficient manner (Bansal et *al.* 2005).

In this paper, it is proposed an agent based framework in order to promote collaborative disruption risk management under the reality of a manufacturing supply chain.

In this paper a multi-agent based framework for SCM is developed, to accommodate high level of cross organizational collaboration in response to the needs of agile supply chains. The framework supports the fulfilment of production, event and disruption risk management constituted by coordination, communication and task agents.

The findings from this exploratory research are two-fold. Firstly, the experts have identified that the framework incorporates innovative elements especially at the part that concerns disruption risk management process which could be used as a "learning tool" by organizations to identify the level of responsiveness of their supply chain to different types of risks. Secondly, the panel of experts pinpointed that the most important limitation of the proposed framework is its theoretical and generic character, mainly owned to the lack of thorough empirical research under the reality of a single supply chain.

LITERATURE REVIEW

In the current economic and business conditions disruption and risk management strategies are increasingly important for businesses. However, one of the most important drawbacks within in the literature is the absence of a formalized methodology in mitigating those disruptions (Bansal et *al.*, 2005). Several authors have proposed disruption management strategies. Chopra and Shodhi (2004) for example highlight mitigation strategies for different types of risks which manufacturing organizations apply to deal with uncertainty. They identify drivers for a wide variety of different risks and pinpoint alternative proactive mitigation strategies for each corresponding risk. Other researchers have focused specifically on information systems risks. Kleindorfer and Saad (2005) underline the importance of collaborative information sharing as the vehicle to shed light upon vulnerabilities within the supply chain, to manage disruptions under a cost efficient manner and to devise strategies for their effective control in a crisis situation. Moreover, the assessment as the quantification of the risk have been identified as critical factors in order the level of the risk to be understood, initiating correspondingly the proper countermeasures.

Im et *al.* (2007), proposed an agent based framework called MACE-SCM that utilizes case based reasoning (past decisions cases can be utilized as instances for current decision making) in order to deal with uncertainty, which through the use of an experimental design it was proved that can successfully deal with supply and demand uncertainty. Bansal et *al.* (2005) provided a generalized collaborative framework for disruption management oriented to the reality of refinery supply chains. In this paper, their approach is adapted in order to develop a framework under the reality of manufacturing supply chains. The framework has been enriched with case based reasoning in order learning capability to be enabled, taking into consideration integration issues so as to be used as an add-on module to legacy systems.

FRAMEWORK FOR DISRUPTION MANAGEMENT SYSTEM

The proposed framework has the capability to proactively mitigate a series of risks in operational and tactical levels, as to propose and execute rectification strategies for disruptive situations. In particular, the framework can manage: a) risks that can harm a specific order, where monitoring agent informs disruption manager for an abnormal event and then a collaborative mitigation process begins, b) disruptive situations that can imposed a significant delay of the final product to the ultimate consumer. The whole disruption management agent is constituted by five agents:

Communication agent: it is responsible for the inter-organizational agent communication among partners. For instance, a logistic service provider and a manufacturer can communicate through the facilitation of this agent.

Coordination agent: it has the responsibility to coordinate the agents within the limits of an organization. In addition, it gives a feedback to the learning module of disruption manager concerning the level of effectiveness given through rectification strategies.
Monitoring agent: it is responsible to provide the required monitoring information by gathering and analyzing all the corresponding data, under an inter-organizational scale. It has the ability to identify the type of risk that emerges for a specific order.

Wrapper agents: these agents can offer information integration among legacy and agent software. For example, an expert system for inventory management or an ERP system can be integrated with agent software. The main technique applied is to "wrap" around the legacy code with agent software, so as to "agentify" it into a normal agent. Under this basis, wrapping software is used as a "facilitator" to interpret messages from agent to legacy software and vice versa, aiming to provide an understandable communication for both sides (Davidsson and Wernstedt, 2002).

Disruption manager: it is the main cell of the disruption management system. It is constituted by a built – in simulator that accounts for the risk assessment and the optimization processes, and moreover a learning module that utilizes case based reasoning for the identification of a potential disruptive cause as the suggestion of rectification strategies.

Below, the whole process followed by the system is analytically described.

1. Monitoring of **Key Performance Indicators**: As it was mentioned in the previous sector the quantification as the assessment of the risk are considered as critical factors in managing disruptions. Thus, in the proposed framework a wide range of KPI's related to supply chain partners (e.g. suppliers, LSP) are monitored. The level of in-stock inventory, production throughput, capacity utilization and delivery lead time are some of the key performance indicators that could be used in order to identify an abnormal situation. In particular, the actual values of those KPI's can be monitored at a specific time frame in comparison to predefined values. Significant deviations of the actual values from the predefined can be identified through the use of statistical tests. In figure 1, it can be seen that a significant deviation of the actual amount of the in stock inventories from the forecasted values could be a cause for the generation of an alarm.

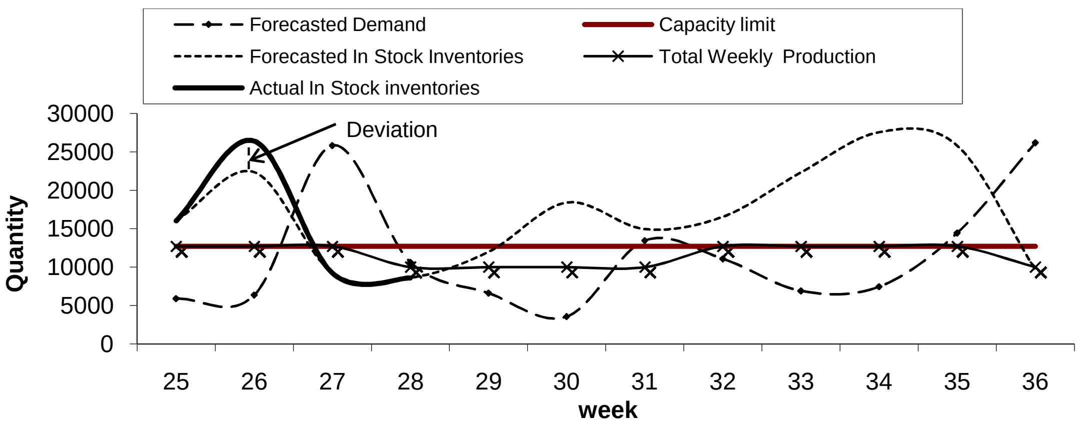

Figure 1. Production plan monitoring through the use of KPI

In figure 2 the architecture of the disruption management system it is depicted analytically. As it can be seen from the figure, learning takes place at the stages where the cause for an alarm is identified and a rectification strategy is proposed. In the whole process a static and a dynamic database are utilized situated within the entity of the disruption manager agent. Relatively, in the **Static database** are situated data that remain unchanged in the short run (e.g. the location of the manufacturing plants, the number of the manufacturing machines). The **Dynamic database** stores data that are continuously updated such as the status of the manufacturing equipment, the exchange rates.

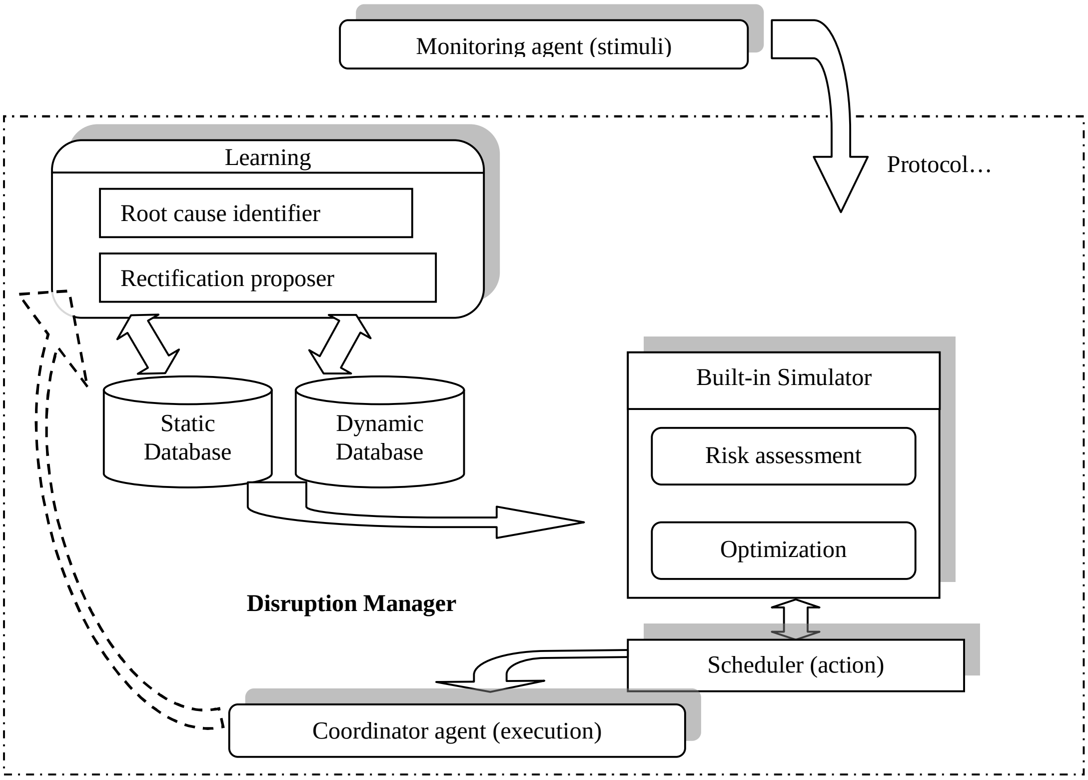

Figure 2. The internal structure of Disruption manager agent (based on Bansal et *al.* 2005; Gan and Goh 2005)

2. Root cause identifier: Through a combined use of case based reasoning and causal models is identified the potential cause for the alarm triggered by the monitoring of the KPI's. As a consequence, previous causes of alarms that have a relevance with the triggered one, are reviewed in order to be investigated if the previous case "fits" with the current one.

Case base structure

Case no.	Manufacturer profile	Supplier profile	Relationship type	Component characteristics
1				
2				
3				
.				
.				
.				
n				

Table 1. Case based reasoning (adapted from Im et al.,2007)

3. Rectifications proposer: Through the use of a causal model, corrective actions are generated in order to mitigate the cause of the triggered alarm. Fuzzy logic is also incorporated to this process in order to simulate human mechanics in decision making (Bodendorf et *al*. 2006). Each of the corrective actions is simulated through the use of a built-in simulator to evaluate its feasibility and efficiency in terms of the global supply chain performance. Analytically, utilizing the framework of Shavell (cited in Kleindorfer and Saad, 2005) for risk mitigation, the main ideology followed by the built-in simulator is firstly the risk assessment process. In particular, the level of the danger, the cost for its mitigation and the potential financial loss in case the alarm leads to a disruption, are quantified. Thus, it is calculated hierarchically: **a)** the probability **P(y)** for the disruption to become reality is estimated (through the use of causal models), **b)** the amount of financial loss **L(y)** for the specific disruption to become reality, **c)** thereafter, the investment cost **y** to mitigate the probability **P(y)**, in order to lessen the specific disruption risk, **d)** an optimal **y*** investment cost for the mitigation of the risk in order to minimize the expected cost that is to arise in case the risk become a reality, figure 2.

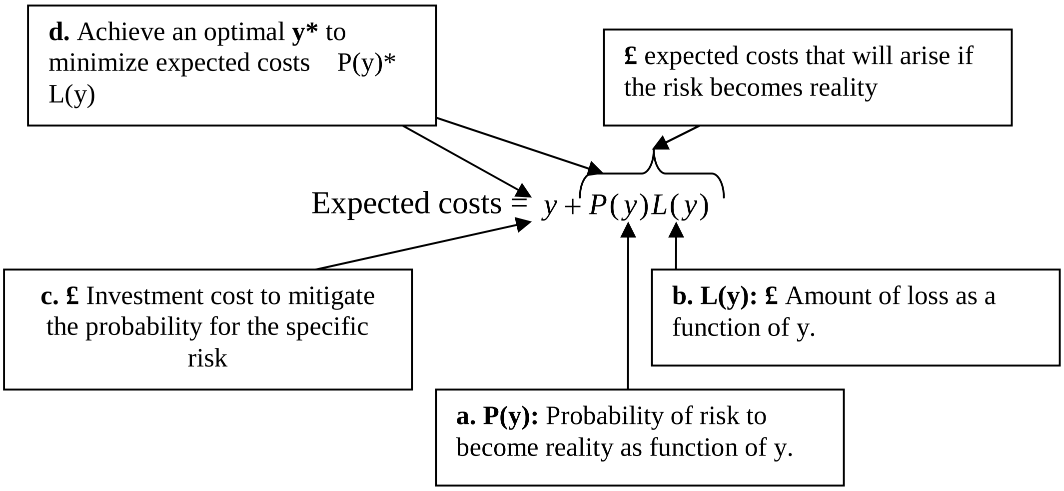

Figure 3 *Risk assessment (based on Kleindorfer and Saad,2005)*

4. Optimization: After the risk assessment process global supply chain profit is calculated. A formula that quantifies global supply chain profit for decentralized supply chains under disruptions regime, proposed by Chongchao, H., et *al.* (2006) could be used. Then, through the application of "what-if" scenarios by the built-in simulator: i)risk is managed to achieve a higher global supply chain efficiency risk return curve, increasing in this manner global supply chain profit and decreasing the risk (point A in figure 3) or alternatively ii) to retain global supply chain efficiency in the same level, (point B in figure 3) decreasing in this manner both the risk and the profit, in case that a shift to **point A** is not feasible to be achieved. The output of this process is the selection of the rectification strategy that is considered as beneficial for all the members of the supply chain.

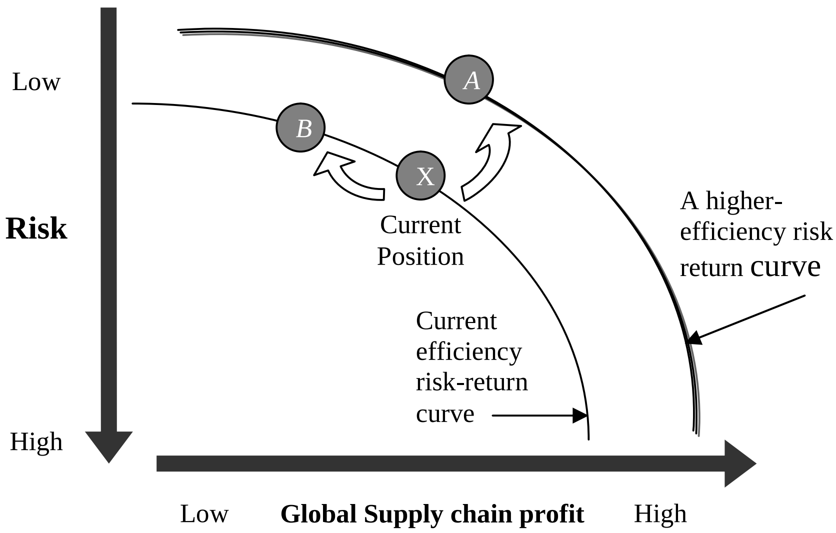

Figure 4 *The optimization process (adapted from Chopra and Sodhi 2004)*

5. Coordinator: After the selection of the best corrective action, coordination agent is to initiate the necessary actions in order for the rectification of the disruption. In figure 3, it is depicted the agent society in an inter-organizational and intra-organizational level.

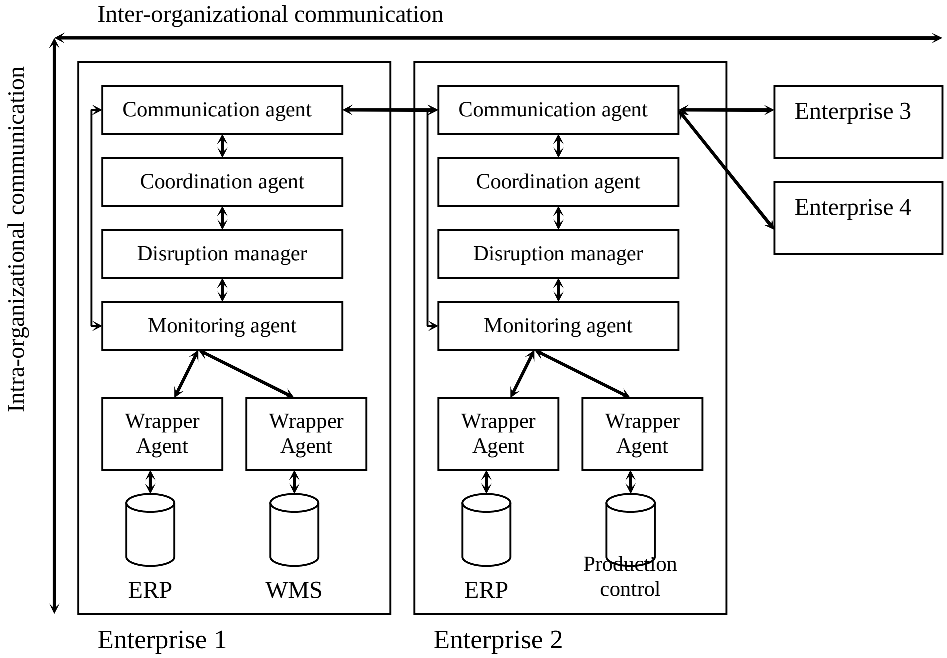

Figure 5. Agent Society (based on Bodendorf et *al.* 2006; Bansal et *al.* 2005)

Case Study

Assume the scenario under which the actual production deviates significantly from the planned one and as a result an alarm is generated by the monitoring agent. In particular, real production is substantially lower than this indicated by the production plan, fact that generates a delays risk[1] of the requested orders to the ultimate consumer. Root cause identifier, investigates three potential causes that might be responsible for triggering the alarm: a) raw materials delay, b) low capacity utilization, c) high demand of raw materials. Thus, initially communication agent contacts the selected logistic provider and compares the requested delivery date with the planned one, which indicates that no arrival delay will be done on behalf of the logistics service provider. Subsequently, the status of manufacturing machines as their utilization, indicate that there is no problem with capacity utilization. Thereafter, after a communication with the sales department the diagnosis reveals that the actual demand is higher than the forecasted, incident that lead to an unexpected increase in demand. The rectification proposer agent suggests three potential strategies: a) to initiate emergency procurement action of the required raw materials to additional suppliers in order to meet the excessive demand, b) to assign the excess production to potential contractors, c) to inform the ultimate consumer that the requested order is to delay awarding a discount in correlation to its net present value for the business. The agent responsible for the optimization process evaluates the three options and flags the first as the optimal strategy. Scheduler agent makes the proper arrangements and thereafter coordinator agent is informed, in order the required raw materials to be order through the facilitation of the responsible agents.

[1] It is the risk associated with delays on behalf of the supplier when demand fluctuations can not be met due to manufacturing inflexibility or other causes (Chopra and Shodhi, 2004).

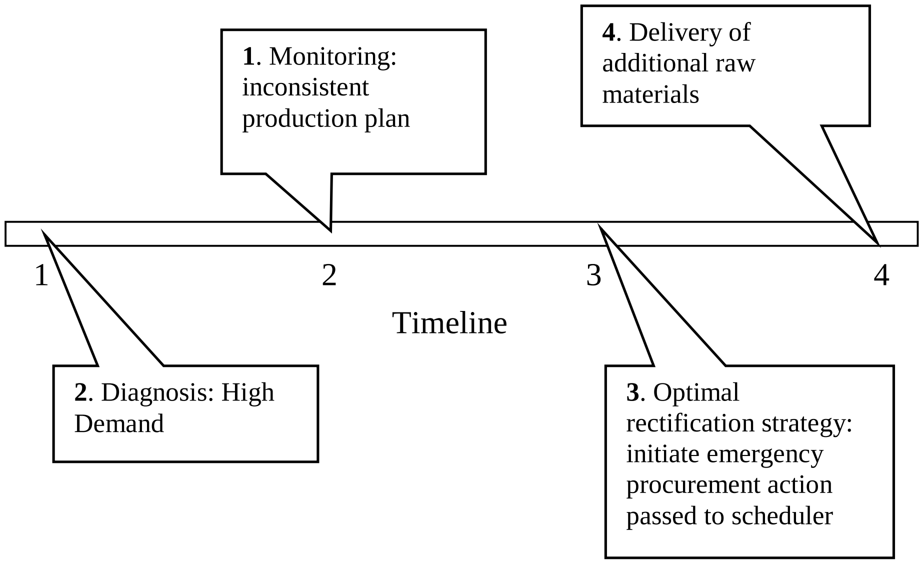

Figure 6. Event flow for the case study

The proposed framework could be also used for the proactive mitigation of other risks such as the inventory risk which is related to the danger in-stock components to become obsolete (Chopra and Shodhi, 2004). For instance, a warehouse management system through the use of RFID can track down inventories that are about to become obsolete. Thus, in this case rectification proposer to choose the transformation of those inventories to finished products and thereafter the optimization agent to use a dynamic pricing method in order to suggest those products to the ultimate consumer as discounted. Evidentially, dynamic pricing is considered as a mechanism for selling products that are about to become obsolete (Tang, 2006).

DISCUSSION – FUTURE IMPROVEMENTS

To start with, the proposed framework due to its collaborative nature assumes symmetry of information among supply chain partners. In particular, partners are willing to share critical information in order critical risks to be proactively mitigated. However, as Kleindorfer and Saad (2005) underlined partners might have an incentive to hide that information from the other supply chain participants. The modification of the framework in order to take into consideration the type of the relationships among partners (e.g. strategic, transactional) might resolve to some extent this dilemma. Relatively, MACE-SCM framework (Im et *al.*, 2007) for managing supply and demand uncertainty takes into account, the type of relationship among firms in mitigating risks. For instance, if the type of relationship is strategic, operational and strategic information are shared in order to achieve an optimal supply chain performance. On the other hand, if a transactional relationship among partners exists, information sharing is fragmented to non-strategic information.

Regarding the integration of the proposed system with legacy software, it is considered through the literature as feasible. However, according to the literature findings indicate, that might be a factor of instability due to the fact that the integration of ERP and MRP systems with agent technology are considered as a topic for feature research (Hao, Q., et *al.* 2006).

To continue with, the majority of the proposed framework could be implemented through the use of Java Agent Development Framework (JADE). It is a quite mature developing tool for multi agent systems, providing in the same time simplified development environment and the capability to access the system from a wide variety of sources, such as PDA and mobile cell phones. Furthermore, it is available for free, making the research for the development of this conceptual framework more tempting. The use of JADE in developing the system might lead to a significant extent to the solution of security problems that agents can not confront at the moment (Schuster, A., et *al.* 2007).

CONCLUDING REMARKS

In recent years, disruptions have become more common in supply chains. Terrorism, the increasing supply chain complexity that strives for more agility could be considered as the most important parameters for the consolidation of disruptions. The proposed framework, can mange disruptions under a collaborative basis, through the facilitation of communication agents, utilizing previous successful corrective actions as cases for future decisions (case based reasoning). The adaptation of the proposed framework to the single character of a supply chain (e.g. lean, agile) is considered as a paramount factor for its success. Future work will be directed upon the performance of the proposed framework using agent-based simulation.

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SIMULATION-BASED IMPROVEMENT OF RELIABILITY OF INTRALOGISTICS SYSTEMS

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ABSTRACT
Intralogistics systems are some of the most vital intersections in modern logistics networks. Due to this significance the reliability and availability of these systems is highly important for the performance of the entire network. Nowadays reliability and availability of these systems are ensured by an overdimensioning of the performance capacity as well as the durability of the material flow technology (static and cost-intensive approach). Research within the Collaborative Research Centre 696 "Logistics on Demand" show the disproportion between performance of the intralogistics systems and the operational demands in order to guarantee the reliability and availability (R&A) of the system. According to this a new approach is aimed with which the intralogistics systems will be run demand-orientedly sized. In this context the warranty of R&A of this newly sized system becomes essential. This chapter presents an alternative dynamic and cost-optimal approach to ensure performance as well as reliability and availability by using a simulation based approach. The basic idea behind this approach is the notion, that capacitive as well as technological overdimensioning causes higher investment and operating costs and therefore might not deliver the best results. Using a simulation model to anticipate the changes according to the varying system load the Anticipatory Change Planning (ACP) is to be seen as a possibility to reduce the redundancy of the material flow technology and to maintain availability without endangering the system performance. In this context the shelving of the material flow technology due to downsizing of the intralogistics system has also to be analyzed.

INTRODUCTION AND MOTIVATION
Globalization and increasing interconnectedness of markets as well as production networks pose continuously new challenges for modern logistics. Especially the growing uncertainty concerning the potential success of new products on different markets (domestic and global) as well as the rising fluctuation of production amounts within the different manufacturing programs force even highly competitive and successful companies to continuously adapt new circumstances to improve and enhance their production and logistics-related skills. Key factors within these networks, upon which planners focus more and more, are the intralogistics systems of the central network nodes, like factories, distribution warehouses, or cross docking points. The term intralogistics is in Germany widely acknowledged as the organization, realization, and optimization of in-company material flows by means of technical systems [1], like continuous and discontinuous conveyors. Within plants, intralogistics with in-company conveyor and storage facilities represent an important factor of success of the entire logistics system. Due to this integral position within the network and the security aspects related to it, these systems usually are oversized in order to ensure their reliability, availability and performance. These security-related aspects basically result in two different kinds of precaution measures. On the one hand, intralogistics systems are designed to handle bigger workloads. Due to the unpredictability of the future market development the actual handling capacity of the systems exceeds the workload which in all likelihood will occur in any time in future. This gives the system ample capability to react to unpredicted changes. On the other hand the components of the system are much more durable than necessary. Based on this structural as well as performance-related oversized construction of these systems the reliability, availability and performance is ensured.

The workload this systems need to be able to cope with over their lifetime period can not be estimated as a constant stream of orders rather as an oscillating amount of batches varying depending on the success of the products as well as seasonal fluctuations. Moreover innovations, regarding the material flow technology, transport units as well as the control systems need to be taken into account. Each change or innovation in one of these mentioned areas will have an influence on the system as a whole. But as it turns out the sole overdimensioning of components or the systems as a whole can not be an adequate answer to the problems of performance or reliability, especially not under economic aspects. Spare capacities, which can be interpreted as buffer or redundancy, cause higher investment costs as well as rising operational expenses. The overdimensioning of these intralogistics systems can therefore be seen as a precaution which is once installed during the planning process and which causes cost.

Within the Collaborative Research Center 696 "Logistics on Demand" a new approach is generated in order to dimension the intralogistics systems adequately. This will not only save costs but also improve the energy efficiency of the whole system. Simultaneously the R&A of this system which will accordingly not be determined statically by overdimensioning should be guaranteed otherwise. In this context the simulation is an important method to ensure dynamically the R&A of these intralogistics systems with anticipating the effects of fluctuating system load and showing the resulting constraints which should be outweighed by relevant measures in order to maintain the availability. In this context, the downsized system should also be analyzed as to stress and shelving. The Anticipatory Change Planning (ACP) poses for this purpose a dynamic simulation-based approach to validate reliability and availability in systems with less constructional performance buffers.

BASICS

In order to describe the interplay of reliability and availability on the one hand and material flow simulation on the other hand, it will initially be necessary to define basic terms of both simulation in general and reliability & availability. A fundamental understanding of the contents described below is necessary in order to understand not only material flow simulation in general but also the ACP-approach in particular.

SIMULATION

Over the last couple of decades computer technology has advanced a great deal so that modern simulation tools enable planners and controllers to plan and monitor the utilization of intralogistics systems. Besides this, possible future developments can be estimated and checked against existing models of intralogistics systems to ensure their performance. To avoid potential risks regarding system-breakdowns, it is necessary to ensure the performance and availability by means of simulation than by simply oversizing the intralogistics systems and their components.

Simulation is understood as modeling a system with its dynamic processes in an experimentable model, in order to get a realization which are transferable to the reality. A model is in this context a simplified replication of a planned or existing system with its processes in a conceptual or representational system [2]. So, simulation serves as a method to conduct experiments on dynamic systems.

In detail, the simulation of intralogistics systems is assigned to discrete-event simulation (see Fig. 1), which is also the major application in the field of production and logistics [3]. "Discrete-event simulation concerns the modeling of a system as it evolves over time by a representation in which the state variables change instantaneously at separate points in time" [4]. Material flow simulation is predominantly understood as an analysis verifying the performance of alternative system designs so as to validate and enhance managerial decisions. Furthermore material flow simulation is also used to design a yet not existing system. The material flow simulation is widely used by contractors on the basis of real data and/or forecast of the customer to ensure a realistic representation regarding dynamics and structure of articles, contracts, loading equipment, etc. Simultaneously capacities, performance and intended control conception of alternative system designs can be tested. Apart from that, simulation is also applied to teach users by playing with parameters and observing the effects. [1, 2, 5] Summing up, material flow simulation is used for these purposes more often in day-to-day business, but currently there is no simulation application which focuses exclusively on maintaining or enhancing reliability and availability. This is probably due to the initially stated fact of overdimensioning according which the system is never able to reach its maximum perfomance.

Simulation			
continuously	discrete		
	event-based	activity-based	process-based

Fig. 1 Classification of material flow simulation according to nature of state transition according to [4, 6, 7, 8]

Following the explanations above, simulation runs can serve various purposes and applications. To run a simulation it is appropriate to follow a general pattern to guarantee valid results. In general, according to diverse literature [5, 9, 10, 11] a simulation run can be divided into three main phases; preparation, performance and analysis. This is also relevant for the new approach presented in this chapter. Furthermore the system load needs to be taken into account which is the central impact variable in intralogistics system, especially in the preparation phase, and which will be discussed in the following.

THE SYSTEM LOAD

The key factor for the planning of intralogistics systems is the number of transportations and production orders the system should be able to handle over a given time period. In the German-speaking part these two figures often have been subsumed under the concept of the system load [2]. Establishing the system load is the first step in designing logistical systems [12], which is accordingly the case for the developed simulation model in this chapter. Due to this significance in the planning process some definitions concerning the concept as well as the content of the term system load will be discussed.
The VDI2 guideline 3633 defines the system load as the "amount of work assignments of a system" [2]. This includes the previously already mentioned transport orders and the manufacturing orders. Following this distinction Wenzel and Mayer separate the data describing the system load into the two categories of order related data (covering the aspects of production, transportation orders, and lots and dates) and product related data (work breakdown structure or the bill of materials) [13].

Bernhard et al. define the system load as the flow of objects entering a system or as the number of objects entering a sozio-technical system in a given time period [14] i.c.t. [15]. In the field of the material flow simulation the moment an object enters the system is of special interest as well as the number of objects entering the system at certain point in time and the time slot between. These figures are the basis from which the system load is derived. Depending on the system analyzed different kind of attributes can be attached to the objects. Such attributes can be static, e.g. information or dynamic, e.g. describing a process changing an object within the system.

Kuhn on the other hand defines the system load as the total amount of movement between the sinks and sources of a logistical system. The system load is thereby described via the sources and is usually described in form of base units of measurement per time unit. [16] Base units or objects can be any kind of information or material which is supposed to move along the process chain. Furthermore Kuhn divides base units like Bernhard et al. in active and passive as well as permanent and temporary elements.

[2] VDI is the Association of German Engineers which amongst others works out technical guidelines

Concerning the analysis of material flow systems Großeschallau defines the system load as the performance-describing parameter of these systems. The term material flow system herby describes sub-system of a logistics system controlling and performing all material movement [17].

Gudehus defines the system load in analogy to Großeschallau regarding material flow systems and specifies the term "quantitative system load" as the outgoing stream of a source. In this context the parameters volume and time (might be interpreted as density) of the different sources can be monitored and in a next step the key figures of the system load can be deduced [18] i.c.t. [19].

Looking at the previously mentioned definitions a focus on order volume and its composition, batches or arrival times becomes obvious. Regarding the goals of the ACP such a mono-directional approach is not sufficient, especially as to the simulation-based approximation of the signs of wear and tear of the components of intralogistics systems in conjunction with the downsizing of these systems.

RELIABILITY AND AVAILABILITY OF INTRALOGISTICS SYSTEMS

As already mentioned before the availability and reliability of intralogistics systems is crucial for the functioning and the success of modern logistical networks. Thus, the simulation of intralogistics systems should support to maintain a highly reliable level of R&A.

Trying to dimension intralogistics systems to an efficient extent, reliability and availability play a decisive role. In practice the terms „reliability "and „availability" are frequently used synonymously. But the reliability of a system or a machine describes only the time till its first failure and indicates the probability for their functioning in a certain period of time. The availability however considers also the influence of the down-time after the appearance of a failure. Thereby the failure behavior and the repair behavior of a system are also taken into account. The term availability states that a technical product, system or a system component can actually be used for an intended task under specified conditions. [20, 21] In principle it is the relation between the sum of the expected down-times and the whole theoretically usable operating time. [22] Other authors describe the availability as the relation between the mean time between failure and the sum of mean time between failure and mean time to repair. [20]

In general there are a lot of options to affect the availability and reliability in the phase of operating and planning of intralogistics systems. An improvement can be obtained either by extension of the time between the appearance of a failure (time-to-failure) or by reduction of the time for repair (time-to-repair). [23] Systems for error diagnosis can be used in order to reduce the downtime in the planning phase. During the construction phase the accessibility and modularity of the single components should be considered. In the operating phase the spare part management and corrective maintenance become more important. By the extension of the operating time during the planning phase the structure of the system, redundancy and the dimensions should be regarded. Whereas in the operating phase utilized capacity, employees and preventive maintenance receive more relevance. The simulation-based Anticipatory Change Planning in this context is a dynamic approach to maximize the working time in the operating phase and to keep the availability and reliability on a constantly high level with a special focus on wear and tear. In the course of reducing the complexity of intralogistics systems the Anticipatory Change Planning is a good option to achieve system availability and reliability.

Summing up, the Anticipatory Change Planning deals with technical, operational and total availability, and regards less the theoretical availability [20]. The theoretical availability is affected exclusively by construction unit malfunctions, which are within the responsibility of the unit manufacturer, whereas the technical availability considers also component failure and their consequences as a result of abrasion, for which the systems manufacturer is in charge. The operational availability covers additional failures which are caused by the system itself or due to operating processes and therefore can be accounted to the operator. The total availability also takes failures caused by external influences into account.

In the basics regarding simulation, system load and reliability & availability the insufficiency of the current concepts concerning ACP was stated at given points. In the following the lack of concepts regarding the enhancement of R&A of intralogistics systems through simulation will be discussed.

STATE OF RESEARCH AND THE RESEARCH GAP

Over the last two decades a large number of publications in the field of simulation in production and logistics has been published [e.g. 9, 24, 25, 26]. In the following the present state of research concerning the contribution of material flow simulation ensuring availability is summarized as part of simulation in production and logistics.
Reviewing today's literature [2, 5, 9, 11] one important key factor becomes obvious. No research is exclusively focusing on the contribution of material flow simulation to the reliability and availability of such systems. This is not surprising because, like mentioned above, the intralogistics systems are overdimensioned with redundancies in actuators, rollers, etc. As already mentioned and described in the previous pages, nowadays intralogistics systems are primarily designed to ensure performance, reliability and availability by oversized components. In addition to this, this static approach limits furthermore the options to analyse the additional costs arising from these supplementary resources and components.

Apart from that, further great problem concerning simulation-based assurance of availability of intralogistics systems in conjunction with the downsizing of intralogistics systems lies in the seldom performed monitoring and measuring of the physical shelving of the system's components due to batches and the attributes of the goods, handling materials or units. To enable a simulation-based analysis and measurement of the components strain caused by the goods transported, the number and size of different batches or the different weights and surfaces, the sole consideration of number, time and lot size is not sufficient. Such an approach has proven sufficient for a performance or capacity related planning of these systems, but the sole consideration of number of objects passing certain points or areas within the system do not provide sufficient information concerning the operational shelving of single components. To make such an approximation feasible it is necessary to survey data concerning a variety of other aspects and to classify the different relevant attributes. In the following the new approach is presented which takes these aspects into account.

THE ACP-MODEL TO IMPROVE R&A IN INTRALOGISTICS SYSTEMS

According to the information above, a new simulation-based approach is necessary for ensuring R&A of intralogistics system which will be desized to an efficient dimension by diminishing the redundancies of the components. For this purpose the specific and necessary data have to be collected, the simulation model has to be developed, tested and an analysis has to be conducted which will lead to the selection of relevant optimization measures. So, the R&A will be guaranteed dynamically in a less-redundant intralogistics system.

THE PREPARATION PHASE

During the preparatory stage the necessary data need to be collected, the simulation model needs to be developed and necessary specifications need to be defined. The input specifications for a simulation run (the necessary data) are essential for the quality of the results and their usability in the planning process [27]. Basic specifications for modeling are technical specification, organizational specification, system load specification as well as simulation experiment specification. The technical specification is generally understood as the summarized data of the factory and the manufacturing structure, the material flow as well as the material break down [2]. The data of the operational and organizational structure as well as the allocation of the material-related data are summarized in the organizational specification [2]. These two specifications are necessary for modeling an intralogistics system, but are not sufficient. In order to describe an intralogistics system holistically, the system load must be specified as well. Besides the previously mentioned specifications it is necessary to define the simulation experiment in detail. In order to do so, the duration of a simulation run, duration of a settling phase, indication of identified key factors or definition of animation are vital. [27] All these preparations are necessary and need to be taken into account in order to conduct a successful simulation run.

In order to ensure the performance, results and documentation of a simulation run it is necessary to follow some "basic" rules. Many authors offer plenty of advice for a successful implementation of a simulation run [26, 28, 29, 30]. In general incorrect definition of the study objective, insufficient participation of the client, unbalanced mix of core competencies, unsuitable detail, wrong choice of simulation tool, lack of validation and poor presentation of results are seen as seven "deadly sins of the simulation". [31]

In order to ensure a holistic system load profile for the ACP it will be necessary to take administrative data (with order number, storage slot, order date and time, value and date of expire), geometrical data (with length of objects, surface design, stability and center position), and physical data (with weight, durability, constancy, material property, surface, characteristics and emissions) into account. [32] These are solely goods-related aspects that need to be covered. In order to monitor the interaction between the goods or the transport units and the parts of the material flow system and to derive the abrasion of the components it will be necessary to analyze component-related data as well. Parameters like durability, bearing strength, kind of surface or the friction coefficient have to be taken into account. An observation and collection of all these parameters will be necessary, especially considering the interactions between the handling units or the transported goods with the conveyor technique. An adequate dimensioning of the actuators powering the conveyor technique for example will only then be possible, when the necessary conveying capacity as well as the impact of the transported material on the structural elements of the system have been evaluated. In this context the exact relation between usage and shelving of the intralogistics system has to be known via empirical experiments which must be parameterized in the simulation model.

Due to the fact that the composition of the transported material can only be derived via a differentiated analysis of the system load over a given period of time, establishing the system load and ascertain its connection to the previously mentioned parameters of the transported goods is a necessary pre-condition to realize the concept of the ACP.

The iterative simulation model
In the following the idea behind the ACP-approach will be presented.

Fig. 2 shows a function sketch about using a simulation model of an intralogistics system for ACP. The first step in order to use the material flow simulation within the ACP concept it is necessary to model an intralogistics system with a material flow simulator. After the data collection and the parameterization of the model it is possible to start a first simulation run. The result of this first run is a better knowledge about the control variables (capacity and shelving data). These variables have to be compared with the reference input variables. This comparison can produce two possible outcomes. Firstly, if the control variable and the reference input variable are equal, there is no need to variegate any parameter within the model or adopt the structure. That means the findings of the simulation process can go directly into the real intralogistics system. Secondly, if the control variable and the reference input variable are not equal, it is necessary to variegate parameters and structure of the model. That means new data must be fed into the simulation model. These new data have to be checked whether there are environmental influences, like new distributing strategy, new package size, etc. After the data is fed into the model a new simulation run has to be started. The result (control variable) of this simulation process has to be compared with the reference input data. The possible results of the comparison are the same as written before. This procedure has to be done till the control variables and reference input variables are equal.

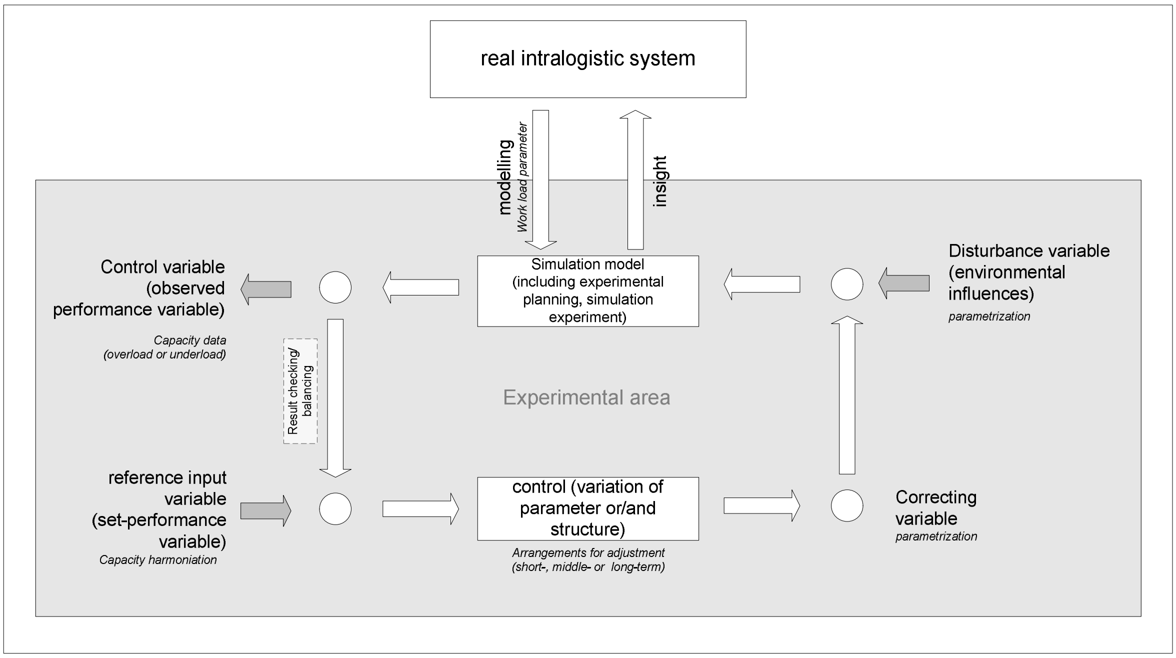

Fig. 2 Function sketch for ACP in intralogistics system according to [2, 7]

According to this iterative simulation model it is possible to identify not only capacitive but shelving-based availability problems.

THE ANALYSIS PHASE AND THE MEASURE SELECTION

The results of a simulation run can be analyzed by graphical tools (e.g. animation) and/or statistical methods (e.g. bar graphs) [6]. With the help of statistical methods it is possible to monitor the movement and the behavior of an object within the system over the defined length of time. Statistical benefits of a simulation can be derived in two categories; general and specific ones. [33] General statistics can be characterized as statistic data, which describe a functional expression of a stationary object (for example: module in the simulator). Specific statistics are required to provide specific functionalities of a static object. Depending on the simulator used these two kinds of statistics can be implemented as a standard function within the system or have to be implemented manually by the user. Tab 1 shows some specification for general and specific statistics. With these statistical data it is possible to provide information on various issues. Simulation is an appropriate tool to decide on planned or implemented production systems in terms of their logistical capacity [34], and with this ACP-approach in terms of the shelving.

Tab 1 Statistical data of a material flow simulation according to [33]

general statistic	specific statistic
throughput, current and maximum content, percentage and average occupancy, capacity utilization, blockade loading, malfunction period, pause time and waiting time	waiting time for workers, setup times, percentage of unload drive, percentage of load drive and doubles share

After analyzing the simulation results, it is appropriate to derive relevant measures to solve both capacitive and shelving-based problems. For this purpose a measure selection model is developed, which consists of five filters. This model functions as a decisive model which facilitates the systematic choice of measures due to capacitive and shelving-orientated optimization as well as adaptation of intralogistics systems to modified framework. Within the ACP, the choice of measures for absorption of corporate system load fluctuation by means of demand changes is decisive.

Prior to the use of the measure selection model, the definition of the existing problem is essential. For this, it is necessary to note in detail which problem dimension exists. By means of the Dortmund Process Chain Model [16], the problem can be located more clearly (e.g. problem of control, personnel, process or resource). As this process chain model facilitates a holistic view of processes, it is a well-founded basis for the classification of measures. Moreover, the type of problem needs to be judged, i.e. if capacitive or shelving-orientated problems exist. In addition to that, the problem progression has to be determined whereas acute (seasonal, etc.) or chronic problems are possible. If the problem progression is not regarded, serious incorrect decisions can be made.

A measure list (depot) represents the basis of the measure selection model. The measures for these problems can be summed up structuredly. On the basis of the process parameters and potential classes of the Dortmund Process Chain Model, a general classification can be made. On this basis, holistic and complete measures can be found for the considered intralogistics system. For instance, measures for single resources can be derived from this. Regarding personnel, e.g. adjustment of employee (local, temporal, quantitative, qualitative) are possible. For working equipment, capacity adjustments as well as load adjustments can be arranged.

These measures show interdependences which need to be analysed (I-filter). It is possible that some measure support or limit others. It is also possible that there are no interdependences between measures which means that they can coexist independently. The consideration of these interdependences is relevant for looking out supporting measures in order to enhance the optimization
.

				measure 1	measure 2	measure 3	measure 4	
dimension	resources	x						
	process							
	structure							
	direction							
problem	capacitive							
	adjustment							
	shelving-based	x						
gression	acute	x						
	chronic							
measures	measure 1				-	-	-	I-filter
	measure 2			-		+	+	
	measure 3			-	-		-	
	measure 4			-	-	-		
			emphasis	measure 1	measure 2	measure 3	measure 4	
flexibility	aspect 1			1	1	0,5	0,5	F-filter
	aspect 2			0	0	1	1	
	aspect 3			1	1	1	1	
	aspect 4			1	0,5	1	1	
	Π specific flexibility			0	0	0,5	0,5	
target triangle	short	50						T-filter
	purchasing	30				4	2	
		15				3	3	
	releasing time	5				5	3	
	low costs	10						C-filter
	implementation	6				4	1	
	application	3				4	4	
	releasing costs	1				5	1	
	high contribution	40						Q-filter
	process	30				3	1	
	social ability to integrate	10				3	3	
	loading	5				3	5	
	Σ target triangle					342	192	
impor-tance	absolute					171	96	
	relative					0,64	0,36	
	ranking					1	2	

Fig. 3 The measure selection model

According to this ideal planning and analysis, the real planning needs to be defined by regarding the flexibility (F-filter). If, for instance, there are legal restrictions (especially of the work council or labour union) some measures could not be implemented, i.e. there will be no realisation potential for these measures. By means of multiplication of the specific data within the matrix (1 for total accordance, 0.5 for partial accordance and 0 for no accordance), the specific flexibility results from this. Although the absolute flexibility of measure 1 and 2 (see

Fig. 2) are very high, they have no specific realization potential and they can therefore not be implemented.

Subsequently, the flexible measures are interpreted with regard to time, cost, and quality (T-, C-, and Q-filter). For this, criteria need to be determined, which have to be classified by their relative emphasis or importance. The quality is measured by means of their contribution to target achievement. Afterwards, the single measures are evaluated due to their achievements of these criteria and by means of multiplication of this specific data with the emphasis factor the specific emphasis of the measure is calculated. If all specific emphases are summed up, the comparison value results from this.

Having determined the features of the single measures within the target triangle, the importance of the measures is calculated by multiplication of the comparison value of the target triangle (time, cost, and quality) with the specific flexibility. Therefore, the optimal measure for the absorption of changes and problems (capacitive or shelving-based ones) caused by fluctuation is determined. The most important measure is to be considered as most effective and most efficient. If this measure correlates positively with others, there will be further support which can optimize the result.

On the basis of this procedure, case-specific and holistic relevant measures can be derived especially for shelving-induced problems. According to the ACP approach it is possible to anticipate the effects of demand fluctuations on the intralogistics systems, especially in the case of increasing system load. Regarding the diminishing of the redundancies in an intralogistics system, the increasing system load could have a significant effect on the shelving of the conveyer technique. Therefore this ACP approach is important so as to see foresightedly the required changes regarding the availability of the system and make adjustments via relevant measures in order to avoid availability problems early enough before they occur.

CONCLUSION

As it becomes obvious for this chapter, the ACP presents a serious alternative for securing performance as well as availability and reliability of intralogistics systems in a dynamic way in less-redundant intralogistics system. The question whether the ACP approach is economically sound and provides better results than the classic overdimensioning-strategy is at this stage subject to further research.

Therefore the simulation model will be parameterized according to real data system specifications of industrial partners in order to validate the capability of the method as well as the simulation model. Also the relation between usage and shelving has to be analyzed empirically.

In order to extend possible application areas, the adaptability of the system to the needs of material system manufacturers need to be analyzed and further research needs to be conducted concerning the area of lifetime system-monitoring as an additional service.

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SECTION 6 – Supply Chain Dynamics and Inventory Management

IMPROVING AND SOLVING THREE NEW SUPPLY CHAIN INVENTORY CONTROL MODELS FOR PERISHABLE ITEMS USING JUST-IN-TIME LOGISTIC

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ABSTRACT
This paper presents three new inventory Control models for perishable items in three-level supply chains using just-in-time logistics. The goal is to minimize the total cost of the whole supply chain. This includes cost of production, cost of freight, cost of preservation, cost of early or late delivery, and cost of perished goods. The first model, for the purpose of simplification, has been developed with the assumption that all goods are delivered to the customers prior to their expiry date and hence there are no perished items. To develop a more realistic model, the second model includes cost of perished goods and considers cases where some of the goods are expired prior to delivery to customer. The third model has been developed to improve the second model even further by considering cases where close-to-expiry items are sold at a cheaper price. Genetic Algorithm (GA) and CPLEX are used to solve and validate the models.

1. INTRODUCTION
The globalized and competitive market in twenty first century requires appropriate supply chain management. In supply chain management all of the processes (such as planning, supply, delivery, operating and assessment) present in the network of organizations have to be considered. The interactions among different economic institutions (such as supplier, wholesaler, final retailer, etc.) have to be analyzed as well. One major difficulty in supply chain is when dealing with perishable goods (e.g., food). These goods, if not delivered prior to their expiry date, are considered as lost sale. On the other hand, designing inventory control mechanisms to determine the optimal size of orders, the frequency and time of orders, and total cost of inventory for perishable products is very complex. Therefore, organizations dealing with these kinds of products try to use modern ways to preserve them as much as possible and also employ ways to minimize the cost of the decaying items while trying to meet the customer's expectation. In 1963 the effect of decaying items on the function of inventory system was investigated for the first time by Ghare and Schrader [1]. Philip and Covert [2] designed inventory control model for items with variable decaying rate. They ignored shortage and assumed that demand is fixed and the rate of decaying items is based on a Weibull density function with three parameters. Shah and Jaiswal [3] analyzed and designed a model for inventory control of decaying items considering a fixed decaying rate. Hwang [4] investigated a perishable-item inventory model to determine the economical size of order using genetic algorithms. Variability in demand and distances are considered in the model. The objective is to minimize the logistics costs. Weibull density functions are used for the probability distributions. There are some limitations in the model regarding the number and type of vehicles and the time, capacity, and speed of transportation. In addition, it is assumed that the demand is met in full.

Model I

(1) $$Min \quad Z1=(\sum_t\sum_m\sum_l\sum_j\sum_i pc^t_{ijlm}.X^t_{ijlm}+\sum_t\sum_m\sum_l\sum_k\sum_j dc^t_{jklm}.Y^t_{jklm})$$
$$+(\sum_t\sum_i pf^t_i.PZ^t_i+\sum_t\sum_j df^t_j.DZ^t_j)+(\sum_t\sum_l\sum_i pb^t_{il}.(\sum_j\sum_m X^t_{ijlm})+$$
$$(\sum_l\sum_j\sum_{t\neq T} dh^t_{jl}(\sum_i\sum_m\sum_{t'=1}^{t} X^{t'}_{ijlm}-\sum_k\sum_m\sum_{t'=1}^{t} Y^{t'}_{jklm}))+(\sum_l\sum_k\sum_t \sigma^t_{kl}.B^t_{kl}+\sum_l\sum_k\sum_t \pi^t_{kl}.In^t_{kl})$$

Subject to:

(2) $$\sum_m\sum_j Y^t_{jklm}=d^t_{kl} \qquad \forall k,l,t$$

(3) $$\sum_m\sum_j Y^t_{jklm}=d^t_{kl} \qquad \forall k,l,t$$

(4) $$(\sum_l pv^t_l.\sum_j\sum_m Y^t_{jklm})\leq CU^t_k \qquad \forall k,t$$

(5) $$\sum_l pv^t_l(\sum_i\sum_m X^t_{ijlm})\leq DU^t_j.DZ^t_j \qquad \forall j,t$$

(6) $$\sum_m\sum_k\sum_{t'}^{t} Y^{t'}_{jklm}\leq\sum_m\sum_i\sum_{t'}^{t} X^{t'}_{ijlm} \qquad \forall j,l,t\neq T$$

(7) $$\sum_i PZ^t_i\leq PW \qquad \forall t$$

(8) $$\sum_j DZ^t_j\leq DW \qquad \forall t$$

(9) $$\sum_j\sum_l pv^t_l.X^t_{ijlm}\leq PV^t_{im} \qquad \forall i,m,t$$

(10) $$\sum_k\sum_l pv^t_l.Y^t_{jklm}\leq DV^t_{jm} \qquad \forall j,m,t$$

(11) $$\sum_j\sum_m\sum_{t'=1}^{t} Y^{t'}_{jklm}-\sum_{t'=1}^{t} d^{t'}_{kl}=In^t_{kl}-B^t_{kl} \qquad \forall k,l,t\neq T$$

(12) $$In^t_{kl}\leq Q'^t_{kl}.v^t_{kl} \qquad \forall k,l,t\neq T$$

(13) $$B^t_{kl}\leq bl^t_{kl}.(1-v^t_{kl}) \qquad \forall k,l,t\neq T$$

(14) $$\sum_i\sum_m\sum_t X^t_{ijlm}=\sum_k\sum_m\sum_t Y^t_{jklm} \qquad \forall l,j$$

(15) $$\sum_i\sum_m\sum_{t'=1}^{t} X^{t'}_{ijlm}-\sum_k\sum_m\sum_{t'=1}^{t} Y^{t'}_{jklm}\leq Q^t_{jl} \qquad \forall j,l,t\neq T$$

(16) $$\sum_{t'=1}^{t}\sum_j\sum_i\sum_m X^{t'}_{ijlm}\leq\sum_{t''=1}^{\min(t+EX_l,T)}\sum_k d^{t''}_{kl} \qquad \forall l,t\neq T$$

(17) $$\sum_{t'=1}^{t}\sum_i\sum_m X^{t'}_{ijlm}\leq\sum_{t''=1}^{\min(t+EX_l,T)}\sum_k\sum_m Y^{t''}_{jklm} \qquad \forall l,j,t\neq T$$

(18) $$PZ^t_i,DZ^t_j,v^t_{kl}=0 \quad or \quad 1 \qquad \forall i,j,t$$

(19) $X^{t}_{ijlm}, Y^{t}_{jklm}, In^{t}_{kl}, B^{t}_{kl} \geq 0 \qquad \forall i,, k, l, m, j, t$

<u>Model II</u>

$$Min \quad Z2 = (\sum_t\sum_m\sum_l\sum_j\sum_i pc^t_{ijlm}.X^t_{ijlm} + \sum_t\sum_m\sum_l\sum_k\sum_j dc^t_{jklm}Y^t_{jklm})$$

(20)

$$+(\sum_t\sum_i pf^t_i.PZ^t_i + \sum_t\sum_j df^t_j.DZ^t_j) + (\sum_t\sum_l\sum_i pb^t_{il}.(\sum_j\sum_m X^t_{ijlm}) +$$

$$(\sum_l\sum_j\sum_{t\neq T} dh^t_{jl}(\sum_i\sum_m\sum_{t'=1}^{t} X^t_{ijlm} - \sum_k\sum_m\sum_{t'=1}^{t} Y^t_{jklm})) + (\sum_l\sum_k\sum_t \sigma^t_{kl}.B^t_{kl} + \sum_l\sum_k\sum_t \pi^t_{kl}.In^t_{kl}) +$$

$$(\sum_t\sum_l\sum_i\sum_j\sum_m X^t_{lijm} - \sum_{t'}\sum_k\sum_l d^{t'}_{kl})*w$$

Constraints of model II: Includes constraints 2 to 15, 18, 19 and

(21) $$\sum_{t'=1}^{T}\sum_i\sum_m X^{t'}_{ijlm} > \sum_{t''=1}^{\min(t+EX_l,T)}\sum_k Y^{t''}_{jklm} \qquad \forall l, j, t \neq T$$

(22) $$\sum_{t'=1}^{T}\sum_i\sum_m X^{t'}_{ijlm} > \sum_{t''=1}^{\min(t+EX_l,T)}\sum_k d^{t''}_{kl} \qquad \forall l, j, t \neq T$$

<u>Model III</u>

(23)

$$Min \quad Z3 = (\sum_t\sum_m\sum_l\sum_j\sum_i pc^t_{ijlm}.X^t_{ijlm} + \sum_t\sum_m\sum_l\sum_k\sum_j dc^t_{jklm}.Y^t_{jklm})$$

$$+(\sum_t\sum_i pf^t_i.PZ^t_i + \sum_t\sum_j df^t_j.DZ^t_j) + (\sum_t\sum_l\sum_i pb^t_{il}.(\sum_j\sum_m X^t_{ijlm}) +$$

$$(\sum_l\sum_j\sum_{t\neq T} dh^t_{jl}(\sum_i\sum_m\sum_{t'=1}^{t} X^t_{ijlm} - \sum_k\sum_m\sum_{t'=1}^{t} Y^t_{jklm})) + (\sum_l\sum_k\sum_t \sigma^t_{kl}.B^t_{kl} + \sum_l\sum_k\sum_t \pi^t_{kl}.In^t_{kl}) +$$

$$(\sum_{t'=1}^{\min(t+Ex_l,\,T)}\sum_m\sum_l\sum_j\sum_i X^{t'}_{ijlm} - \sum_{t''=1}^{\min(t+Ex_l-tr,\,T)}\sum_m\sum_l\sum_j\sum_i X^{t''}_{ijlm})*Rp$$

Constraints of model III: Including constraints 2 to 15, 18, 19 and

(24) $$\sum_{t'=1}^{t}\sum_j\sum_i\sum_m X^{t'}_{ijlm} \leq \sum_{t''=1}^{\min(t+EX_l-tr,\,T)}\sum_k d^{t''}_{kl} \qquad \forall l, t \neq T$$

(25) $$\sum_{t'=1}^{t}\sum_i\sum_m X^{t'}_{ijlm} \leq \sum_{t''=1}^{\min(t+EX_l-tr,\,T)}\sum_k\sum_m Y^{t''}_{jklm} \qquad \forall l, j, t \neq T$$

$$\sum_{t'=1}^{\min(t+Ex_l,\,T)}\sum_i\sum_m\sum_j X^{t'}_{ijlm} \geq \sum_{t''=1}^{\min(t+Ex_l-tr,\,T)}\sum_i\sum_m\sum_j X^{t''}_{jklm} \qquad \forall l, t \neq T$$

Description of the models

The purposes of the three models are:

- Determining the number of suppliers (factories) and warehouses and their locations.
- Reduction in the cost of using factories and warehouses (activation cost).
- Reduction in the cost of early or late delivery.
- Reduction in the cost of purchasing goods.
- Reduction in the transportation cost of warehouse and retailers.
- Consumption of goods prior to their expiration date by selling them at discounted price (model I and model III).
- Minimizing the cost of perishable goods (model II).
- Minimizing the costs of the discounted goods (model III).

1. Computational Results

In this research ten sample problems with different dimensions (Table 1) have been solved in order to examine the proposed models. These problems have been produced randomly since there was no literature containing problems with such extent of assumptions. For each sample problem the number of factories (I), the number of intermediate warehouses (J) and the number of retailers (K) are given in the second, third and forth column respectively. The fifth column shows the number of product types (L) and the sixth column shows the number of available transportation modes (M). Finally the last column gives the number of periods (T).

Table 1: Sample Problems

Sample	I	J	K	L	M	T
1	2	3	3	2	1	4
2	2	4	4	3	2	4
3	2	4	4	3	2	8
4	3	5	5	4	2	6
5	3	5	7	4	3	4
6	4	6	7	4	3	6
7	4	6	6	6	3	8
8	5	8	6	6	3	8
9	5	8	6	6	3	12
10	6	10	10	6	4	12

Table 2: CPLEX 10.2 Test Results

Sample Problem	Run Time ( )	Model I	Model II	Model III
1	0.02	51857	57239	54102
2	0.06	64163	70765	68190
3	0.15	132224	141001	137300
4	0.23	168296	179501	172876
5	0.27	117352	129521	122749
6	0.47	179870	190320	184901
7	1.04	286935	300587	291865
8	1.56	282488	295879	286310
9	3.00	427896	448387	436376
10	7.10	585782	617001	594989

Table 3: GA Results

Sample Problem	Run Time	Model I	Model II	Model III
1	5.2	54167	62340	57587
2	16.5	69722	76780	72906
3	72.9	166918	175100	169960
4	85.7	208260	215502	212008
5	66.3	131810	144389	136946
6	192.5	221856	334408	226712
7	529	348860	357099	351444
8	1077.4	375705	391120	381980

5. CONCLUSION

The literature was reviewed and despite many available research materials, the modeling of supply chain inventory control for perishable items is extended even further. Some real-life features that must be considered in today's competitive supply chain management of perishable goods is incorporated in the presented models. The models are capable of both considering some items being expired prior to delivery and some others being sold at cheaper price prior to their expiry. The validation of all three models is done using CPLEX 10.2 Solver and the genetic algorithm. Further research can include investigating and adding further real life features to the models to make the models closer to reality as well as implementing other meta-heuristic algorithms especially for problems of larger dimensions. The other work to be done is to examine the limits of CPLEX 10.2 in solving problems of larger size. Also the models can be solved using the latest version of CPLEX 11 solver that is now available in the market.

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A STUDY OF FORECASTING GUESTS DEMAND FOR A FAMILY RESTAURANT

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ABSTRACT
A manager should consider a business management on running a store. A business management means inventory control of merchandise, schedule control of employee, customer service and so on. In our study, we take notice of a business management in a family restaurant. Especially, we consider about forecasting guests demand. If forecasting precision of guests demand is higher, wastes of inventory of foods are reduced. The forecasting precision of current forecasting system for a family restaurant is not suitable. The method of the current forecasting system is simply that number of guests is forecasted from the number of guests on the same day of the previous year. In this paper, we propose a new forecasting method for guests demand for a family restaurant. Our method is based on multiple regression analysis. Firstly, we execute correlation analysis, and we select factors which have high level of correlation to numbers of guests. Secondary, we conduct multiple regression analysis, in which these factors are used as explanatory variables. From the above, we lead forecasting formula based on multiple regression analysis. We compare the forecasting precision between our proposal method and current forecasting system. And we find out that forecasting precision of our proposal method is better than that of current forecasting system with a residual analysis.

INTRODUCTION
The state of affairs in a community is very strict today. In this condition, we should make efforts to reduce the total cost, and we should make efforts to save the total cost. Thus a manager should consider a business management on running a store. Here, a business management means inventory control of merchandise, schedule control of employee, customer service and so on. In our study, we take notice of a business management in a family restaurant. A family restaurant means it that a restaurant makes families an objective of guests. The manager of a family restaurant has been forecasting a number of guests. This forecasting method is called "the original model" in this paper. Although, the original method is explained in the next section, it is very simple. So, forecasting precision of guests demand for the original method is not suitable. Then, we propose two kinds of new forecasting methods for guests demand. These new forecasting methods are based on a multiple regression analysis. And, weather information and a day of the week information and so on are used as explanatory variables by a multiple regression analysis. Moreover, one of new forecasting methods considers also the menu change added to a multiple regression analysis. Each method is called "the regression model" and "the regression and menu change model", respectively, in this paper. Consequently, we report the results which forecasting precision of the all proposal methods are better than that of the original model.

From next section, we explain the forecasting method of "the original model", and, we propose the forecasting method of "the regression model" and "the regression and menu change model". And, we show the forecasting results of guests demand for a family restaurant. Moreover, we evaluate the forecasting precision of guests demand for a family restaurant.

THE FORECASTING METHOD OF "THE ORIGINAL MODEL"

The forecasting method of "the original model" is explained. In figure 1, D_M in Y year is assumed to be a forecasting day. The definition of the sign is described below.

D: January 1 is assumed to be D=1, and December 31 is assumed to be D=366. If it is not the leap year, D is treated as a missing value.
M: January is assumed to be M=1, and December is assumed to be M=12.

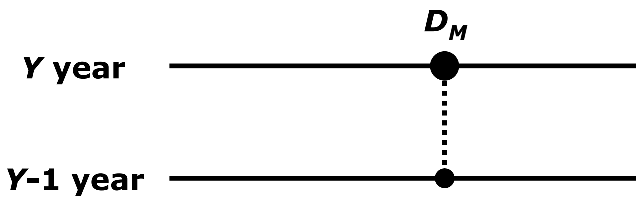

Figure 1: The concept of "the original model"

The number of guests on D_M in Y year is forecasted based on that on D_M in previous year (Y-1 year). It, however, is adjusted that a day of the week of D_M in Y year becomes the same a day of the week of D_M in Y-1 year. That is, it is as shown in figure 2.

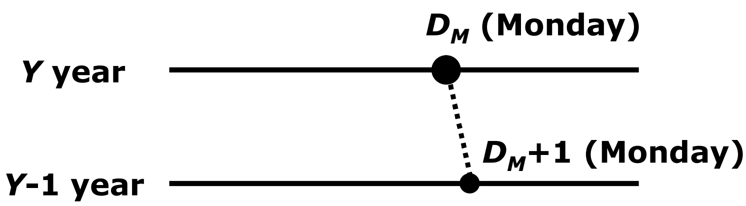

Figure 2: The actual concept of "the original model"

In figure 2, a day of the week of a forecasting day (D_M in Y year) is Monday. A, however, day of the week of D_M in Y-1 year is Sunday. So, the number of guests on D_M in Y year is forecasted using that of D_M+1 in Y-1 year. The forecasting formula of "the original model" is shown in equation 1.

$$Z^{(Y)}(D) = \hat{\alpha}_D \bullet z^{(Y-1)}(D) \tag{1}$$

Here, $Z^{(Y)}(D)$ is a forecasting number of guests on D_M in Y year, $z^{(Y-1)}(D)$ is a actual number of guests on D_M in Y-1 year. And, $\hat{\alpha}_D$ means the increasing rates of the Y year's number of guests to the Y-1 year's number of guests. This is calculated as shown in equation 2.

$$\hat{\alpha}_D = \frac{1}{14} \bullet \frac{\sum_{i=1}^{14} z^{(Y)}(D-i)}{\sum_{i=0}^{13} z^{(Y-1)}(D-i)} \tag{2}$$

As shown in equation (2), $\hat{\alpha}_D$ is calculated by the method of moving averages using the number of guests data for 2 weeks before D_M, not included D_M, in Y year and that before D_M, included D_M, in Y-1 year. Thus, "the original model" is very simple. The, however, forecasting precision is not so high. Because, we consider that "the original model" does not consider the change irregularly generated like weather information, seasonal variation and so on. So, we propose two of the new forecasting method for guests demand for a family restaurant. From next section, "the regression model" and "the regression and the menu change model" are proposed.

THE PROPOSAL FORECASTING METHOD OF "THE REGRESSION MODEL"

As one of the proposal methods, we propose "the regression model". The proposal method consists of following three steps.

Step1 : Selection of explanatory variables by multiple regression analysis
Step2 : Period of regression data and many years' data
Step3 : Correction of a multiple formula by the ratio of the yearly fluctuation

In step 1, we select the explanatory variables. At first, sixteen of factors which are influenced the change of the number of guests are picked up. These factors are shown in Table 1.

Table 1: The factors which are influences the change of the number of guests

Day usually	Vacation (Summer etc.)	Monday	Tuesday
Wednesday	Thursday	Friday	Saturday
Sunday	National holiday	Sunny	Cloudy
Rainy	Daily maximum temperature	The number of guests in previous year	Number of guests of reservations

Next, a multiple regression analysis is performed using these factors as explanatory variables. And, a multiple regression analysis is performed using data for 3 years. A multiple regression formula is represented in equation 3.

$$\begin{aligned} Z(D) &= \hat{\alpha}_0 + \hat{\alpha}_1 \bullet x_1 + \cdots + \hat{\alpha}_n \bullet x_n + \varepsilon \\ &= \sum_{i=0}^{n} (\hat{\alpha}_i \bullet x_i) + \varepsilon, \quad (x_0 \equiv 1) \end{aligned} \tag{3}$$

Here, $\hat{\alpha}_i$ are the estimated values by a multiple regression analysis, and x_i are the explanatory variables. And, ε is an error term. From the result of this multiple regression analysis, the ratio of contribution of this model becomes 0.88, and the conformity of this model is considered to be good. Moreover, to raise the conformity of this model, Fisher's test is performed about each picked up explanatory variable. And, from the result of Fisher's test, the explanatory variables which are performed a multiple regression analysis are selected. Seven of selected explanatory variables are shown in Table 2.

Table 2: The explanatory variables for forecasting the number of guests

Daily maximum temperature	Monday	Tuesday	Sunny
Rainy	The number of guests in previous year	Number of guests of reservations	

"Monday", "Tuesday", "Sunny" and "Rainy" of the explanatory variables are used as a scalar variable (1 or 0).

In step 2, we set the period of regression data and many year's data. The concept of the period of regression data and many years' data is shown in Figure 3.

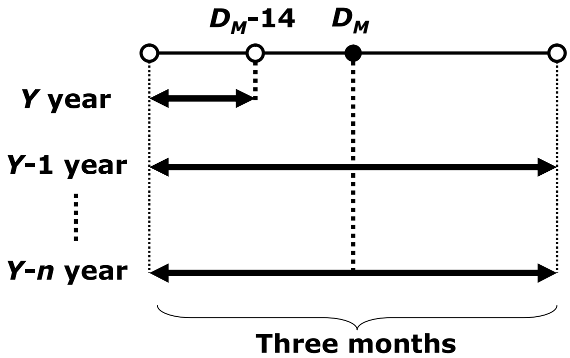

Figure 3: The concept of the period of regression data and many years' data

In Figure 3, D_M is assumed to be a forecasting day. In Japan, four seasons are existed, spring (from March to May), summer (from June to August), autumn (from September to November) and winter (from December to February). To omit the difference among the seasons, one year is divided into four sections. And, the number of guests is forecasted for every section. Therefore, we set the period of regression data for three months. In *Y* year, we set the period of regression data before D_M-14.

Next, we explain it that many years' data are used. In Figure 4, we show a part of the transition of the number of guests every year for three years. In this figure, a horizontal axis represents date, and a vertical axis represents the number of guests. As shown in Figure 4, the number of guests is different among each year. So, in each year, a multiple regression analysis is performed. That is, *n* of multiple regression formulas are leaded by a multiple regression analysis. And, every leaded multiple formulas are averaged. This averaged multiple formula is shown in equation 4.

$$\hat{Z}(D) = \frac{1}{m}\left(\sum_{i=0,\, j=0}^{n,m} \left(\hat{\alpha}_i^{(Y-j)} \bullet x_i^{(Y-j)} \right) + \varepsilon \right) \tag{4}$$

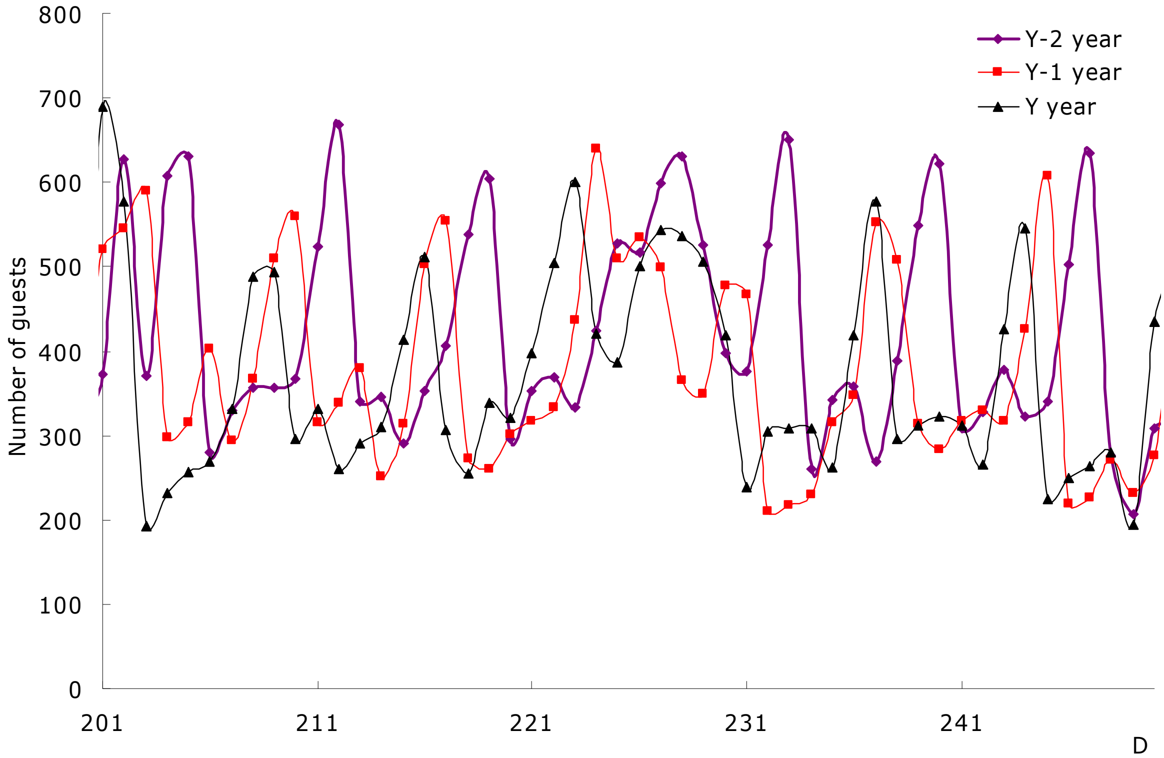

Figure 4: A part of the transition of the number of gurests

In equation 4, $\hat{\alpha}_i$ are the estimated values by a multiple regression analysis ($i = 0, \cdots, n;\quad (n = 7)$), and x_i are the explanatory variables of Table 2 ($i = 0, \cdots, n;\quad (n = 7)$). And, j is a past year ($j = 0, \cdots, m$).

In step 3, we explain a correction of averaged multiple regression formula by the ratio of yearly fluctuation. In step 2, the averaged multiple regression formula ($\hat{Z}(D)$) is leaded by a multiple regression analysis every year. It, however, is thought that error of the yearly fluctuation is still included. This yearly fluctuation is removed by the following ratio as shown in equation 5.

$$\hat{\beta} = \frac{\frac{1}{l} \bullet \sum_{i=1}^{l} z^{(Y)}(D_M - i)}{\frac{1}{n+1}\left(\frac{1}{l} \bullet \sum_{i=1, j=0}^{l,n} z^{(Y-j)}(D_M - i)\right)} \tag{5}$$

In equation 5, $z^{(Y)}(D_M)$ is the actual number of guests on D_M in Y year. That is, in each year, the moving average of the number of guests from D_M–l to D_M–1 (not included D_M) is calculated. And, the ratio to the average of the moving average in all year (from Y year to Y-n year) of the moving average in Y year ($\hat{\beta}$) is calculated. Therefore, the forecasting formula of "the regression model" is shown in equation 6.

$$\hat{Z}'(D) = \hat{\beta} \bullet \hat{Z}(D)$$

$$= \frac{\frac{1}{l} \bullet \sum_{i=1}^{l} z^{(Y)}(D_M - i)}{\frac{1}{n+1}\left(\frac{1}{l} \bullet \sum_{i=1, j=0}^{l,n} z^{(Y-j)}(D_M - i)\right)} \bullet \frac{1}{m}\left(\sum_{i=0, j=0}^{n,m}\left(\hat{\alpha}_i^{(Y-j)} \bullet x_i^{(Y-j)}\right) + \varepsilon\right) \tag{6}$$

THE PROPOSAL FORECASTING METHOD OF "THE REGRESSION AND THE MENU CHANGE MODEL"

As another proposal method, we propose "the regression and the menu change model". Generally, there is a menu of the season in the restaurant. Then, we consider that the increase and decrease of the number of guests by this menu change is added to the forecasting method by a multiple regression analysis. The concept of this model is assumed as shown in Figure 5.

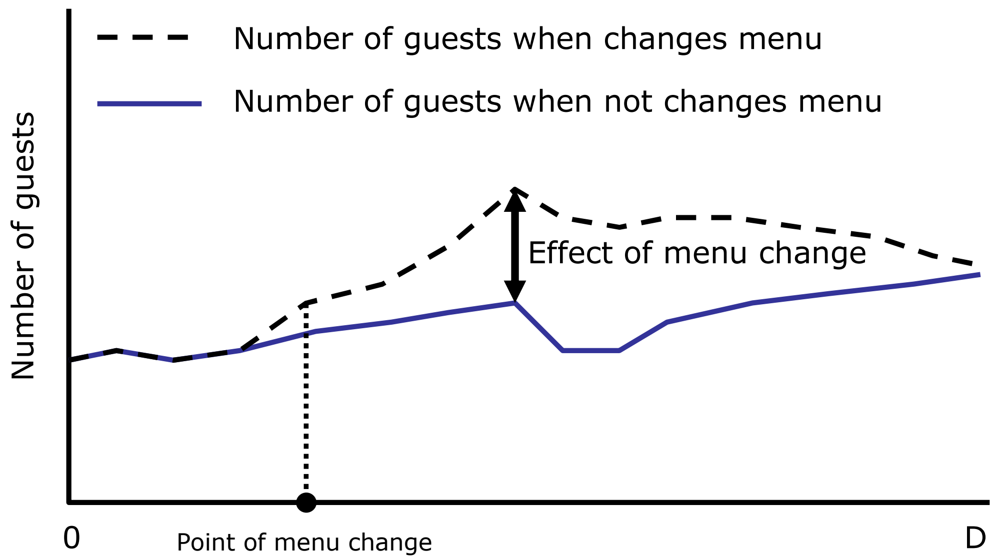

Figure 5: The concept of "the regression and the menu change"

In Figure 5, a horizontal axis represents date, and a vertical axis represents the number of guests. It is assumed that a round mark is the point of the menu change. It is assumed that the solid line is the forecasting number of guests when there is no menu change. And, it is assumed that the dotted line is the forecasting number of guests when there is menu change. That is, it is considered that the difference between the number of guests of solid line and that of dotted line is the effects of the menu change. Therefore, about "the regression and the menu change model", we propose two kinds of forecasting methods. One of them is the model when there is no menu change. The other of them is the one when there is menu change. In this paper, each model is called "the no menu change model" and "the menu change model", respectively.

The forecasting method of "the no menu change model" is base on "the regression model". That is, a multiple regression analysis is performed using seven of explanatory variables shown in Table 2. and, that is performed using many years' data. The period of regression data, however, sets from D_M-k to D_M-1 as shown in Figure 6 (D_M is the point of menu change.).

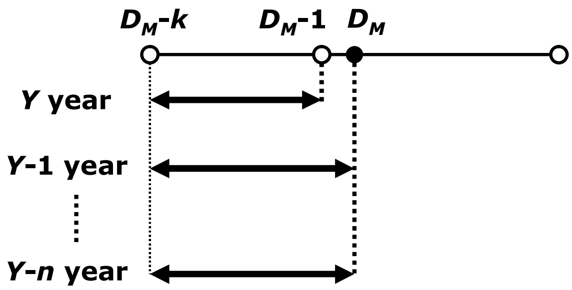

Figure 6: The period of regression data of "the regression and the menu change"

The leaded multiple regression formula by a multiple regression analysis is the forecasting formula of "the no menu change model". This forecasting formula is shown in equation 7.

$$\hat{W}(D) = \frac{1}{n} \bullet \sum_{i=0,\, j=0}^{m,n} \left(\hat{\alpha}_i^{(Y-j)} \bullet x_i^{(Y-j)} \right) + \varepsilon, \qquad (x_0 \equiv 1) \tag{7}$$

Next, the forecasting method of "the menu change model" is proposed. This method is based on the forecasting formula of "the no menu change model". This method is estimated the effects of the menu change. Firstly, the data of D_M is substituted for the forecasting formula, and number of guests on D_M ($\hat{W}(D)$) is calculated. Next, a single regression analysis is performed set $\hat{W}(D)$ as objective variable, and set the actual number of guests on D_M in Y-1 year. $\hat{W}(D)$ is corrected using the leaded single regression formula, and this corrected formula becomes the forecasting formula of "the menu change model" as shown in equation 8.

$$\hat{P}(D) = \hat{\alpha} \bullet \hat{W}(D) + \hat{\beta} \tag{8}$$

Here, $\hat{\alpha}$ and $\hat{\beta}$are an estimated variables by a single regression analysis. The data of D_M is substituted for each forecasting formula, and number of guests of each forecasting model on D_M is calculated.

RESULTS AND EVALUATION

The forecasting results of number of guests for a family restaurant are shown. The regression data for the analysis are the number of guests for three years. Weather information is acquired from web page of The Meteorological Agency. And, period of the evaluation is shown in Table 3.

Table 3: Period of the evaluation

Kinds of forecasting model	Period of the evaluation
The regression	From 1 July *Y* to 19 November *Y*
The no menu change	Form 20 November *Y* to 22 December *Y*
The menu change	Form 20 November *Y* to 22 December *Y*

The date of the point of menu change is 20 November *Y*. As the forecasting result, each forecasting day of the relative error of the evaluation period for each forecasting model is calculated as shown in equation 9. The period of evaluation is difference between "the regression model" and "the regression and the menu change". The average of the relative error of the evaluation period for each forecasting model is shown in Table 4a and Table 4b.

$$(relative\ error) = \left| \frac{(forecasting\ number\ of\ guests) - (actual\ number\ of\ guests)}{(actual\ number\ of\ guests)} \right| \times 100 \quad (9)$$

Table 4a: The result of average of the relative error of the evaluation period

Kinds of forecasting model	Average of the relative error (%)
The original	10.22
The regression	8.48

Table 4b: The result of average of the relative error of the evaluation period

Kinds of forecasting model	Average of the relative error (%)
The original	13.41
The no menu change	13.40
The menu change	9.87

As shown in Table 4 and Table 5, the forecasting precision of all proposed forecasting model are better than that of "the original model". Moreover, the result of a residual analysis is good as shown in Figure 7a and Figure 7b.

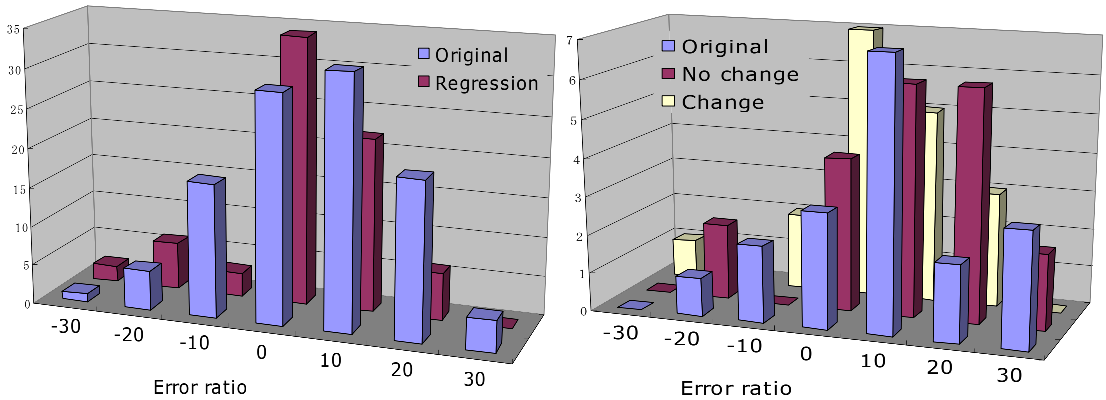

Figure 7a and 7b: The result of residual analysis

CONCLUSION

In this paper, we propose three kinds of new forecasting method for guests demand for a family restaurant based on multiple regression analysis. And, we consider that the increase and decrease of the number of guests by this menu change is added to the forecasting method by a multiple regression analysis. As the result, we find out that forecasting precision of our proposal method is better than that of current forecasting system. Future tasks are to examine whether the proposed forecasting method can be applied to other forecasting demands.

REFERENCES

The Meteorological Agency (http://www.jma.go.jp/JMA_HP/jma/index.html)

INTEGRATED PRODUCTION, INVENTORY AND MAINTENANCE POLICIES FOR A SINGLE-VENDOR SINGLE-BUYER SYSTEM WITH IMPERFECT PRODUCTION PROCESS

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ABSTRACT
In this paper we deal with the single vendor single buyer integrated production inventory and maintenance problem in the context of imperfect production process. The production unit, assumed to randomly shift to an out-of-control state, is subject to a new setup and a maintenance action at the end of each production cycle. The main purpose of this study is to establish an optimal plan of production, shipment and maintenance which allows satisfying the demand at a minimum total cost. We propose two different strategies. The first one suggests that the buyer orders batches of size nQ and the vendor produces nQ and makes equal shipments of size Q. The second policy proposes that to satisfy the same ordered quantity, the vendor produces separately smaller batches of size Q, n times. The total integrated average cost per time unit corresponding to each strategy is considered as the performance criterion allowing choosing the best policy for any given situation.

INTRODUCTION
The Economic Ordering Lot sizing (or Economic Production Lot sizing) problem have been widely and differently treated in the literature in both single and joint context. The models proposed, since Harris's classic square root economic order quantity (EOQ) model, have been improved relaxing assumptions and/or taking into account more factors and parameters.

Many of these models related to the case of imperfect production process. Individual models such as those developed by Rosenblatt and Lee (1986), Cheng (1991) and Khouja and Mehrez (1994) assumed that the production process shifts to an out-of-control state after a random period of time but didn't suggest any maintenance policy to resolve this unreliability problem. On the other hand, Lee and Srinivason (2001), Ben-Daya and Khursheed (2002) and Ben-Daya (2002) considered integrated production-inventory and preventive maintenance models. Later on, Sheu and Chen (2004) made a lot-sizing model to determine the level of preventive maintenance for an imperfect process control. Aghezzaf et al. (2006) proposed a combined production and maintenance strategy in a batch production system context. Their model allows determining an integrated production and maintenance plan that satisfies the demand over the entire horizon without backlogging, and which minimizes the expected total production and maintenance costs. Recently, Chelbi et al (2008) have modelled an integrated production-maintenance strategy for unreliable production systems producing conforming and non-conforming items. The related optimal solutions, minimising the total average cost per time unit, correspond to the optimal values of the lot size and the age at which preventive maintenance must be performed.

As regards joint vendor-buyer models in the context of imperfect or deteriorating items, one can say that all of them integrate production, inventory and quality control management policies. For example, Yang and Wee (2002) develop a model in a single vendor with a deteriorating production system and multi-buyers. Their results show that the integrated approach is much better than the independent one. Ouyang et al. (2003) assumed in their study about buyer-vendor inventory problem that an arrival order lot may contain some defective items of a random rate. They gave an integrated mixture inventory model with backorders and lost sales. Huang (2004) considered a defective process, in a single-vendor and single-buyer supply chain, which produces a random percentage of imperfect items. He derived an analytic solution in a practical situation where the delivered quantity, at each replenishment, is identical.

In this paper we propose and compare two joint single-vendor single buyer strategies integrating production, inventory and maintenance policies. The expected total integrated cost per time unit, yielded by these strategies in optimal conditions, corresponds to the decision criterion for the choice of the best strategy for any given situation. We assume that the production process is imperfect; it may shift randomly from an in-control to an out-of-control state characterized by a fixed production rate of imperfect items. Contrarily to the joint models cited above, we propose to perform a maintenance action at the end of each production cycle searching to minimize costs related to the production of non-conforming items. The maintenance action depends on the state of the system (preventive for the in-control state and corrective for the out-of-control one) and is assumed to restore the system to an as good as new condition.

In next section, we formulate the problem. Notation and assumptions are presented in section 3. The mathematical model is developed and the numerical procedure is described in section 4. Section 5 presents an illustrative example with the obtained results. Finally, some concluding remarks are summarized in section 6.

PROBLEM FORMULATION

This paper develops two integrated vendor–buyer production, inventory and maintenance strategies in the context of an imperfect production process that may shift randomly to an out-of-control state characterized by the production of non-conforming units at a fixed rate. We develop a framework allowing choosing one of two proposed strategies in order to minimize the total integrated average cost rate for any given situation.

We assume that the production cycle starts with a new system in an in-control state producing items of acceptable quality at a rate P greater than the average demand rate D. After a random period of time τ, the production system (considered as a single unit) shifts to an out-of-control state producing non-conforming units, at a fixed rate α, which are instantaneously detected and rejected thanks to a 100% screening process. At the end of each production cycle, a maintenance action and a new setup are performed. The maintenance action could be either preventive in case the system has not shifted to the out-of-control state, or corrective (overhaul) in case such a shift has occurred. Both types of maintenance actions allow restoring the system to an as good as new condition before the next production cycle start.

In such a context of imperfect production process, the two proposed integrated vendor-buyer production-inventory policies are the following. The first one, we call continuous production strategy, suggests that the buyer orders batches of size nQ every time his on hand inventory reaches the reorder point s after the reception of all the last ordered quantity. The vendor manufactures the quantity nQ continuously but delivers periodically by lot of size Q every Q/D time units. At the end of each production cycle, a preventive or a corrective maintenance action is undertaken depending on whether the production unit has shifted or not to the out-of-control state generating non-conforming rejected items. In case the shift has occurred, the quantity shipped at each of the shipment dates could be inferior to Q and then the buyer would incur a shortage cost since he would not be able to satisfy his customer's orders.

The second policy, called lot-for-lot strategy, consists in producing and delivering the ordered quantity *nQ* in smaller batches of size *Q* separately. A preventive maintenance action is performed immediately after the production of each lot, in case the system has not shifted to the out-of-control state, in order to restore the system to the as good as new condition before launching the production of the next lot. In case the shift to the out-of-control state occurs, only the quantity in the vendor's stock (inferior to *Q*) will be delivered before undertaking a corrective maintenance action. Each item non-chipped on time won't be replaced and a related shortage cost will be incurred by the buyer.

The total integrated average cost per time unit corresponding to each strategy is considered as the performance criterion. The mathematical expressions of this cost rate are developed for each policy and a computational procedure is used to find the best choice (n*,Q*) for any given situation with given costs related to inventory (held by the buyer and the vendor), maintenance and quality; and given the probability distribution associated to the time to shift to the out-of-control state.

ASSUMPTIONS AND NOTATION

We adopt the following notation and assumptions to formulate the proposed model. Some additional notations and assumptions will be listed where used.

Notation:

D	average demand rate in units per unit time
P	production rate in units per unit time
a	production rate of non-conforming units
τ	time to shift to the out-of-control state (random variable)
n	number of lots ordered by the buyer from the vendor
Q	elementary lot size
c_t	the capacity of the transport equipment
K	setup cost for the vendor
A	ordering cost for each order of size nQ
F	transportation cost for each shipment
h_v	holding cost per unit per unit time for the vendor
h_b	holding cost per unit per unit time for the buyer
$ETC^{(1)}$	expected total cost per unit time for the continuous production strategy
$ETC^{(2)}$	expected total cost per unit time for the lot-for-lot strategy
C_{cm}	Corrective maintenance action cost
C_{pm}	Preventive maintenance action cost
C_s	Shortage cost per non delivered item
C_{cq}	Quality control cost per unit
C_{nq}	Incurred cost per non-conforming unit
$f(\tau)$	probability density function associated to the time to shift to the out-of control state

Assumptions:

1. All costs are supposed to be constant and known.
2. The capacity of the transport equipment is fixed and known.
3. The shift to the out-of-control state is instantaneously detected.
4. The production rate of non-conforming items a is inferior to the vendor's inventory accumulation rate: $a \le P-D$.
5. All non-conforming items produced are detected and automatically rejected.
6. The buyer incurs a constant penalty cost (shortage cost) per each non-shipped item by the vendor
7. Maintenance actions take negligible durations and restore the system to the as good as new state.

MODELS DEVELOPMENT

The expected total integrated cost per time unit for both strategies is expressed as follows:

$$ETC^{(i)}(n,Q)=TC_b^{(i)}+TC_v^{(i)}$$

$$= EC_O^{(i)}+EC_T^{(i)}+EC_P^{(i)}+EC_{SB}^{(i)}+EC_K^{(i)}+EC_M^{(i)}+EC_{SV}^{(i)}+EC_{NQ}^{(i)}+EC_{CQ}^{(i)} \quad (1)$$

TC_b and TC_v are the expected total costs respectively for the buyer and the vendor. TC_b corresponds to the sum of the ordering cost (EC_O), the transportation cost (EC_T), the Shortage cost (EC_P) and the buyer's inventory holding cost (EC_{sb}). TC_v is composed of the setup cost (EC_K), the vendor's inventory holding cost (EC_{sv}), the cost of non-conforming items (EC_{NQ}), the quality control cost (EC_{CQ}) and the maintenance cost (EC_M). Let's detail all components to make up the expected total integrated cost rate expression for each policy.

CONTINUOUS PRODUCTION STRATEGY

The expected ordering and transportation costs correspond respectively to:

$$EC_O^{(1)}=\frac{A}{\frac{nQ}{D}}=\frac{AD}{nQ} \quad (2)$$

$$EC_T^{(1)}=\frac{nF}{\frac{nQ}{D}}=\frac{FD}{Q} \quad (3)$$

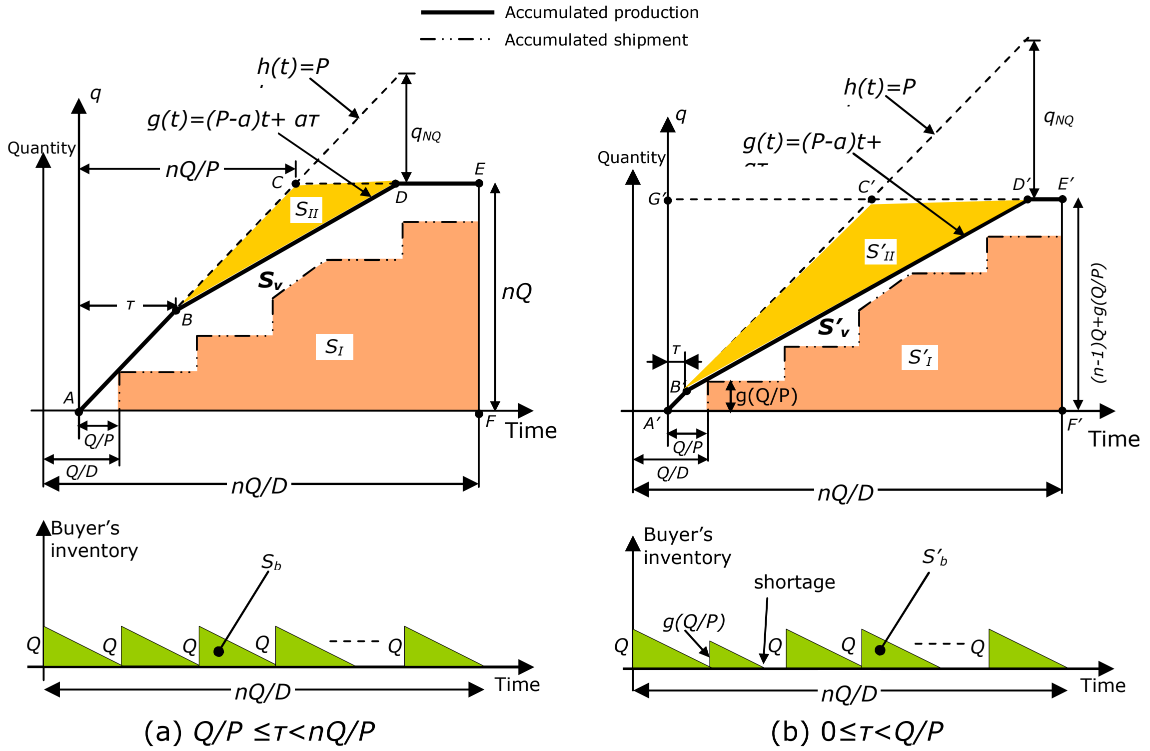

Figure1. Vendor's accumulated production and shipment, and buyer's inventory variations for the continuous production strategy

Looking at figure 1 and particularly figure 1-b, one has to notice that shortage would occur only, at the first shipment date Q/D or Q/P time units after the production launch, if $\tau<Q/P$ (figure 1b). Even if $\tau=0$ and the vendor's inventory is accumulated at a rate D (i.e. $a=a_{max}=P-D$) the inventory level at each of the following shipment dates will be

equal to Q. Let $q_S(\tau)$ be the shortage quantity. Hence, the expected shortage cost is equal to:

$$EC_p^{(1)} = \frac{C_S D}{nQ}\int_0^{+\infty} q_S(\tau) f(\tau)d\tau = \frac{C_S D}{nQ}\int_0^{Q/P}\left(Q - g\left(\frac{Q}{P}\right)\right)f(\tau)d\tau$$

$$= \frac{C_S D}{nQ}\int_0^{Q/P}\left(Q-(P-a)\frac{Q}{P} - a\tau\right)f(\tau)\,d\tau = C_S aD\left[\frac{1}{nP}\int_0^{Q/P} f(\tau)d\tau - \frac{1}{nQ}\int_0^{Q/P}\tau f(\tau)d\tau\right] \quad (4)$$

To calculate the buyer's expected inventory holding cost $EC_{SB}^{(1)}$, we have to determine the surfaces, under the buyer's inventory variation curves, S_b and S'_b corresponding respectively to the case where the system shifts to the out-of-control state during the production of the first lot and the case where this shift occurs after the first shipment date (surfaces in green on figures 1a and 1b).

$$EC_{SB}^{(1)} = \frac{h_b D}{nQ}\left[\int_0^{Q/P} S'_b f(\tau)d\tau + \int_{Q/P}^{+\infty} S_b f(\tau)d\tau\right]$$

$$= \frac{h_b D}{nQ}\left[\int_0^{Q/P}\left[\frac{Q^2}{D}\left(\frac{n}{2} - \frac{a}{P} + \frac{a^2}{2P^2}\right) + \frac{aQ}{D}\left(1-\frac{a}{P}\right)\tau + \frac{a^2}{2D}\tau^2\right]f(\tau)d\tau + \int_{Q/P}^{+\infty}\frac{nQ^2}{2D}f(\tau)d\tau\right]$$

$$= h_b\frac{Q}{2} + \frac{h_b}{n}\left[Q\left(\frac{a^2}{2P^2} - \frac{a}{P}\right)\int_0^{Q/P} f(\tau)d\tau + a\left(1-\frac{a}{P}\right)\int_0^{Q/P}\tau f(\tau)d\tau + \frac{a^2}{2Q}\int_0^{Q/P}\tau^2 f(\tau)d\tau\right] \quad (5)$$

The expected setup and maintenance costs correspond to:

$$EC_K^{(1)} = \frac{K}{\frac{nQ}{D}} = \frac{KD}{nQ} \quad (6)$$

$$EC_M^{(1)} = \frac{D}{nQ}\left[C_{cm}\int_0^{nQ/P} f(\tau)d\tau + C_{pm}\int_{nQ/P}^{+\infty} f(\tau)d\tau\right] = \frac{C_{pm}D}{nQ} + (C_{cm} - C_{pm})\frac{D}{nQ}\int_0^{nQ/P} f(\tau)d\tau \quad (7)$$

The vendor's inventory holding cost $EC_{SV}^{(1)}$ for the continuous strategy is obtained considering the surfaces between the accumulated production curve and the accumulated shipment one S_v and S'_v, for the same cases considered for $EC_{sb}^{(1)}$ (see figure 1a and 1b):

$$EC_{SV}^{(1)} = \frac{h_v D}{nQ}\left[\int_0^{Q/P} S'_v f(\tau)d\tau + \int_{Q/P}^{nQ/P} S_v f(\tau)d\tau + \int_{nQ/P}^{+\infty}(S_{ACEF} - S_I)f(\tau)d\tau\right]$$

$$= \frac{h_v Q}{2}\left[n\left(1-\frac{D}{P}\right) - 1 + 2\frac{D}{P}\right]$$

$$- h_v\frac{aDQ}{P}\left[\frac{n}{2(P-a)}\int_0^{nQ/P} f(\tau)d\tau + \frac{1}{n}\left[\frac{a}{2P^2} - \frac{n-1}{P} - \frac{an}{P(P-a)} + \frac{a^2}{2P^2(P-a)}\right]\int_0^{Q/P} f(\tau)d\tau\right]$$

$$+ h_v\frac{aD}{nP}\left[\frac{nP}{P-a}\int_0^{nQ/P}\tau f(\tau)d\tau - \frac{(n-1)P+a}{P-a}\int_0^{Q/P}\tau f(\tau)d\tau\right]$$

$$- h_v\frac{aD}{2nQ(P-a)}\left[P\int_0^{nQ/P}\tau^2 f(\tau)d\tau - a\int_0^{Q/P}\tau^2 f(\tau)d\tau\right] \quad (8)$$

The expected cost of non-conforming items is given by:

$$EC_{NQ}^{(1)} = \frac{C_{nq}D}{nQ}\int_0^{+\infty} q_{NQ}(\tau) f(\tau)d\tau \quad (9)$$

where, q_{NQ} represents the quantity of non-conforming items depending on τ. Obviously, q_{NQ} is equal to zero when there is no shift to the out-of-control state (case $\tau \geq nQ/P$). Consequently, $EC_{NQ}^{(1)}$ is obtained by:

$$EC_{NQ}^{(1)} = \frac{C_{nq}D}{nQ}\left[\int_0^{Q/P}\left[h(t_{D'}) - \left[(n-1)Q + g\left(\frac{Q}{P}\right)\right]\right]f(\tau)d\tau + \int_{Q/P}^{nQ/P}(h(t_D) - nQ)f(\tau)d\tau\right]$$

$$= \frac{C_{nq}D}{nQ}\left[\int_0^{Q/P}\left[\frac{(nP-a)Q}{P-a} - nQ - a\left(\tau - \frac{Q}{P}\right)\right]f(\tau)d\tau + \int_{Q/P}^{nQ/P}\left(\frac{nPQ - aP\tau}{P-a} - nQ\right)f(\tau)d\tau\right]$$

$$= \frac{aC_{nq}D}{P-a}\left[\int_0^{nQ/P}f(\tau)d\tau - \frac{a}{nP}\int_0^{Q/P}f(\tau)d\tau - \frac{P}{nQ}\int_0^{nQ/P}\tau f(\tau)d\tau + \frac{a}{nQ}\int_0^{Q/P}\tau f(\tau)d\tau\right] \quad (10)$$

Letting q_{CQ} be the whole produced quantity (conforming and non-conforming items), the expected quality control cost $EC_{CQ}^{(1)}$ can be written as:

$$EC_{CQ}^{(1)} = \frac{C_{cq}D}{nQ}\int_0^{+\infty} q_{CQ}(\tau)f(\tau)d\tau$$

$$= \frac{C_{cq}D}{nQ}\left[\int_0^{Q/P}h(t_{D'})f(\tau)d\tau + \int_{Q/P}^{nQ/P}h(t_D)f(\tau)d\tau + \int_{nQ/P}^{+\infty}nQ\cdot f(\tau)d\tau\right]$$

$$= \frac{C_{cq}D}{nQ}\left[\int_0^{Q/P}Pt_{D'}f(\tau)d\tau + \int_{Q/P}^{nQ/P}Pt_Df(\tau)d\tau + nQ\int_{nQ/P}^{+\infty}f(\tau)d\tau\right]$$

$$= \frac{C_{cq}D}{nQ}\left[\int_0^{Q/P}\left(\frac{(nP-a)Q}{P-a}\right)f(\tau)d\tau + \int_{Q/P}^{nQ/P}\left(\frac{nPQ}{P-a} - \frac{aP}{P-a}\tau\right)f(\tau)d\tau + nQ\int_{nQ/P}^{+\infty}f(\tau)d\tau\right]$$

$$= C_{cq}D + \frac{aC_{cq}D}{P-a}\left[\int_0^{nQ/P}f(\tau)d\tau - \frac{1}{n}\int_0^{Q/P}f(\tau)d\tau - \frac{P}{nQ}\int_{Q/P}^{nQ/P}\tau f(\tau)d\tau\right] \quad (11)$$

Using equations (2) to (11) we obtain the expression of the expected total cost rate for the continuous production strategy:

$$\begin{aligned}ETC^{(1)}(n,Q) = {} & \frac{D}{Q}\left(\frac{A + K + C_{pm}}{n} + F\right) + \frac{Q}{2}\left[h_b + h_v\left[n\left(1 - \frac{D}{P}\right) - 1 + 2\frac{D}{P}\right]\right] + C_{cq}D \\
& + \frac{aD}{nP}\left[C_S - \frac{P}{P-a}C_{cq} - \frac{a}{P-a}C_{nq} + h_b\frac{Q}{D}\left(\frac{a}{2P} - 1\right)\right. \\
& \qquad \left. - h_vQ\left(\frac{a}{2P^2} - \frac{n-1}{P} - \frac{an}{P(P-a)} + \frac{a^2}{2P^2(P-a)}\right)\right] \times \int_0^{Q/P}f(\tau)d\tau \\
& + \frac{aD}{P-a}\left[C_{cq} + C_{nq} + \frac{P-a}{naQ}(C_{cm} - C_{pm}) - \frac{nQ}{2P}h_v\right] \times \int_0^{nQ/P}f(\tau)d\tau \\
& + \frac{aD}{n(P-a)}\left[nh_v - \frac{P}{Q}C_{nq}\right] \times \int_0^{nQ/P}\tau f(\tau)d\tau - \frac{aPD}{nQ(P-a)}C_{cq}\int_{Q/P}^{nQ/P}\tau f(\tau)d\tau \\
& + \frac{aD}{n}\left[\frac{a}{(P-a)Q}C_{nq} - \frac{C_S}{Q} + \frac{h_b}{D}\left(1 - \frac{a}{P}\right) - \frac{(n-1)P + a}{P(P-a)}h_v\right] \times \int_0^{Q/P}\tau f(\tau)d\tau \\
& + \frac{a^2}{2nQ}\left[h_b + \frac{D}{(P-a)}h_v\right] \times \int_0^{Q/P}\tau^2 f(\tau)d\tau - \frac{aPD}{2nQ(P-a)}h_v\int_0^{nQ/P}\tau^2 f(\tau)d\tau \quad (12)\end{aligned}$$

LOT-FOR-LOT STRATEGY:

The expected ordering transportation and shortage costs are given by:

$$EC_O^{(2)} = \frac{A}{\frac{nQ}{D}} = \frac{AD}{nQ} \quad (13)$$

$$EC_T^{(2)} = \frac{nF}{\frac{nQ}{D}} = \frac{FD}{Q} \quad (14)$$

$$EC_p^{(2)} = \frac{C_S D}{nQ}\int_0^{+\infty} q_S(\tau) f(\tau)d\tau = \frac{C_S D}{nQ}\left[n\int_0^{Q/P}\left(Q - g\left(\frac{Q}{P}\right)\right) f(\tau)d\tau\right]$$
$$= \frac{C_S D}{nQ}\left[n\left(\frac{aQ}{P}\int_0^{Q/P} f(\tau)d\tau - a\int_0^{Q/P} \tau f(\tau)d\tau\right)\right] = \frac{aC_S D}{Q}\left[\frac{Q}{P}\int_0^{Q/P} f(\tau)d\tau - \int_0^{Q/P} \tau f(\tau)d\tau\right] \quad (15)$$

q_S represents the shortage quantity.

Considering the surface between the buyer's inventory variation curve and the time axis (the green surface in figure 2 which represents one possible scenario), the expected buyer's inventory holding cost is expressed by:

$$EC_{SB}^{(2)} = \frac{h_b D}{nQ}\left[n\left(\int_0^{Q/P}\frac{[g(Q/P)]^2}{2D} f(\tau)d\tau + \int_{Q/P}^{+\infty}\frac{Q^2}{2D} f(\tau)d\tau\right)\right]$$
$$= \frac{h_b D}{nQ}\left[n\left(\int_0^{Q/P}\frac{[Q + a(\tau - Q/P)]^2}{2D} f(\tau)d\tau + \int_{Q/P}^{+\infty}\frac{Q^2}{2D} f(\tau)d\tau\right)\right]$$
$$= \frac{h_b D}{Q}\left[\frac{Q^2}{2D} + \frac{aQ^2}{PD}\left(\frac{a}{2P} - 1\right)\int_0^{Q/P} f(\tau)d\tau + \frac{aQ}{D}\left(1 - \frac{a}{P}\right)\times\int_0^{Q/P}\tau f(\tau)d\tau + \frac{a^2}{2D}\int_0^{Q/P}\tau^2 f(\tau)d\tau\right] \quad (16)$$

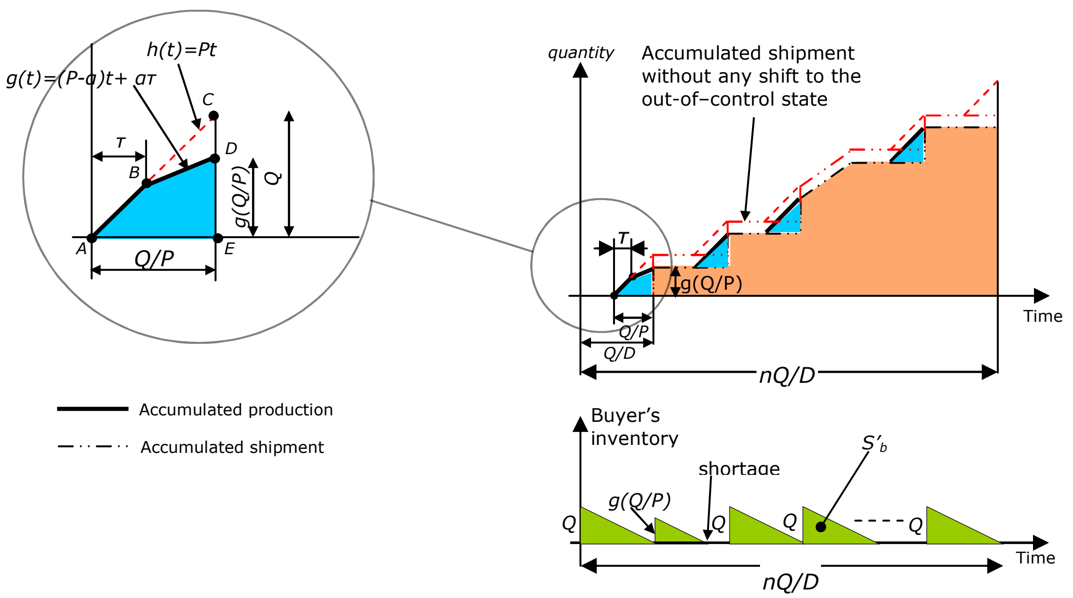

Figure2. Vendor's accumulated production and shipment, and buyer's inventory variations for the lot-for-lot strategy (scenario corresponding to only one shift to the out of control state during the first production cycle)

The following expressions represent the setup and maintenance costs:

$$EC_K^{(2)} = \frac{nK}{\frac{nQ}{D}} = \frac{KD}{Q} \quad (17)$$

$$EC_M^{(2)} = \frac{D}{nQ}\left[n\left(C_{cm}\int_0^{Q/P} f(\tau)d\tau + C_{pm}\int_{Q/P}^{+\infty} f(\tau)d\tau\right)\right] = \frac{D}{Q}\left(C_{pm} + (C_{cm} - C_{pm})\frac{D}{nQ}\int_0^{nQ/P} f(\tau)d\tau\right) \quad (18)$$

To calculate the expected vendor's inventory holding cost, we have to consider the surface between the accumulated production curve and the accumulated shipment one (e.g. the surface in blue in figure 2 related to the case of only one shift to the out-of-control state during the production of the first lot). Therefore, $EC_{sv}^{(2)}$ corresponds to:

$$
\begin{aligned}
EC_{SV}^{(2)} &= \frac{h_v D}{nQ}\left[n\left(\int_0^{Q/P} S_{ABDE} f(\tau)d\tau + \int_{Q/P}^{+\infty} S_{ACE} f(\tau)d\tau\right)\right] \\
&= \frac{h_v D}{nQ}\left[n\left(\int_0^{Q/P}\left[\frac{Q^2}{2P} - \frac{1}{2}\left(Q - g\left(\frac{Q}{P}\right)\right)\times\left(\frac{Q}{P} - \tau\right)\right] f(\tau)d\tau + \int_{Q/P}^{+\infty}\frac{Q^2}{2P} f(\tau)d\tau\right)\right] \\
&= h_v D\left[\frac{Q}{2P} - \frac{aQ}{2nP^2}\int_0^{Q/P} f(\tau)d\tau + \frac{a}{nP}\int_0^{Q/P}\tau f(\tau)d\tau - \frac{a}{2nQ}\int_0^{Q/P}\tau^2 f(\tau)d\tau\right] \qquad (19)
\end{aligned}
$$

Regarding the expected cost of non-conforming items and the quality control cost, they are given respectively by:

$$
\begin{aligned}
EC_{NQ}^{(2)} &= \frac{C_{nq} D}{nQ}\int_0^{+\infty} q_{NQ}(\tau) f(\tau)d\tau = \frac{C_{nq} D}{nQ}\left[n\left[\int_0^{Q/P}\left(Q - g\left(\frac{Q}{P}\right)\right) f(\tau)d\tau\right]\right] \\
&= \frac{aC_{nq} D}{Q}\left[\frac{Q}{P}\int_0^{+\infty} f(\tau)d\tau - \int_0^{+\infty}\tau f(\tau)d\tau\right] \qquad (20)
\end{aligned}
$$

$$
EC_{CQ}^{(2)} = \frac{C_{cq} nQ}{\frac{nQ}{D}} = C_{cq} D \qquad (21)
$$

We can finally conclude, from equation (13) to (21), that the expression of the expected total integrated cost rate for the lot-for-lot strategy can be written as:

$$
\begin{aligned}
ETC^{(2)}(n,Q) = {} & \frac{D}{Q}\left(\frac{A}{n} + K + C_{pm} + F\right) + \frac{Q}{2}\left(h_b + h_v\frac{D}{P}\right) + C_{cq} D \\
& + \frac{aD}{P}\left[C_S + C_{nq} + \frac{P}{aQ}(C_{cm} - C_{pm}) - \frac{h_v Q}{2nP} + \frac{h_b Q}{D}\left(\frac{a}{2P} - 1\right)\right]\times\int_0^{Q/P} f(\tau)d\tau \\
& + aD\left[\frac{h_v}{nP} + \frac{h_b}{D}\left(1 - \frac{a}{P}\right) - \frac{C_{nq}}{Q} - \frac{C_S}{Q}\right]\times\int_0^{Q/P}\tau f(\tau)d\tau \\
& + \frac{a}{2Q}\left[ah_b - \frac{D}{n}h_v\right]\times\int_0^{Q/P}\tau^2 f(\tau)d\tau \qquad (22)
\end{aligned}
$$

NUMERICAL PROCEDURE

Due to the complexity of the models, we developed a numerical procedure (figure 3) to obtain approximate optimal solutions ($ETC^{(i)}*$, $n*$, $Q*$) for the proposed strategies for any given situation. The best strategy to adopt corresponds to the one yielding the lowest expected total integrated cost per time unit.

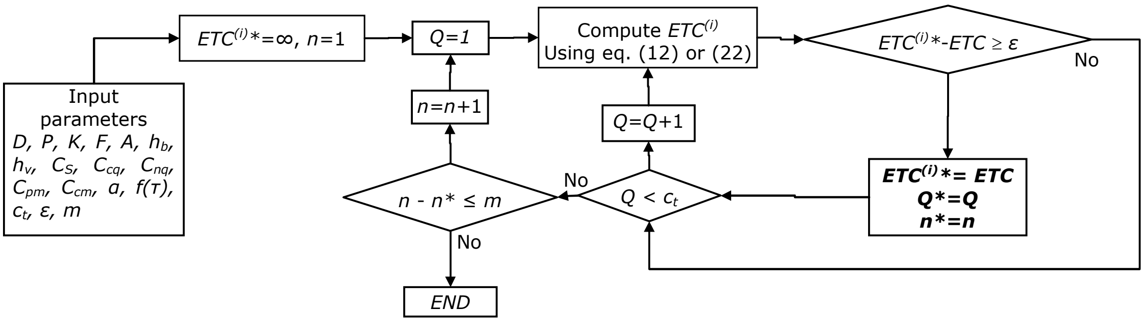

Figure3. Approximate optimal solution computation algorithm

NUMERICAL EXAMPLE AND DISCUSSION

To illustrate our approach, we consider a situation with the following input data which have been arbitrarily chosen. The obtained results are shown in table1.

Input data:

- The distribution associated to the time to shift to the out-of-control state is a Weibull law with shape parameter θ=1.5 and scale parameter λ=2.
- P= 3200units/time unit, D=1000 units/time unit.
- K=200\$, F= 25\$, A=50\$.
- h_b=5\$/unit/time unit, h_v=3\$/unit/time unit.
- C_{cm}=200\$.
- C_{cq}= 0.5\$/unit, C_{nq}= 20\$/unit, C_S= 20\$/unit.

		Lot-lot-lot strategy			*Continuous strategy*			$ETC^{*(2)}$- $ETC^{*(1)}$
	C_{pm}	n^*	Q^*	$ETC^{*(2)}$	n^*	Q^*	$ETC^{*(1)}$	
α = 1000 units/time unit	5	389	222	2487.40	3	106	2449.58	37.82
	50	409	242	2671.10	3	112	2574.28	96.82
	100	343	262	2857.70	3	119	2703.47	154.23
	190	430	295	3158.24	4	103	2907.81	250.43
α = 1250 units/time unit	**5**	**258**	**213**	**2547.96**	**3**	**98**	**2572.50**	**-24.54**
	50	**348**	**232**	**2739.40**	**3**	**104**	**2708.41**	**30.99**
	100	240	252	2934.53	3	110	2849.70	84.83
	190	311	283	3249.06	3	121	3082.93	166.13
α = 1500 units/time unit	5	316	206	2604.96	2	127	2704.70	-99.74
	50	256	224	2804.28	3	96	2861.35	-57.07
	100	**370**	**242**	**3006.75**	**3**	**102**	**3016.04**	**-9.29**
	190	**298**	**272**	**3334.82**	**3**	**111**	**3272.42**	**62.40**

Table1. Obtained numerical results

The results shown in table1 demonstrate that the best approximate solution can be yielded by either one of both considered policies depending on the set of input parameters. It is interesting to notice that, a decrease of the preventive maintenance action cost tends to favour the lot-for-lot strategy except in the case where non-conforming items are produced at a relatively reduced rate (e.g. α=1000units/time unit). Even for this case where the continuous production strategy remains more economic for C_{pm}≥5\$, the profit made, compared with the lot-for-lot strategy, diminishes considerably with the decrease of C_{pm} ($ETC^{*(2)}$-$ETC^{*(1)}$ decreases from 250.43\$ to 37.82\$/time unit when C_{pm} varies from 190\$ to 5\$). In fact, it seems that for the considered situation, the lot-for-lot strategy yields the best approximate optimal solution when C_{pm} becomes lower than a certain threshold C_{pm}^*(5\$<C_{pm}^*<50\$ for α=1250units/time unit and 100\$<C_{pm}^*<190\$ for α=1500units/time unit). The continuous production strategy will be adopted when C_{pm}>C_{pm}^*. In addition, as C_{pm} gets lower and lower than C_{pm}^* the lot-for-lot strategy becomes more and more economic (e.g. for α=1500units/time unit $ETC^{*(2)}$-$ETC^{*(1)}$=9.29\$/time unit and reaches 99.74\$/time unit when C_{pm} changes from 100\$ to 5\$).

We also notice that globally, an increasing rate of non-conforming items would encourage the buyer and the vendor to choose the lot-for-lot strategy. Indeed, for ɑ=1000units/time unit the continuous production strategy provides the best solutions even for small values of the preventive maintenance cost (C_{pm}=5$); however, in the case of a higher rejection rate (1500units/time unit), the lot-for-lot strategy remains the most economic for great values of C_{pm} ($C_{pm} \leq 100$\$). Furthermore, we note that the threshold value $C_{pm}*$ increases with ɑ, making the lot-for-lot strategy more likely to be the best. In this perspective, we point out that for a given constant preventive maintenance cost, the lot-for-lot strategy becomes more and more profitable than the continuous one, when the production rate of non-conforming items rises (for C_{pm}=5$, $ETC^{*(2)}$-$ETC^{*(1)}$=24.54$/time unit and becomes 99.74$/time unit when ɑ rises from 1250 to 1500units/time unit).

We can conclude that the lot-for-lot strategy, characterized by a great number of maintenance actions, is intended for systems which generate relatively high rates of non-conforming items. This strategy reduces the period of time between suucessive maintenance actions (time to produce one lot of size *Q*) which allows decreasing the probability to shift to the out-of-control state. Consequently, the expected cost of non-conforming items and the expected shortage cost would be reduced.

Contrarily, the continuous production strategy is more interesting for small production rates of non-conforming units. In this case, the incurred expected costs related to shortages and the rejection of non-conforming items would not be prevailing compared to the maintenance cost. That is, it would not be justified multiplying the number of maintenance actions since it would cost more than shortages and the production of non-conforming items.

CONCLUSION

In this paper we proposed two single-vendor single-buyer management strategies in the context of an imperfect process that may shift randomly to an out-of-control state. Unlike the hitherto studies we considered simultaneously production inventory and maintenance policies. Arbitrarily chosen numerical data have been used to illustrate our approach. We demonstrated how one or the other policy could turn out to be more cost-effective depending on the values taken by the different input parameters.

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DETERMINING APPROPRIATE SUPPLY CHAIN INVENTORY STRATEGY FROM DIFFERENT PRODUCT LIFE CYCLE PATTERNS

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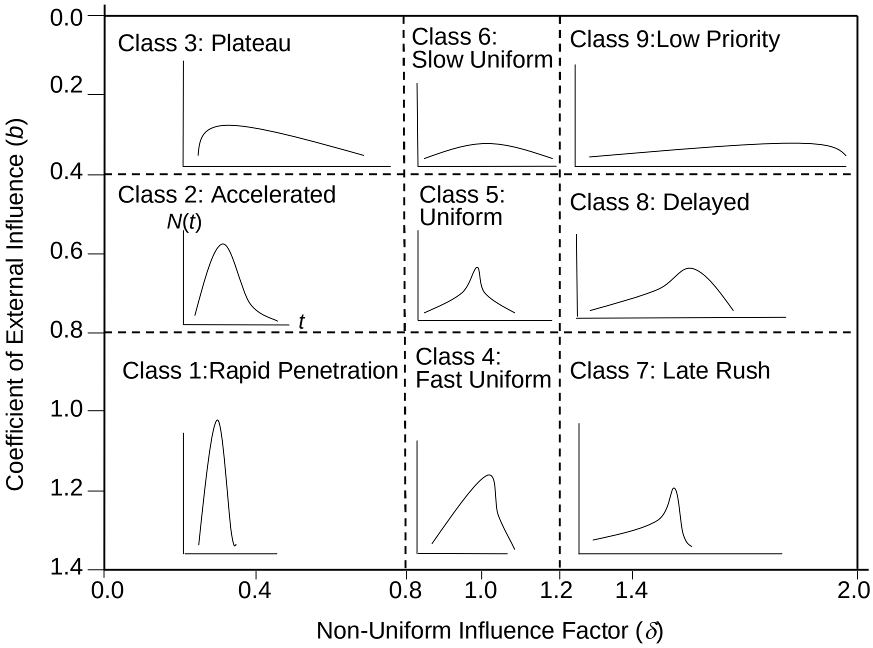
ABSTRACT
The Easingwood's (1998) product life cycle (PLC) model based on diffusion theory shows that larger external influence factor, b, induces spontaneous demand with high variation, while smaller non-uniform influence coefficient, δ, makes the peak demand occur earlier. Past research indicates that information sharing has higher benefits when demand variation is larger. Based on distinct PLC patterns, we experiment with simulation to study the benefits of implementing VMI practices as compared to traditional (*s,S,R*) policy. Two hypotheses regarding the effects *b* and δ on inventory benefits for VMI practice v.s. (*s,S,R*) policy are proposed and verified. The results suggest that for products with larger *b* and smaller δ, companies can gain more benefits from implementing VMI practices than for products with smaller *b* and larger δ.

INTRODUCTION
The supplier in a supply chain usually has difficulty in making appropriate inventory strategy due to the distorted market demand information caused by the multiple echelons of a supply chain. Therefore, suppliers having close relationship with their downstream members can implement special practices, e.g. VMI, to reduce inventories while maintaining high level of customer services by obtaining both inventory and market demand information from downstream members. However, in many cases, suppliers cannot easily acquire precise market demand as well as inventory statuses of downstream members. In addition, the costs of implementing special supply chain management (SCM) practices may alleviate or even counterbalance their benefits. Since diverse market demands incur different benefits in inventory saving and customer service levels, we need to evaluate the benefits of SCM practices before implementing them. This research is to study the benefits generated from implementing the SCM practices of VMI vs. ordinary order-up-to inventory strategy under different market demand patterns. We construct a simulation model with a four-echelon supply chain and compare the performances in inventory costs and customer services of supply chain members.
To model distinct market demand patterns, we employ the non-uniform influence (NUI) diffusion model of product life cycles (PLC) for its ability in quantifying the product demand over the entire life cycle to represent different product demand patterns (Easingwood, et al., 1981 & 1983; Easingwood, 1988). In the NUI diffusion model proposed by Easingwood (1988), an NUI factor: *δ,* which describes the varying influence of adopters on non-adopters during the life cycle of a product, and an external influence coefficient: *b* are utilized to classify the NUI model into 9 classes of PLC demand patterns based on three ranges of *δ* and *b*. Since each class corresponds to a specific range of the diffusion model parameters, different diffusion curves can be obtained to represent certain product demand patterns. The formula of the NUI model to generate PLCs of diverse products is:

$$S(t) = a \cdot |\, \overline{N} - N(t) \,| + b \cdot |\, N(t) / \overline{N} \,|^{\delta} \cdot |\, \overline{N} - N(t) \,| \tag{1}$$

, where $S(t)$ is the new adoptions at time period t, $\overline{N}$ is the saturation level of adoptions, $N(t)$ is the cumulative adoptions by time period t, and a is the coefficient of internal influence. Figure 1 shows the nine classes defined in the Easingwood's (1988)

NUI model and their corresponding illustrative shapes, where *x*-axis is time period *t*, and



y-axis is *N*(*t*).

Figure 1 The diffusion map of the Easingwood's PLC model

In equation (1), $\left|\overline{N}-N(t)\right|$ represents the potential but yet unfilled purchase quantity of the market, while $N(t)/\overline{N}$ is the proportion of the sold quantity over the potential market demand. Therefore, $b\left|N(t)/\overline{N}\right|^{\delta}$ is the proportion of non-adopters who are influenced by adopters. As δ remains unchanged, larger *b* extends more the value of $b\left|N(t)/\overline{N}\right|^{\delta}$, which means adopters have higher influence on non-adopters. The same is also true for smaller δ and fixed *b*. In either case, the product demand augments rapidly and the peak demand is reached in a short time. As a result, larger *b* values induce spontaneous demand with high variation, while smaller δ causes the peak demand to occur earlier and demand variation tends to be larger. Lee et al. (2000) found that as demand variation increases, the benefits of information sharing increase as well. Therefore, we propose that

1. Larger external influence coefficient *b* evokes larger demand increase rates than smaller *b* and induces larger savings by implementing VMI practice than ordinary order-up-to inventory strategy.
2. Smaller δ triggers earlier peak demand to occur than larger δ and induces larger savings by implementing VMI practice than ordinary order-up-to inventory strategy.

EXPERIMENTAL DESIGN

To study the effectiveness of information sharing on supply chain performances along the PLC, we simulate a four-echelon supply chain model, which is driven by 9 different patterns of market demand. For the base model, the four echelons of the supply chain follow the (*s, S, R*) inventory policy. In the contrast model, the VMI policy is implemented so that the manufacturer and the distributor can obtain market demand information to pre-plan their schedules and purchases. We model the supply chain with AutoMod simulation language, which is a 3D discrete simulation software currently supported by Applied Materials, Inc. Figure 2 and 3 show the inventories of supply chain members implementing (*s, S, R*) and VMI policies during the life cycle of a product. Apparently, the inventories occurred along the PLC is lower when implementing the VMI practice as compared to implementing the (*s, S, R*) policy.

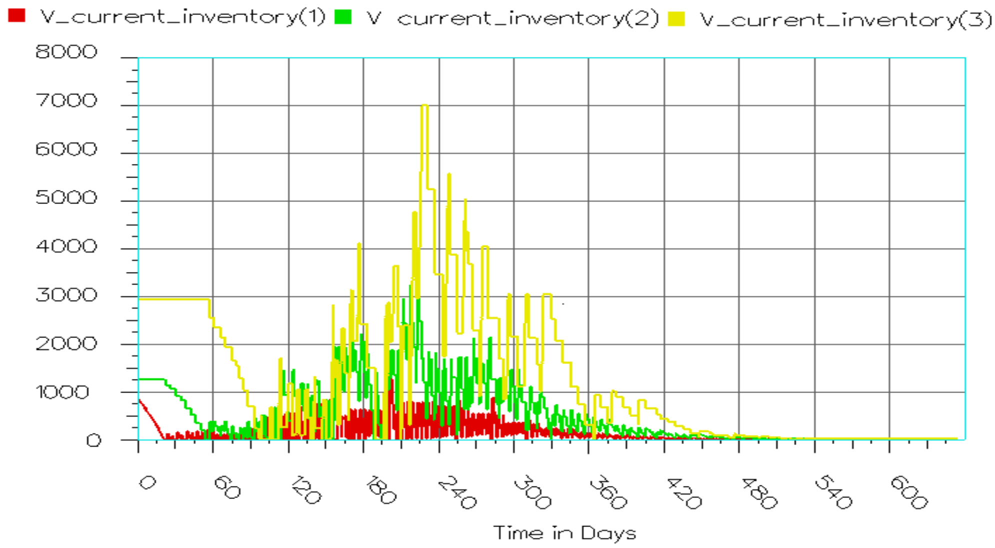


Figure 2 The inventorie s of supply chain members implementing (*s,S,R*) policy

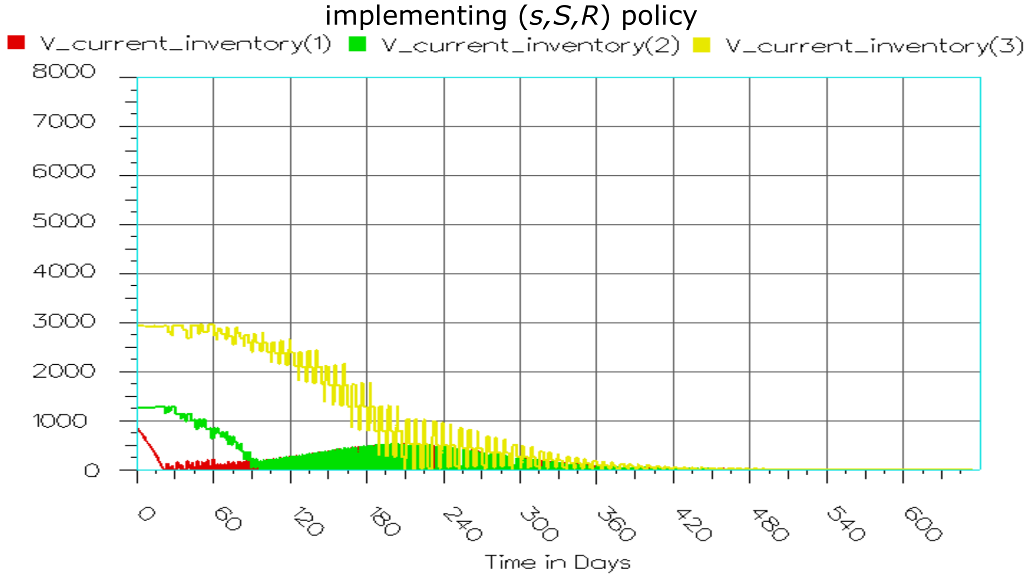


Figure 3: The inventories of supply chain members implementing VMI policy

Following the classification of Figure 1, we simulate each of the nine classes to compare the performance differences. The values of *b* selected are 0.2、0.6、1.2, while δ has values of 1.4、1.0、0.4. The performances considered include the average inventory amount and the average shortage amount. Table 1 shows the improvement of implementing VMI over (*s, S, R*) policy in inventory amount.

Table 1 Supply Chain Inventory Improvement

		Hypothesis 1 Non-uniform influence factor(δ)		
Hypothesis 2 External influence coefficient (*b*)	(b , δ)	b =0.2 , δ =0.4	b =0.2 , δ =1.0	b =0.2 , δ =1.4
	VMI improvement over (*s, S, R*)	197	130	103
	(b , δ)	b =0.6 , δ =0.4	b =0.6 , δ =1.0	b =0.6 , δ =1.4
	VMI improvement over (*s, S, R*)	691	290	197
	(b , δ)	b =1.2 , δ =0.4	b =1.2 , δ =1.0	b =1.2 , δ =1.4
	VMI improvement over (*s, S, R*)	1228	925	524

From Table 1, it shows that as δ increases, the performance improvement amount reduces; while as *b* increases, VMI gains much more improvement as compared to traditional (*s, S, R*) policy, which coincides with the two hypotheses.

CONCLUSION AND DISCUSSION

The above two propositions provide us with deeper insights into the relationship between the variations of the market demand and savings resulted from implementing SCM practices. In many a case, suppliers may request their customers to provide sales and inventory information to execute VMI-like practices in order to reduce inventory costs. However, implementing the practices requires both suppliers and customers to make a lot of efforts and investments, such as organization reformation, information system improvement, material management system adaptation, etc. Our study shows that the benefits obtained from implementing VMI practices deviate for products with distinct PLC curves. By using our model, supply chain members are able to estimate the benefits they can obtain as compared to the efforts required to implement VMI-like practices. From Figure 1 and Table 1, products belonging to Class 1, the rapid penetration, have the most benefits out of the information sharing among supply chain members. The products with strong external influence from media create a fad demand. Cellular phones, TV games, etc. are typical examples of Class 1. The same is also true for products in Class 2, the accelerated, and Class 4, the fast uniform. On the contrary, the benefits from implementing VMI practices might be trivial for companies having products in Class 9, 6 and 8. Those companies might need to reconsider the necessity of following the industry standard in implementing VMI-like practices. Therefore, by knowing the impacts of PLC classes on the benefits obtained from information sharing, supply chain managers can make appropriate SCM practices without investing too much but gaining too little.

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A COMPREHENSIVE OUTSOURCING ANALYSIS FROM THE SYSTEM DYNAMICS PERSPECTIVE

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ABSTRACT

Purpose
This study applies system dynamics (SD) methodology to explore factors affecting an outsourcing decision in the early stage of industry life cycle, which is critical in determining firm's future competitive advantage.

Design/methodology/approach
Through the application of SD framework, this research offers a more systematic outsourcing cause and effect analysis. This study establishes a dynamic model of various factors affecting an outsourcing decision through the causal loop diagram also known as the cause-and-effect chain. The causal loop diagram will include the main interactive dimensions, such as product attractiveness, product demand, product standard, product technology, and product compatibility, associated with an outsourcing decision.

Findings
The conventional discourse on outsourcing often stresses the role of the benefit and risk associated with any outsourcing decision. However, such analysis of outsourcing is incomplete without recognizing forces, such as industry entrants, technology evolution, and product design, which enticed firms in an industry to consider outsourcing. In addition to these forces, it is also crucial to consider the changing roles of benefit and risk associated with outsourcing throughout the industry evolution.

Originality/value
This study is a first attempt to analyze outsourcing from a system dynamics perspective. The SD approach simplifies the complex relationship of factors affecting an outsourcing decision and might be useful in assisting firm's outsourcing decision making process.

Keywords:
Outsourcing, system dynamics, outsourcing benefits and risks, industry life cycle

Paper Type: Conceptual paper

INTRODUCTION

Outsourcing is more than managing its related benefit and risk. Outsourcing benefit and risk are not static and often take on different role as industry evolves through various stages in a life cycle. The classic case of IBM lost control over its personal computer (PC) architecture to its component supplier, Intel, serves as a cautionary example of poor outsourcing management.

Outsourcing improved IBM's product to market speed at the beginning of its PC battle against Apple Computer. However, a possible miscalculation from IBM's perspective, the so called "Intel Inside" phenomenon eventually replaced IBM and has dominated the development of the personal computer industry. At the end, IBM was forced to withdraw from the PC industry.

It is essential for the original equipment manufacturers (OEMs) to manage their outsourcing strategy effectively in order to avoid the so called "Intel inside" phenomenon.

This article maps out necessary outsourcing factors at the beginning of an industry life cycle in which during this stage firms' objective is trying to outperform each other in creating an industry standard product. Current outsourcing literatures focus on benefit and risk are too static.

To bridge such a gap, the interrelationships of these outsourcing factors are also examined closely through system dynamics diagram of outsourcing. The IBM/Intel example serves as a case study that connects outsourcing factors in the context of benefit and risk.

LITERATURE REVIEW

The current literature on outsourcing analysis can be divided into two major view points: benefits/risks analysis and industry characteristics analysis (Figure 1). Conventional outsourcing analyses emphasize the importance of managing outsourcing benefit and risk (Domberger, 1998; McIvor, 2005). Outsourcing benefit and risk are tradeoffs. Any effective outsourcing strategy has to utilize outsourcing benefits while controlling risks associated with outsourcing. Outsourcing has become an important strategy for the OEMs.

Outsourcing could bring OEMs such benefits as reducing transaction costs, increasing product to market speed, improving production and financial flexibility, and strengthening specialization. At the same time, OEMs also face risks such as loss control of its contract manufacturers (CMs), loss learning opportunity, and potential loss of critical skills. An effective outsourcing is to strike a balance between its related risks and benefits. However, the question is that what is the right balance? Knowing the risks does not mean OEMs have the capability to control outsourcing risks. It is often too late for OEMs to react strategically when they realized that they have lost their competitive edge to CMs as industry progresses throughout the life cycle.

On the other hand, industry characteristics point of view stresses the nature of outsourcing arrangement and industry characteristics as determinants of outsourcing outcome. It is increasingly evident that the success of outsourcing contingent upon various industry dynamics such as industry speed, product specification, technological performance, and the dependent relationship between the OEMs and CMs (Fine, 1998; Takeishi, 2002).

As complexity of outsourcing increases, it is becoming more difficult for the OEMs to strike a balance between outsourcing benefits and risks. Many previous studies have cautioned against the possibility of contract manufacturers (CMs) become OEMs' future competitors (Quinn & Hilmer, 1994; Arrunada & Vazquez, 2006). In order to have a fruitful outsourcing relationship, it is very crucial for the OEMs to have the control over their CMs.

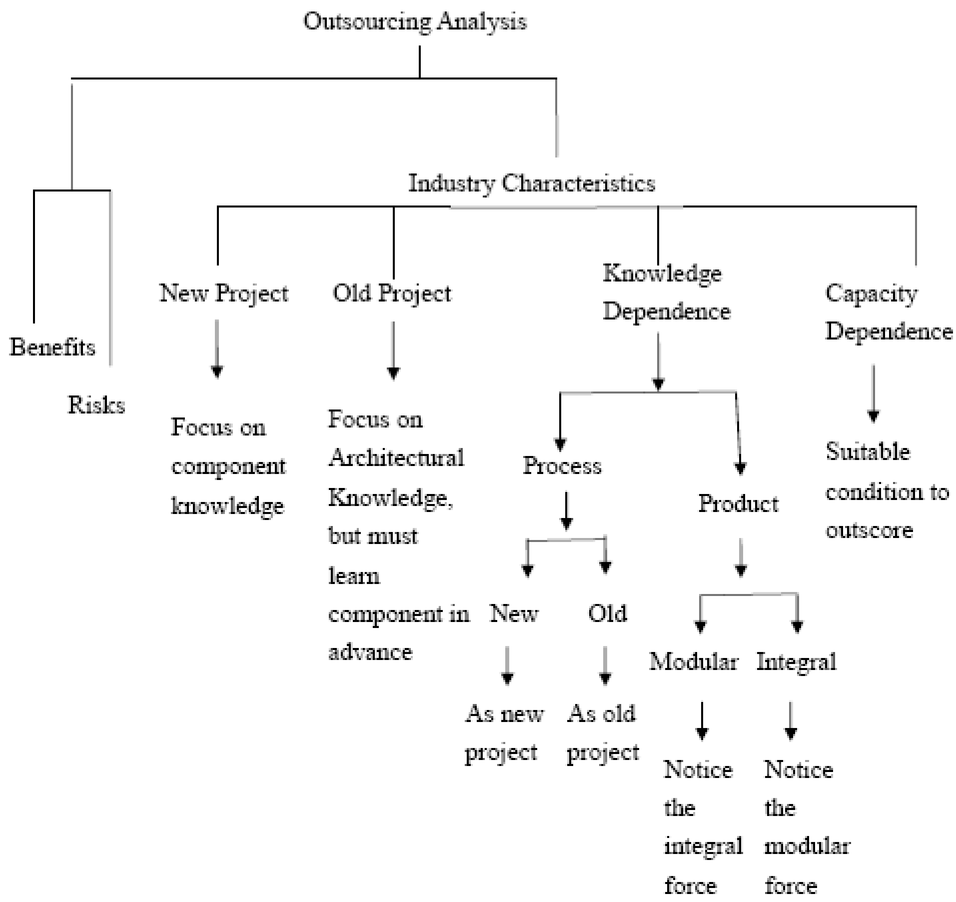

Figure 1 Outsourcing literature

The SD method, developed by Professor Jay W. Forrester et al at the Sloan School of Industrial Management of the Massachusetts Institute of Technology, is a tool that assists the understanding of a complicated system, and perceive how an internal feedback loop within a system impact the whole system's behaviour. SD is a methodology that aids the decision making process through the understanding of systemic forces that created and continues to sustain a problem (Roberts, 1978). The real world decision making process is complex. In general, there are four hierarchically levels of feedback system: variable, linkage, feedback loop, and feedback system (Robert). A variable is a quantity that changes over time. A feedback loop includes two or more linkages connected such that, beginning with any variable, the arrows can be followed until they return to the starting variable. A feedback system contains two or more connected feedback loops. SD uses a causal loop diagram to analyze a complex managerial problem (Roberts, 1978). In the causal loop diagram each link is given a + (positive) or – (negative) directional sign. The positive sign reveals the loop acts to reinforce variable whereas the negative sign means the loop acts opposite to a variable.

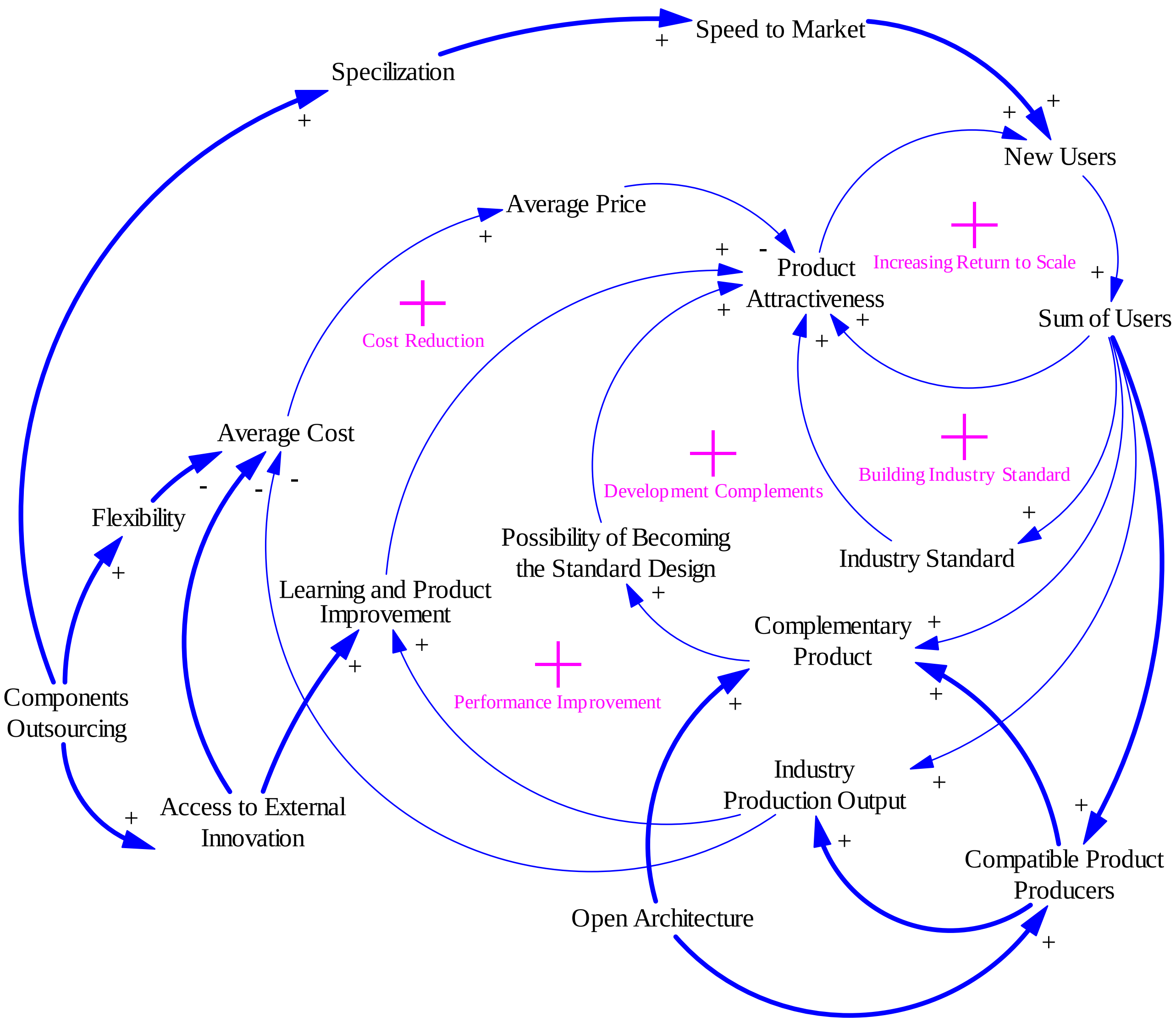

Figure 2 Casual loop diagram for outsourcing

Based on Figure 2, there are five positive feedback loops revealing five different aspects in the early stage of an industry life cycle which could strengthen emergence of the industry standard product: increasing return to scale, building industry standards, development complements, performance improvement, and cost reduction. Factors mentioned in these loops serve as reinforcement of the outcome that is product attractiveness. In the early stage of an industry life cycle, firms are competing against each other to create industry standard product. The primary role of outsourcing at this stage is to improve product to market speed for the OEMs. Product attractiveness becomes a critical factor in any outsourcing decision. Outsourcing reduces number of tasks that firms have to perform internally and improves product speed to market as firms learning more about customer preferences through market trial and error. Product attractiveness creates positive loop for new users and also increases user sum. As the number of users increases the more likely that product standard will emerge which also reinforces overall product attractiveness. With more users buying a particular product, more producers of complementary product are willing to enter the market which also improves the possibility of a particular product design becoming the standard. In light of increasing number of users, firms have to increase product output. With high production intensity, firms gaining product knowledge as well as learning more inter-firm collaborative tasks resulting in better product performance and greater product attractiveness. In addition, as output increases the average costs and market price also reduce which further improves product attractiveness.

IBM was able to utilize various benefits of outsourcing at the early stage of the PC industry life cycle. Through components outsourcing IBM was able to improve its production flexibility which reduced average cost. Outsourcing also provided IBM with access to external innovation from IBM's CMs which reinforced overall product improvement. IBM was able to attract more end users for its PC through specialization which improved product speed to market and allowed users to have more design choices. IBM's PC was based on an open architecture design which stimulated the entry of complementary product producers. With more complementary products available in the market more attractive the product is in the eyes of users.

CONCLUSION

Outsourcing benefit and risk analysis is often vague and is hard to tell the inter-relationship of these outsourcing factors. Outsourcing analysis through the casual loop diagram not only provides managers with an overall view of their outsourcing strategy but also reveals the interrelationship between outsourcing factors in a simple diagram which aids manager's outsourcing decision making.

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SECTION 7 – Decision Support Systems and ICT in Supply Chains

SUPPLY CHAIN RISK MANAGEMENT WITH DATA WAREHOUSES

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1. INTRODUCTION

Supply chains can be coordinated centrally or individually. In both scenarios the information system architecture is crucial, as the right information needs to be at the right supply chain partner at the right time. The use of sophisticated information systems leads to additional transaction costs that must be lower than the production cost advantages to generate a total benefit. If information is delivered incompletely or incorrectly, it carries information risks[3] that lower the total advantage of a supply chain. The reduction of such risks is the main objective of the supply chain management, which can be successful in the long run. This work examines how information risks can be controlled by introducing data warehouses. Two different data warehouse architectures are constructed in the context of a system dynamics approach, before the simulation of the model is executed, which illustrates the system changes compared to the reference solution.

2. INFORMATION RISKS

The need for information of business processes results from an asymmetric information distribution among supply chain partners. As supply chain partners cooperate in the long run, many types of information must be exchanged. Basically, this concerns three types of information: demand information, product information and capacity information. Closely cooperating supply chains also exchange strategic information. Hence, information risks can affect the production, transmission and processing of information (see figure 1).[4]

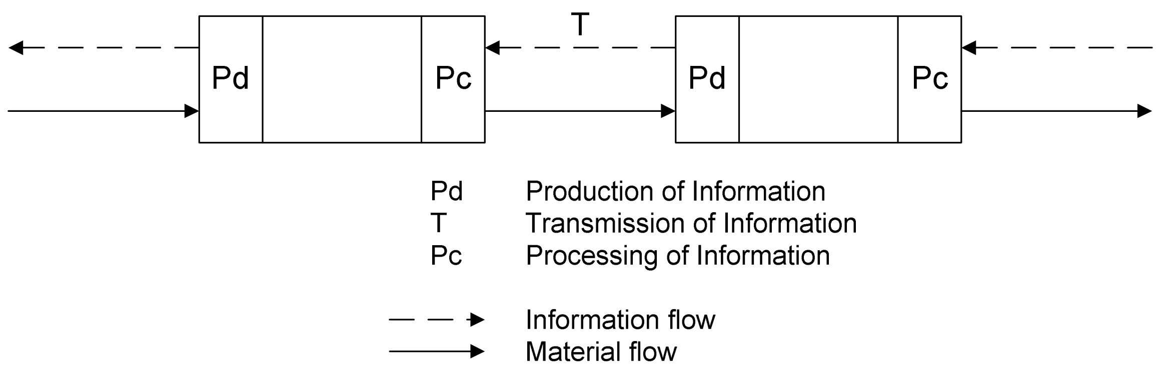

Fig. 1: Sources of risk in the information process

One risk relates to the access of the data that are available, but held back by one supply chain partner. The issue of data privacy is based on the intention to protect competitive advantages and thereby expresses distrust which cannot be excluded even in long business relations. This information risk may cause increased costs on both sides, since the information has to be procured

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[3] Norrman, Lindroth 2004 categorise the different risks in supply chain management
[4] Other risks in a supply chain are analysed by Tang 2006

elsewhere with additional costs if it is necessary for the production process. If the information is not transmitted, it may result in dissatisfaction of the customer and finally in a competitive disadvantage.

The transfer of precise information is crucial for supply chain management. While in a hierarchical firm there is the principle of information profit sharing, members of a supply chain do not benefit equally from the use of information. Rather, the benefits of information are distributed asymmetrically among the participating firms. E.g. demand information that is provided by the retailer might help the partners but not the retailer himself. A re-allocation of those benefits cannot be observed in many cases.

Due to coordination problems in supply chains, information delays frequently occur.[5] Information is not passed on to the supply chain partners immediately after the information process has been completed in the own firm. This leads either to a delayed start of the business processes at the supply chain partners or to the launch of processes under incomplete information. This is one of the information risks that also affects the source of information itself. E.g. if demand information is not forwarded immediately, the product will be delivered later from the supplier. This may lead to a supply shortage with all its consequences.

Furthermore, there is a range of information risks that is not known in other cooperation forms in this intensity. If these risks are not understood, controlled and reduced, existing production cost advantages in a supply chain may get lost. Risks must be judged in the whole supply chain, i.e. including all partners. In particular, existing coordination mechanisms have to be analysed for inherent information risks. There might be the need to establish a system of risk management, which fulfils these tasks for a large number of supply chain partners.

3. CENTRAL VS. DECENTRALISED COORDINATION MECHANISMS IN SUPPLY CHAIN MANAGEMENT

Risk management in a supply chain can be organised either in each firm independently or – within given conditions – by all members together.[6] Traditionally, each firm develops a specific risk policy for itself in order to meet the supply chain risks– and here in particular the information risks – optimally. In a supply chain, where each partner is insufficiently provided with information by the other partners, distributed risk management is executed in three stages:

risk measurement
risk evaluation
risk controlling and recovery, respectively.[7]

If further information risks arise in a supply chain, they must be first of all quantified by the involved firms. It is important to quantify the probability and the consequences of the information risks.[8] This task becomes more complicated by the dilemma of the information assessment. It is generally unknown which information the partners actually possess and to what extent it would have influenced the decision. Usually, firms therefore often fall back on estimating risk based on experience from comparable situations.[9]

For a risk evaluation, the costs of information loss must be calculated. Information risks often become obvious in production and delivery risks, respectively, which in turn leads to higher production or delivery costs. If the data are passed on to a third party, economic consequences may arise in the form of profit shortfalls. The extent to which the risk management of a supply chain partner requires measures of risk reduction or recovery, depends on the assessment of risk and the costs of an intervention.

[5] Angerhofer, Angelides 2000
[6] Beamon 1998, 288
[7] Similar in Jüttner et al. 2003, 206
[8] Blakley et al. 2001, 98
[9] Jüttner et al. 2003, 205

Distributed risk management requires that each firm calculates the risks of its participation in the supply chain and prepares appropriate measures to protect themselves against these risks. As a whole, this flexibility leads to high costs for risk management (transaction costs), which can endanger the success of a supply chain, since no synergies between the firms arise. Therefore, it has to be considered whether a centralised risk management should be established to provide the members with the required information and to protect them against the risks mentioned above. A central risk management has to regard the interests of all supply chain members. If there are conflicting goals within the supply chain,[10] such a risk management will probably not be very effective. It ought to be accompanied by decentralised measures. However, the extent to which a central instance is established for risk control is at the same time an indicator of the existing trust and therefore of the systems stability.

The data warehouse is an information system architecture that can handle the information risks. Contrary to operational data processing, the data warehouse is embedded in a strategic concept, which allows authorised system units to be systematically supplied with information from other units.[11] The concept is briefly explained in the following section.

4. DATA WAREHOUSE CONCEPT

The data warehouse concept has been developed in the end of the 1980's for the purpose of providing the strategic system of a firm with adequate data.[12] In recent papers, a data warehouse was interpreted as a supply chain-wide integrated data base for transaction systems to avoid redundancies.[13]

The requirements for a data warehouse can be deduced from the strategic objective of information risks as follows:[14]

- Data have to be stored in a way that they can be used as generally as possible.
- The storage is organised in a standardised form.
- The access to the data must be ensured during a long period of time.
- The choice of the information system architecture is important as it determines the capabilities for risk reduction of a supply chain. Basically, there are two architectures, which have undergone a considerable development by practical implementation.[15]
- A central data warehouse supports the risk management for all firms not only by storing the data centrally but also by analysing the data integrated. The transmission paths to the other system units are simple, so that even larger volumes of data can be transmitted in time. However, a central data warehouse does not only require considerable investment and maintenance costs for an additional administration system unit.[16] Information risks remain, as the centrally managed information system must still be procured by the individual system units.
- A second architectural approach takes into account the fact that the loss of property rights on information should be limited so that not all private information is transferred to a Collaborative Business instance. Instead, several data marts can be established, which contain only a part of the information of the whole supply chain.[17] Obviously, it is not excluded that in this architecture, increased data redundancy will occur when identical data are stored in a number of data marts. The different architectural approaches are compared in table 1.

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[10] Towill 2005
[11] Regarding the general importance of information and communication systems for risk controlling, see Giunipero, Eltantawy 2004
[12] Inmon 1993
[13] Enterprise Application Integration
[14] Inmon 1993, 33
[15] Different scenarios are found in the literature, see e.g. Du et al. 2004
[16] Kimball 1998
[17] For judgement of the decentralisation of analysis systems see Wyner, Malone 1996

Architecture	Data storage and analysis
No data warehouse	Individual
Data marts	Distributed
Central data warehouse	Central

Table 1: Different architectures of a data warehouse

5. MODEL

A supply chain consists of a finite number of partner firms, which maintain customer-supplier relations with each other. Accordingly, information relations are established in a manner that the information flows backward, thus from the customer to the supplier. In the traditional architecture of supply chain management those flows are concentrated on directly neighbouring partners of a supply chain. In addition, interfaces are defined, at which the data are transferred according to specific requirements.if a data warehouse architecture is implemented to support the information process, other interfaces exist, which are exemplarily illustrated in figure 3

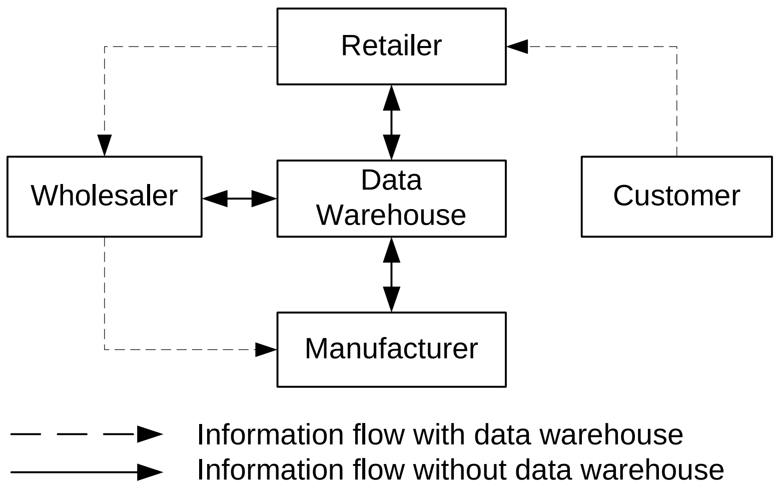

Fig. 3: Data Warehouse Architecture

This complex information and decision making process is modelled with the help of a system dynamics approach.[18] system dynamics offers the possibility of simulating business activities within a period of time as well as describing the flow of information and material by linking those periods. The system dynamics approach has regained importance particularly in the last decade, when many process-orientated procurement and manufacturing systems have been developed. Here it is used to measure the information risk in a supply chain. In the literature, we already find system dynamics simulations considering just-in-time production and the bullwhip effect.[19]

In order to evaluate the information risk of a simple supply chain, three partners are modelled as manufacturer, wholesaler and retailer (cf. Figure 3). All partners keep a stock from which the orders are fulfilled. They apply the order-up-to policy according to the beer game described by sterman[20]. According to sterman the supply chain partners do not consider the stock adjustment and the supply line adjustment correctly. In every period they only adapt a certain ratio of the necessary adjustment. Hence the outgoing order quantity is calculated as the sum of the demand quantity, the partial stock adjustment and the supply line adjustment:

[18] Forrester 1958
[19] The different reasons for the bullwhip effect can be classified according to Chatfield et al. 2004 or Lee et al. 1997
[20] Sterman 1989

$$OO_{t;k} = D_{t;k} + \beta\left(S^*_{t;k} - S_{t;k}\right) + \gamma\left(SL^*_{t;k} - SL_{t;k}\right)$$

where:

OO	outgoing order quantity
D	demand quantity
S	current stock quantity
S*	desired stock quantity
SL	current supply line
SL*	desired supply line ($\text{average demand} \cdot \text{lead time}$)
t	simulation period in units of time (t=0,…,T)
k	supply chain partner (retailer k=1, wholesaler k=2 and manufacturer k=3)
β	stock adjustment coefficient
γ	supply line adjustment coefficient

According to the literature, the smoothing constants $\beta = 0.26$ and $\gamma = 0.09$ were selected.[21]
The supply chain partners are supported by an appropriate data warehouse architecture. The information flows depend on the selected architecture. If no data warehouse exists, the trigger of all supply chain activities is a customer order at the retailer. The order is fulfilled from the stock while, simultaneously, a replacement order is placed. The same order process can be observed at the wholesaler. When an order reaches the manufacturer, he delivers the ordered products and starts with the production of the order quantity to replenish his own stock. Other information channels than described above do not exist. Consequently, there are delays in delivery, as the ordering information is only passed on latest possible:

$$IO_{t;k} = OO_{t-td;k-1}$$

where:

IO	incoming order quantity
td	delivery time

Each member of the supply chain forecasts its demand on its own. Hence, the demand is calculated as follows:

$$D^1_{t;k} = \alpha IO_{t;k} + (1-\alpha)D_{t-1;k} \qquad \text{for } t = 1,\dots,T$$
$$D^1_{t;k} = IO_{t;k} \qquad \text{for } t = 0$$

where:

α Adjustment coefficient ($\alpha = 0.36$)

The implementation of a centralised data warehouse permits an acceleration of information so that customer orders from the retailer's data base are immediately available for all other system units.

In this scenario demand is forecasted centrally by the data warehouse. Besides, a central data warehouse fulfils the task of analysing and forecasting all the demand quantities of the system units. The retailer uses this forecast directly while the two other partners smooth the central forecast by their incoming orders. This leads to a forecast that is influenced by the real demand as well as by the customer demand forecast, which is not affected by any internal disruptions or information risks.

$$D^2_{t;1} = \alpha IO_{t;1} + (1-\alpha)D_{t-1;1}$$
$$D^2_{t;2} = \alpha IO_{t;2} + (1-\alpha)D_{t;1}$$
$$D^2_{t;3} = \alpha IO_{t;3} + (1-\alpha)D_{t;1}$$

[21] See Sterman 1989

Thus, the manufacturer can react promptly to a rising or falling demand.

Considering data marts, two sub models have to be distinguished: First of all, a data mart can be set up for the retailer and the wholesaler. Secondly, another data mart should be available for the wholesaler and the manufacturer. While the customer orders are directly accessible to the wholesaler, the manufacturer has only access to those orders as soon as they have arrived at the wholesaler.

Similar to the scenario of a central data warehouse, a customer demand forecast is calculated in the first data mart. As there is no central data warehouse, these data are only available to the retailer and the wholesaler. Hence, the wholesaler calculates the demand like in the first scenario. As these data are not forwarded to the manufacturer, he has to use the data in the second data mart. This data mart is provided with the demand information of the wholesaler.

Data mart 1

$$D^3{}_{t;1} = \alpha IO_{t;1} + (1-\alpha)D_{t-1;1}$$
$$D^3{}_{t;2} = \alpha IO_{t;2} + (1-\alpha)D_{t;1}$$

Data mart 2

$$D^3{}_{t;3} = \alpha IO_{t;3} + (1-\alpha)D_{t;2}$$

6. SIMULATION RESULTS

The basis of the model analysis is a simple problem description. At the beginning, the regarded supply chain system is in an equilibrium state. The customer orders 1,000 units per week. The retailer, wholesaler, and manufacturer calculate their order quantities to meet the demand during the replacement time.

The order times initially amount to 1 week, the production and delivery times to 3 weeks each. In period 5 the equilibrium is temporarily disturbed by the fact that the order time between the retailer and the wholesaler increases for the next 2 weeks by 2 weeks. This delay represents a typical information risk, which needs to be met by an appropriate risk management. According to the installed data warehouse architecture, the whole system responds quite differently to the disturbances. We analyse how the architectures perform under the given constraints.

The information deficits become particularly visible in the delayed adjustment of the production rate. Given no data warehouse, the impact on the manufacturer is exemplarily shown in figure 5. The delayed order information results in a reduction of the production rate, because the wholesaler and the producer do not recognize that the demand is constant and that there is a delay in the transmission of the information. Hence, both partners forecast the demand based on a myopic view, which leads to the variation in the production process for more than 50 periods.

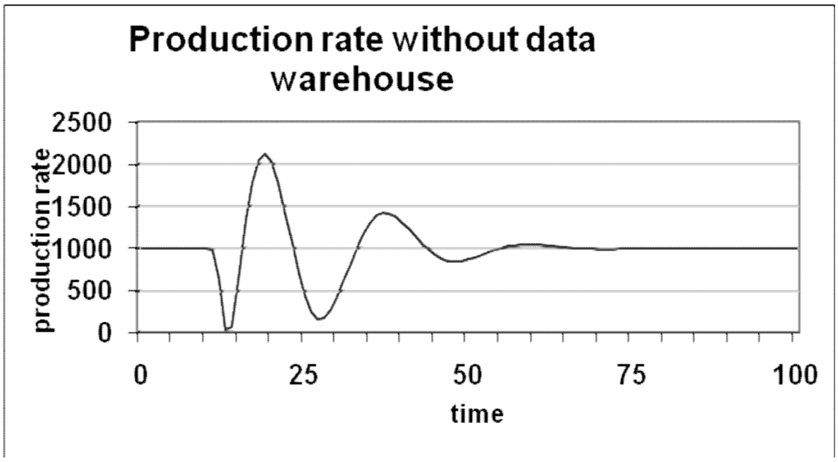

Figure 5: Production rate at the manufacturer

In order to quantify and evaluate the different architectures, several measures are used.[22] First of all, the maximum production rate is taken to measure the amplitude of the production function, and thus the risk of technical over-capacity in the production and inventory range. Secondly, it is examined when the manufacturing process returns to equilibrium (1,000 pieces per week + - 5% tolerance). Finally, the maximum amount of stock is calculated to determine the storage risk.

Table 2 shows the system behaviour based on the selected key figures. On the one hand, the choice of an optimal data warehouse architecture is necessary for risk control. On the other hand, the risks are unevenly distributed among the supply chain partners. Table 2 presents the figures for the manufacturer, because the effects are most evident here.

	No DW	Central DW	Data marts
Maximum production rate	2,126	1,379	1,519
Comparison with No DW		*- 35.1 %*	*- 28.6 %*
Standard deviation of the production rate	337	111	136
Comparison with No DW		*- 66,9%*	*- 59,6%*
Maximum stock	7,342	5,933	5,856
Comparison with No DW		*- 19.2 %*	*- 20.3 %*
Period of steady state demand *	53	39	39
Comparison with No DW		*-14*	*-14*
* (+/- 5 % tolerance)			

Table 2: Risk analysis for the manufacturer with different data warehouse architectures

According to table 2, a long lasting imbalance will occur, when using no data warehouse at all. E.g., the maximum production rate culminates in more than 2,200 units, although the customer demand remains at a level of 1,000 pieces throughout all the simulation. The information delay causes a standard deviation in the production rate of 337 pieces. The production rate corresponds to the customer demand only after 53 periods (+/- 5 % tolerance). The stock fluctuations show a similar behaviour. The stock level of the manufacturer temporarily rises to more than 7,000 units, because the units that were already ordered arrive in a period when they do not meet any demand due to the information delay.

The simulation of the various data warehouse architectures shows that using data warehouses the described risks can be lowered significantly. In both data warehouse architectures the maximum

[22] Compare also Reese, Waage 2007

production rate is strongly reduced by 28 % in the data mart architecture and 35 % in the central data warehouse architecture. As both supply chain partners can use the central forecast of the customer demand, the demand shock does not affect them as hard as in the scenario without a data warehouse. The central data warehouse enables the manufacturer to use the common demand forecast. With this information the maximum production rate is below the maximum production rate in the case of the manufacturer relying on the second data mart.
As the reduction of the outgoing orders is moderate, the stock is not filled that much (fluctuation of about 20 % for both architectures). According to this key figure, the difference between both data warehouses can be neglected.

The analysis of the period of steady state demand shows that the supply chain can regain the balance much faster if a data warehouse is implemented. Differences between the two data warehouse architectures cannot be observed in the simulation experiment.

Finally it can be stated that both data warehouses reduce information risks in the supply chain. Especially the standard deviation of the production rate causes high expenses for the manufacturer because the fluctuations determine much capacity or (if this is not available) cause high lead times with all its consequences. Hence, the implementation of common information systems is primarily efficient if the risks of information delays or other information risks are high.

Furthermore, it must be decided case-by-case if the implementation of a central data warehouse is efficient, as the costs for developing and running such an information system can significantly increase as compared with the data mart solution. It also must be considered that the transaction costs of a central data warehouse are usually much higher, because all partners of a supply chain must cooperate.

7. SUMMARY AND OUTLOOK

The simulation of a supply chain using different information system architectures has shown that choosing the right information system is decisive for running a successful supply chain in an unstable environment. It was demonstrated that organisational parameters have a significant impact on the efficiency of a data warehouse. In our simulation, it was assumed that the delayed transfer of information is the only information risk. If other risks like the storage or the reliability of the data are analysed, further measures have to be regarded. The consideration of costs is difficult as the costs of implementing and running the different information systems can hardly be compared in a simulation analysis.

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REAL TIME ITEM TRACKING USING SERIALIZED GLOBAL LOCATION NUMBER (SGLN) AT CARGO TERMINAL

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ABSTRACT

Because of its high accuracy, high security and speediness, air cargo industry is rapidly expanding its business portion in the global logistics. Compared to port logistics, air cargo logistics has to deal with high-valued goods which require high level of tracking services- real time, item level tracking capability. In the past barcode was the only available technology for cargo logistics but due to the disappointing performance of barcode system, currently there has been wide adoption of Radio Frequency Identification (RFID) technology in cargo logistics.

In this paper, in order to provide item level tracking capability with relatively precise location information at cargo, we suggest a management solution by applying EPCglobal's Serialized Global Location Number (SGLN).

Keywords: Air Cargo, RFID, SGLN

INTRODUCTION

Barcode has been the most widely used technology for product identification. It has been applied to various areas: manage inventory, to track packages, to track patient, etc. As barcode became more common technology, issues has arisen due to its limitation of capability. Since barcode technology was designed to operate in environments where the products for tracking would necessarily pass in close proximity to the scanner. The technology is the most adequate for point of sales (POS) environments or specialized application with controlled condition. The limited information carrying capacity, physical vulnerability, error prone process of barcode technology have led to better technology in modern supply chain and RFID is considered as a technology to overcome some of the perceived shortcomings of barcode technology.

Currently there have been wide adoption of Radio Frequency Identification (RFID) technology in supply chain but there are a number of failures reported due to the overestimation on the capability of RFID. Firstly, in many applications, RFID system was applied for fairly precise location tracking even though it is an identification system for product. In order to track product location precisely, many readers (i.e. interrogators) are required to be used as reference points for location tracking but this kind of requirement will create interference issues. Secondly, RFID system sometimes provides confusing information on the moving direction.

Because of its high accuracy, high security and speediness, air cargo industry is rapidly expanding its business portion in the global logistics. Compared to port logistics, air cargo logistics has to deal with high-valued goods which require high level of tracking services- real time, item level tracking capability. Due to such reason, there have been growing needs for RFID adoption in air cargo logistics.

In this paper, in order to provide item level tracking capability with relatively precise location information at cargo, we suggest a management solution by applying EPCglobal's Serialized Global Location Number (SGLN).

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CARGO OPERATION

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.

Generally it takes 4~24 hours (emergency cargo: 1.5hours) from entering of ULDs into the terminal to loading them to flight: 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.

RFID SYSTEM IN CARGO OPERATION

In aviation industry, major airports have been considering adoption of RFID technology for baggage handling process since 1999. Tests have been done at numerous U.S. and European airports/airline companies including Las Vegas, Jacksonville, Seattle, Los Angeles, San Francisco, Heathrow, Boston, New York and Rome. In the U.S. tests, RFID tags were far more accurate than bar codes when applied to baggage handing operation. Even though higher cost has prevented airports/airline companies from adopting RFID systems, but US government's requirement (after September 11) of screening all bags for explosives and reduced tag price has changed the situation (Chang et. al. 2005).

Recently 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). However, there are not many researches on the RFID application in cargo terminal. Park et al. (2008) studied a new process for bonded warehouse which is supported by RFID system (see, Figure 1). They considered the potential impact of different reading accuracies which generally occurred in real application environment. They also consider the impact of re-work process caused by reading errors.

According to their research, in order to apply RFID system in bonded warehouse process, more than 80% of reading accuracy is required to achieve better cycle time performance than conventional manual based process.

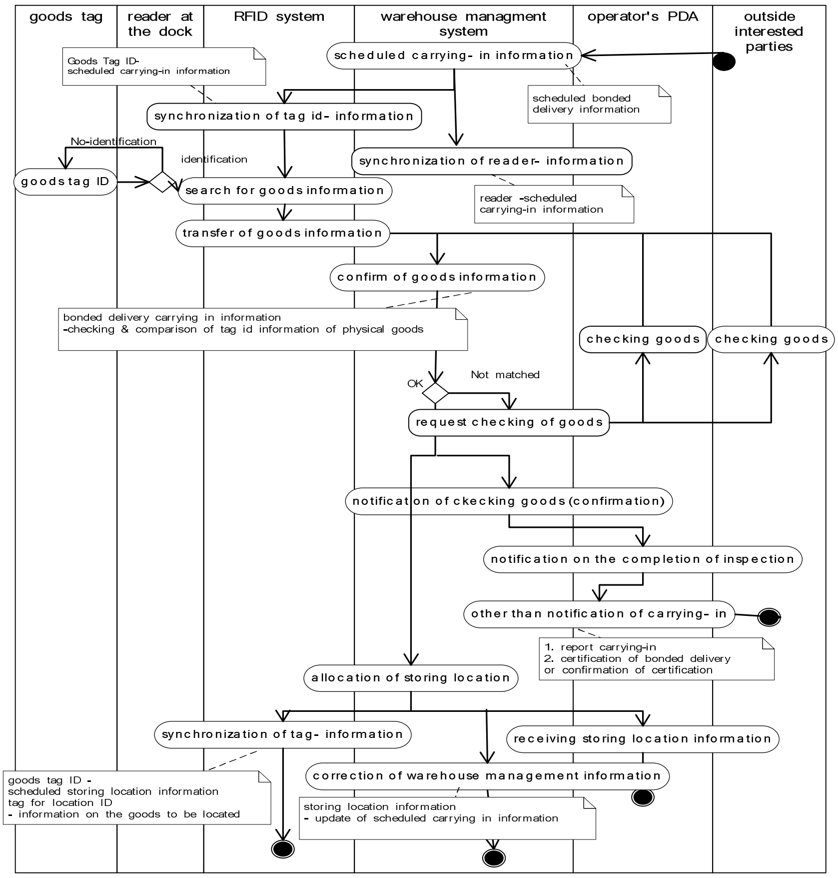

Figure 1. RFID assisted Bonded Warehouse Process (Park et al., 2008)

Yoon et al. (2006) studied real time inventory management system in aviation industry (Figure 2). Figure 2 shows activity diagram on the RFID based Air-cargo ULD process. It is similar to the flow chart and it gives useful guideline for programming. Activity diagram may consist of activity, decision point, branch and start/end.

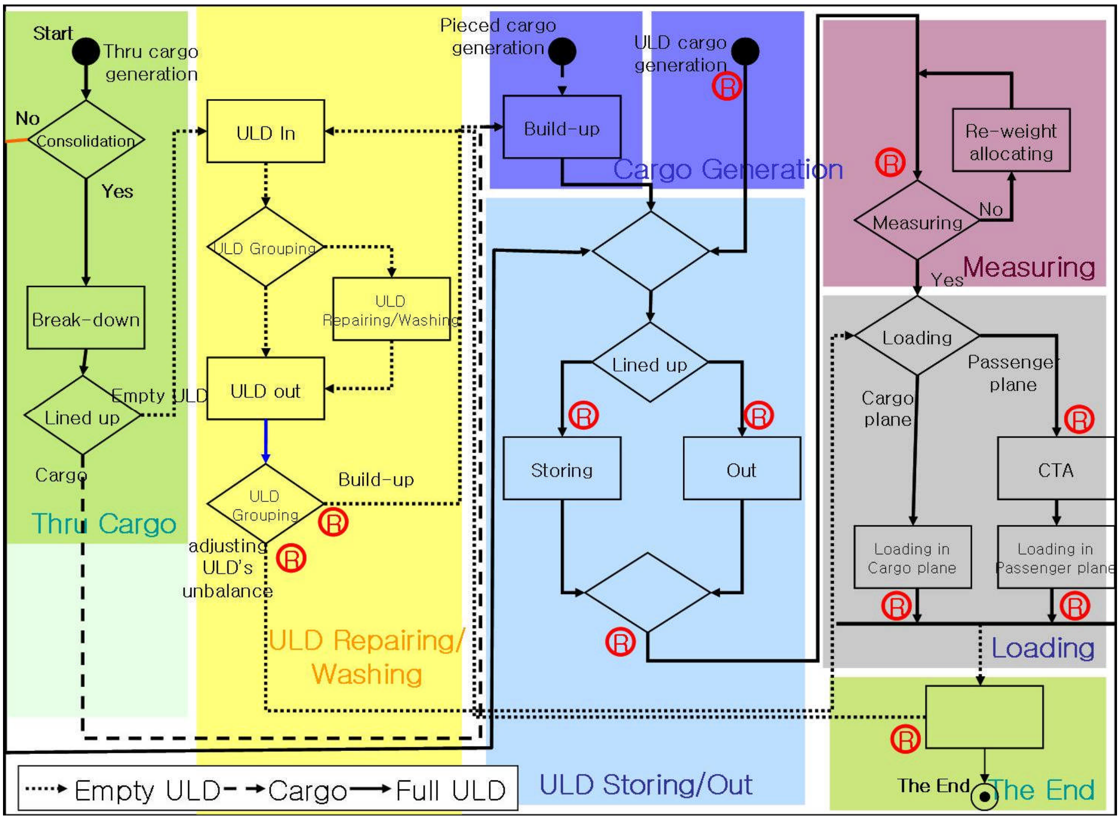

Figure 2. Activity Diagram of ULD Process

They concluded that potential benefits of RFID based cargo processes as follows: cost saving related to operation of air-cargo process; elimination of manual data entry, searching for lost ULD, shipping error reduction and reduction in ULD carrying cost.

EPC NETWORK SYSTEM

EPC Network Architecture consists of various components as in Figure 3. Reader Protocol provides the means for software to control all aspects of RFID Reader operation, including all capabilities implied by features of the Tag Protocols. Reader management monitors the operational status of one or more RFID Readers within a deployed infrastructure. It manages the configuration of one or more RFID Readers and carries out other RFID Reader management functions including discovery, firmware/software configuration and updates, and managing reader power consumption.

Middleware filters and collects raw tag reads. The goal of EPC information service (EPCIS) is to enable disparate applications to leverage Electronic Product Code (EPC) data via EPC-related data sharing, both within and across enterprises. ONS uses the Internet's existing Domain Name System (DNS) for looking up (resolving) information about an EPC (EPC Global, 2005)

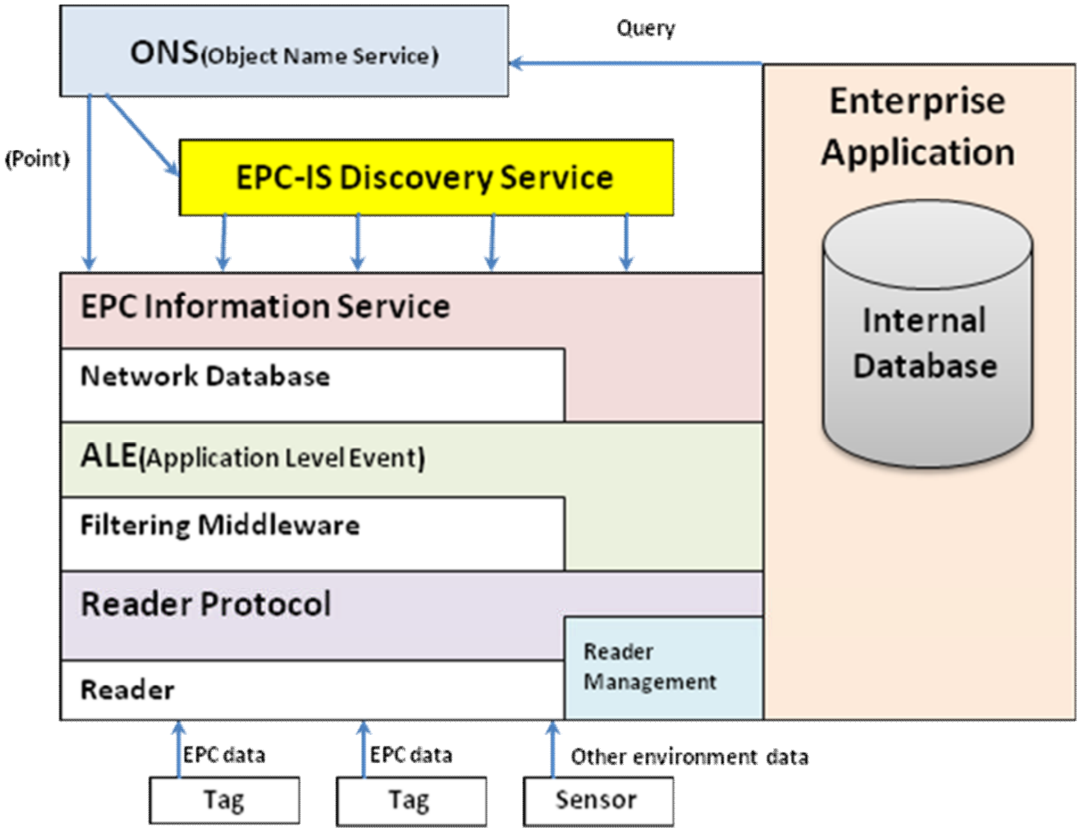

Figure 3 - EPC Network Architecture diagram

EPC is an identification scheme for universally identifying physical objects via RFID tags and other means (EPC global. The standardized EPC Tag Encodings consists of an EPC (or EPC Identifier) that uniquely identifies an individual object, as well as a Filter Value when judged to be necessary to enable effective and efficient reading of the EPC tags (EPC global a, 2008). The EPC Identifier is a meta-coding scheme designed to support the needs of various industries by accommodating both existing coding schemes where possible and defining new schemes where necessary.

LOCATION IDENTIFICATION USING RFID

RFID based location tracking can be done by tracing time-based history of an object. It uses information of fixed reader location and a specific time when object information is collected.

Limitation of Fixed RFID Reader Based Location Tracking

There are some limitations for fixed RFID to be used for location tracking. Firstly, in many applications, fixed RFID reader is used to identify the location of target objects. Generally, cargo terminal has severe noise issue from various sources including forklift, elevator transfer vehicle, transfer vehicle, and walkie-talkie, etc. In order to cover the spacious cargo area while achieving good reading performance, one might set up many readers, but such option requires more budgets and might create interference issue among readers. Secondary, it is not easy to identify the direction of moving objects with fixed RFID reader.

Serialized Global Location Number (SGLN)

Global Location Number (GLN) can represent either discrete, unique physical location such as a dock door or a warehouse slot or an aggregate physical location such as an entire warehouse. A GLN can also represent a logical entity such as an organization. Within the GS1 system, high capacity data carriers use Application Identifiers (AI) to distinguish dataelements encoded within a single data carrier. The GLN can be associated with many AI’s including physical location, ship to location, invoice to location etc (EPCglobal, 2008). The SGLN is not explicitly defined in the GS1 General Specifications. However, it may be considered equivalent to a GS1-128 bar code that contains both a GLN and an Extension Component.

The SGLN consists of the following information elements:

- The Company Prefix, assigned by GS1 to a managing entity. The Company Prefix is the same as the Company Prefix digits within a GS1 GLN decimal code;

- The Location Reference, assigned uniquely by the managing entity to an aggregate or specific physical location;

- The GLN Extension, assigned by the managing entity to an individual unique location.

SGLN-96 is composed of five fields: the Filter Value, Partition, Company Prefix, Location Reference, and Extension Component, as shown in Table 1.

Table 1. SGLN 96 Code

	Header	**Filter Value**	**Partition**	**Company Prefix**	**Location Reference**	**Extension Component**
SGLN-96	8	3	3	20~40	21~1	41
	0011 0010			999,999-999,999,999,999	999,999-0	2,199,023,255,551

SGLN Based Location Tracking in Cargo
We suggest a SGLN based location tracking method which has been implemented using EPC Network (Figure 4). Detail procedures are as follows:

① Installation of the RFID tag on the floor of the cargo (each tag has SGLN code);
② Moving reader installed on the forklift identifies SGLN tag;
③ Almost at the same time, a specific item (i.e. cargo) which is located close to the SGLN tag is identified;
④ By aggregation event parent/child attributes are given to each (by EPC-IS)
⑤ The item location can be traced by its parent’s SGLN code.

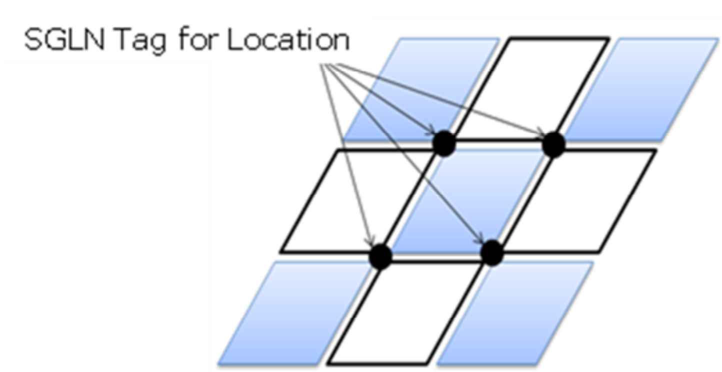

Figure 4. Example of Location Tag Using SGLN

As in Table 2, location reference is used for storage area in cargo, as 000001 and extension component is used to define more detail (more specific) area in the storage area (examples of SGLN code is presented in Table 2).

Table 2. Location Information

Tag ID	EPC Code(URI Based)	Location
L1	urn:epc:id:sgln:000001.000001.1	(1,1)
L2	urn:epc:id:sgln:000001.000001.2	(1,2)
L3	urn:epc:id:sgln:000001.000001.3	(2,1)
L4	urn:epc:id:sgln:000001.000001.4	(2,2)

Figure 5 shows how cargo location can be identified using SGLN. As in the figure, using parent/child relation, cargo location can be identified as (2,1).

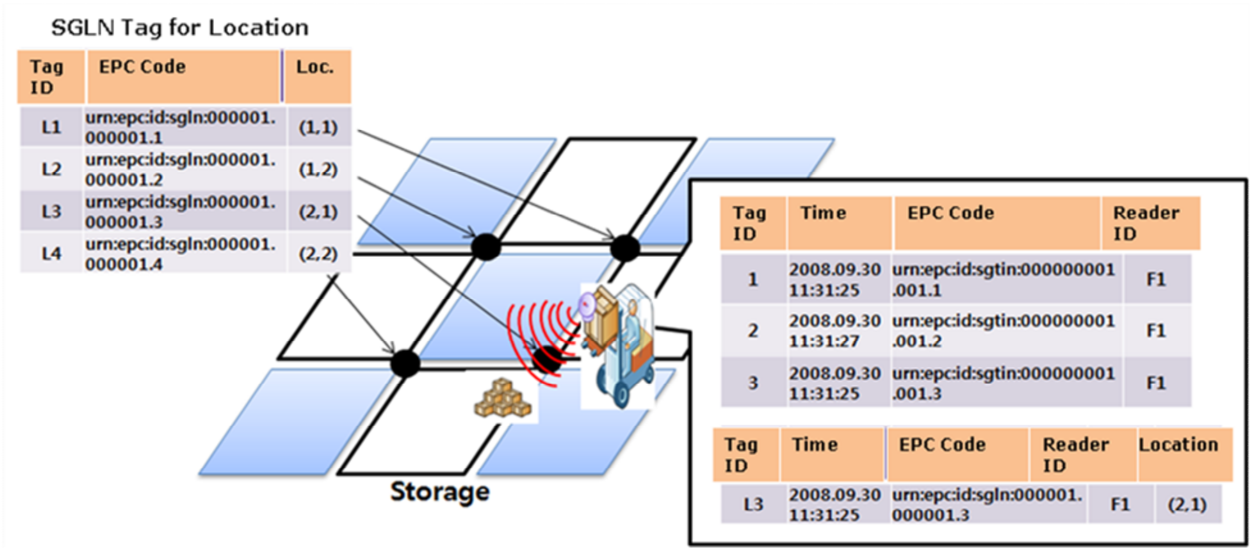

Figure 5. Identification of Cargo Location using SGLN

CONCLUSION

In this paper, we suggest a SGLN based location tracking method. The idea can be implemented with the aid of system components of EPC Network. In some applications RFID is considered as a good technology for location identification. There are different approaches in location identification. For precise location tracking, real time location system is widely used which is similar to the fixed reader based location tracking. However, due to the cost issue from the installation of many readers, careful consideration is required. There are various tag data standards for RFID for different purpose. Among tag data standards, we found that SGLN code scheme can be used for a location tracking system. SGLN based location tracking does not require installation of many readers and relatively easy to implement. The approach has been tested in a cargo warehouse in Korea.

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AUTONOMOUS ORDER ALLOCATION IN LARGE DISTANCE APPAREL INDUSTRY SUPPLY CHAINS BASED ON USE OF RFID TECHNOLOGY (A CASE STUDY)

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ABSTRACT
Apparel supply chains have to bridge large geographic distances and cope with low information quality and delayed information flows. Demand oriented disposition is difficult. Transports have to be redirected, or large stocks have to be kept to deal with supply uncertainty.
This contribution describes a control method for refining, autonomous order allocation of goods and articles along the apparel supply chain of a case study. The method allows goods to allocate themselves to customer orders during transport or while being stored, taking into account critical information concerning customer orders and availability of the goods. The allocation can be modified dynamically.

The paper discusses implementation of the method by use of radio frequency identification (RFID) smart labels, which allow storing of individual product related data and additional logistic process data both at item and at unit level and retrieving the data automatically at the location and time of handling.

As shown in simulations, use of the method in apparel supply chains offers improved management of deficiencies, shortages and remaining quantities of goods during the flow of the goods through the supply chain.

INTRODUCTION
The textile process chain combines manufacture of fibres (yarns and threads), forming, dressing and colorizing of textile surfaces (fabrics), manufacturing and finishing of ready-to-wear garments by the apparel industry and commercial distribution to end customers by garment retailers [Hurcks 1993].

Apparel manufacture of the garments has largely been outsourced to low labour cost countries in East Asia and the Middle East [Scholz-Reiter et. al 2008a]. On the demand side future consumer behaviour and demand can be predicted only with difficulty. Retailers require more flexible reaction times and adaptation of suppliers to demand fluctuations. With business models like never-out-of-stock (NOS) delivery garment suppliers take over responsibility for retailer stock levels, while stock keeping by retailers is strongly reduced [Ahlert and Dieckheuer, 2001].

Due to reduced delivery times demanded by retailers and large geographical distances between production facilities and distribution production garment suppliers have to cope with asymmetries between replenishment times demanded by retailers and their own re-supply times from production. Meeting these requirements depends on timely flow of accurate information between production, transport and DC. Apparel supply chains however often suffer from low information quality, delayed information flows and incompatible information and communication systems. Data on the exact number and distribution of articles in production or transport is often inaccurate, and no demand oriented disposition of pieces or transport control is possible. Suppliers are unable to allocate and distribute their articles proactively to urgent customer orders, or to react flexibly to disturbances and demand modifications, while their ordered material is in transport [Bruckner and Müller, 2003].

DESCRIPTION OF THE CASE STUDY

Information quality problems in apparel supply chains will be studied in exemplary form for a jeans trousers supplier, who operates distribution centres situated in three European countries, Germany, Great Britain and Spain. Each of the three DC satisfies local demand for this product, by supplying retailers based on their orders. The retailers sell the garments to end users and replenish their own stocks by daily ordering of articles from the DC. Demand for each product variant varies both seasonally and stochastically.

To replenish the DC, the supplier runs a garment production plant situated in southern China, which is fed by local raw material suppliers. Transport of the finished garments is executed by sea or, in urgent cases, by air. The ready made garments are transported in cartons in folded form. Each carton contains 20 folded garment pieces of the same product variant, colour and size. A carton with its content forms a package. The filled cartons are consolidated into 20 feet containers. One container can transport 200 packages of 20 pieces.

While air transports are directed immediately to airports near the DC, carrier vessels are by default routed via Dubai as a logistical cross-docking hub, where the next transport step immediately follows. This second transport step can again be executed via container vessel or in urgent cases as air transport.

At the distribution centre incoming goods are put into store. Stored articles of the required variants, colours and sizes are picked according to daily retailer orders for each retail store and dispatched to the customers at the same day.

Bad information quality on the availability of goods poses a major problem for stock level control along the supply chain and causes frequent out-of stock situations. Data on dispatched articles is frequently incorrect concerning the actual number of each article type and variant (colour and size) due to incorrect or incomplete counting of wares or incorrect note keeping. As incoming goods are only randomly controlled after arrival at the distribution centre, such errors are frequently not detected nor corrected. This causes discrepancies between the booked and the real number of pieces of articles or article variants available at the DC. If real stock numbers are lower than booked stock numbers, unforeseen out-of-stock situations may occur during picking, so that customer orders cannot be fully served and the order service quality (share of all customer orders that can be served directly) is reduced.

APPLICATION OF AUTONOMOUS CONTROL TO THE CASE STUDY

Autonomous control has been defined as "processes of decentralized decision-making in heterarchical structures. It presumes interacting elements in non-deterministic systems, which possess the capability … to render decisions independently. The objective of Autonomous Control is the achievement of increased robustness and positive emergence of the total system due to distributed and flexible coping with dynamics and complexity." To summarize the key aspects of autonomous control: "Autonomous control in logistics systems is characterised by the ability of logistic objects to process information, to render and to execute decisions on their own." [Windt and Hülsmann 2008].

In logistic processes, intelligent objects should be able to collect and process information on their environments and to identify and evaluate alternative process executions (e.g. alternative transport routes within a logistic network) according to their individual evaluation system [Böse and Windt 2007].

For the case study, autonomous logistic objects in the model are article pieces, logistic units (which are bundles of article pieces) and customer orders. Individual garment pieces are instances of an article type, which specifies potential customers, quality, colour and size. The integrated smart label based intelligence should enable articles to render and execute their own decisions referring to their own objectives. Two different types of local objectives may be adequate for articles. The first objective should require an article to be sold and delivered to a retailer as soon as possible. The second objective of an article might be to minimize its own transport costs as far as possible.
Articles sharing similar characteristics can be bundled together and form logistic units for storage or transportation. These logistic units should be considered autonomous logistic objects and be provided an identity of their own. Typical bundles are packages and container loads. Additionally, several container loads can be combined to a transport load using the same transport service, i.e. the same ship or aircraft.

Bundling articles into logistic units has to follow predefined rules. A rule may prescribe that only items of exactly the same characteristics may bundle themselves together to form a package (group by product type: e.g. type, quality, and size, colour and production order or production lot). Another rule may prescribe that garment packages may group themselves together to build a transport unit, if they share a common transport destination, (group by destination: e.g. for a distribution centre, or common or similar arrival times at that destination point). Transport loads may split themselves into several new transport loads at each decision point.

Customer orders should be considered autonomous logistic articles, too. A customer order is sent from a customer (retailer) to the garment supplier to initiate delivery of a number of articles. The order specifies a number of garment pieces of one or several article type, to be delivered at a certain delivery date to the customer.

An autonomous allocation of intelligent garments to customer orders and triggering of production orders to prevent out-of-stock situations for a simple two order scenario is illustrated in Figure 1. Part a) shows the inflow of two customer orders to the distribution centre. Order "No. 2" of customer "B" is sent at a later date than order "No. 1" of customer "A". However, it requires an earlier delivery date. The type of the ordered articles is identical for both orders. Part b) shows the dynamic reallocation of articles from their original allocation to order "No. 1" towards the more urgent order "No. 2".

The garments should coordinate their order reallocation behaviour with appropriate messaging and appropriate transport service reselections. If a garment bundle switches its destination order, it has to unsubscribe to the previous order. The switch may initiate additional activities to cope autonomously with the new situation. It may request garments form alternative sources, such as neighbour DC or send a new production order to the production plant, as shown in part b) of Figure 1.

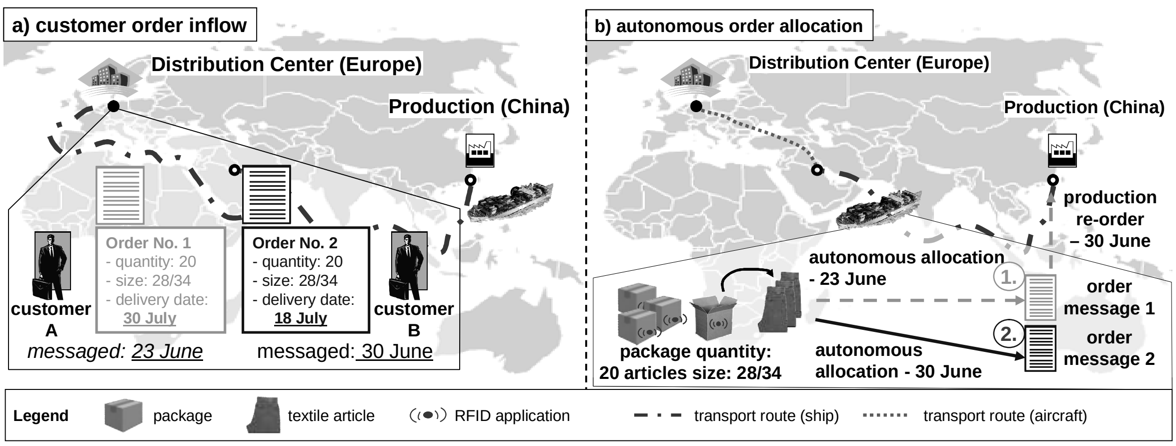

Figure 1 Allocation of autonomous articles to customer orders

Autonomous order allocation should be coupled with dynamic transport route selection by articles. Upon arrival at a decision point autonomous garments should process information whether they will be able to reach their destination in time. If the result is negative, they should separate themselves from the transport and select another transport means or transport route. In Figure 1, part b) the reallocation of the articles from order "No. 1" to order "No. 2" is combined with a change from the original ship transport to air transport at the hub in order to meet the earlier delivery date.

We assume the decisions to be rendered in discrete steps at predefined decision points, where packages should be able to switch their transport destination and their transport means, e.g. from sea carrier transport to air transport. If e.g. a ship transport is delayed, autonomous garments should be able to process this information upon arrival at a decision point in order to find out whether they will still be able to reach their destination in time. If the result is that they will not be able to do so, they should be able to separate themselves from the transport and select another transport means or transport route. In the case study, decision points should be established at each node of the transport network.

USING RFID TECHNOLOGY AS AN ENABLING TECHNOLOGY

RFID technology allows automated identification of physical objects and capture of additional data using radio waves [Finkenzeller 2006]. This allows better synchronization of physical material flows and associated data flows over supply chains [Gillert and Hansen 2007].

The basic RFID application principle for article identification in the case study's supply chain is based on equipping a removable transponder label to each garment piece during the production finishing process, similar to a size label or a price sticker. The transponder stores article specific information, like article number, size and colour information. Optionally an additional serial number of the individual piece can be used to control individual handling of the article.

Transponders may also be sewed into textiles. For this purpose, a variety of special transponders have been developed by several RFID technology providers [Kallmayer et al 2003]. Application is still problematic in some aspects, however. Life expectancy of transponders added before finishing may be strongly reduced by washing and ironing processes, wearing comfort of the garments may be reduced and end customer acceptance is not guaranteed. Removable labels however can be applied after the garment production steps have been completed and removed before sale to the end customers.

When combined with other information and communication technologies, RFID technology offers potential for technical realization of autonomous control. Five steps of RFID technology enhancement can be defined to move RFID technology from simple identification of parts via storage of dynamic data, decentralized data processing and communication to intelligent information based material handling allowing autonomous logistic processes [Scholz-Reiter et al. 2008b].

So called pre-processing labels, which are combinations of passive transponders and a micro-processor with limited processing capacity, have been developed [Overmeyer et al 2006]. If it may be assumed that smart labels will become as cheap and ubiquitously available as simple transponders have become today, single garment articles or bundled stock keeping and transport units of garments may be equipped with such labels. These smart labels can form the basis for autonomous control of the garment articles, providing them capabilities to render decisions and to interact with other system elements. Use of enhanced RFID technologies to the case study is described in Table 1.

No.	enhancement	outline of RFID capabilities	application to case study
1	static data storage	storing of data, which does not change over the artefact's life-	article type, size, colour, quality; optionally a serial

		cycle	number for individual pieces
2	dynamic data storage	real time location recording or sensor data recording	current location, current association to a package or transport means
3	decentralized data processing	hostage of software agents [Bussmann et al 2004] on intelligent RFID readers or Personal Digital Assistants (PDA)	allocation of garments to customer order, selection of distribution centre, transport route or transport service
4	interaction between transponders	communication and data Exchange directly between transponders to interact with each other	bundling of garment pieces into logistic units: articles into packages container selection by package
5	intelligent material handling	initiate actions using flexible material handling systems to execute decisions based on information processing	autonomous automatic packing, robot based container stuffing + stripping

Table 1 enhancement of RFID technology for autonomous logistic processes (adapted from [Scholz-Reiter et al 2008b])

A simple solution based only on static data storage, as described in Table 1, step 1, is being implemented now. This solution does not achieve autonomy, but can solve information quality related problems. During packing of garments into cartons the articles are identified and counted using either mobile RFID readers or tunnel readers. All packages can be checked for the number and article variant of the garments inside. Articles are allocated to the carton loads, as cartons are equipped with several transponder labels, too. This provides the necessary redundancy of RFID transponders to deal with RFID reading errors, as the necessary information is stored on both article and package transponders. If one transponder may fail, all information can be reconstructed from reading the other transponders of a package. Weight control can be used for packages, too.

When the packages are stuffed into a container for transport, the packages are identified and allocated to the container load. The resulting packing list is sent to the distribution centre as an avis. It can also serve as an information document for customs procedures. After arrival at the distribution centre, during unloading of the container at the warehouse entry, the cartons are again identified and counted using RFID. The result is compared to the packing list. Identified cartons and the garment articles are added to the warehouse stock data base. If cartons or their contents have suffered from damaging transport conditions, they can be sorted out automatically. During picking and dispatch the individual articles, which have been taken from the storage areas according to the retailer orders, can be checked for conformity to retailer orders to reduce picking errors without costly manual counting.

Capabilities as described in Table 1, steps 2 and 3, add autonomous capabilities to single garments or stock keeping units, as they are essential for data processing by the autonomous units. Capabilities as described in Table 1, steps 4 and 5, are useful additions, but not absolutely necessary preconditions to achieve autonomous control. To achieve an intermediary level of autonomous control, interaction between transponders during bundling may be substituted by fixed rules for packing articles into packages. Execution of decisions intelligent material handling can also be done manually, if the autonomous decisions of intelligent objects are taken into account.

SIMULATION STUDY OF THE AUTONOMOUSLY CONTROLLED SUPPLY NETWORK

To analyze the effects of autonomous control, a simplified variant of autonomous control is simulated and compared to rigid conventional control. A discrete-event simulation approach has been chosen for the experiments.

To reduce complexity the model includes only three different product variants, small sized blue jeans, medium sized blue jeans, and small sized gray jeans. Yearly demand for each variant at each distribution centre is provided in Table 2.

	Germany			United Kingdom			Spain		
Product variant	Blue, short	Blue, medium	Grey, short	Blue, short	Blue, medium	Grey, short	Blue, short	Blue, medium	Grey, short
yearly demand	18,048	9,346	3,460	36,097	18,693	6,921	36,097	18,693	6,921

Table 2 Assumed yearly demand of each distribution centre

The three distribution centers (DC) are modelled as hubs with storage capacity, while the production plant is modelled as a source object, which creates new article pieces. The transport hub at Dubai is modelled as a switch point, alternatively with or without own storage capacity. Each DC and the transport hub represent a decision point, where autonomous articles may redirect themselves to another destination.

The simulated time period is 365 days. Each DC orders for from the production centre to satisfy its own forecast monthly demand. The stock level control cycle period is five days for autonomous systems with monthly demand orders. Replenishment times are set as four months, including production planning, raw material procurement, production and transport. Ship based transport times between production plant and hub are set as 12 days, while aircraft transport is set as two days. Packages always contain 20 pieces. Containers have a capacity to store 200 packages.

Two methods are compared concerning the service level of customer in the scenario. The first method, conventional control, is characterised by a predefined, fixed transport route and destination and delivery priority. Neither destination nor transport means can be modified according to the real-time demand fluctuations during transport.

The second strategy assumes autonomy for articles, or packages. The products are capable to select their transportation means (either ship or airplane) according to their delivery priority. When the products arrive at the transport hub in Dubai, the transport destination and transport means can be modified regarding the current requirements. During the decision process, the products have to act according to their own given objectives, which regulate them to satisfy the most urgent demand orders.

The two strategies are simulated once with a fixed safety stock coverage of 1000 pieces of each article variant held at the transport hub at Dubai, and once without such a safety stock. The safety stock is assumed to cope with demand level fluctuation and replenishment time.

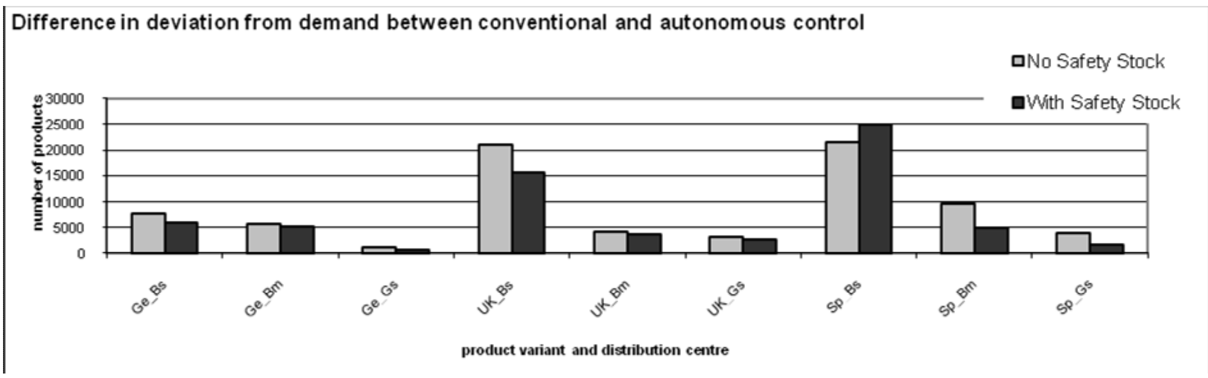

Figure 2 Difference in delivery service levels between conventional and autonomous strategies in terms of their difference values from demands

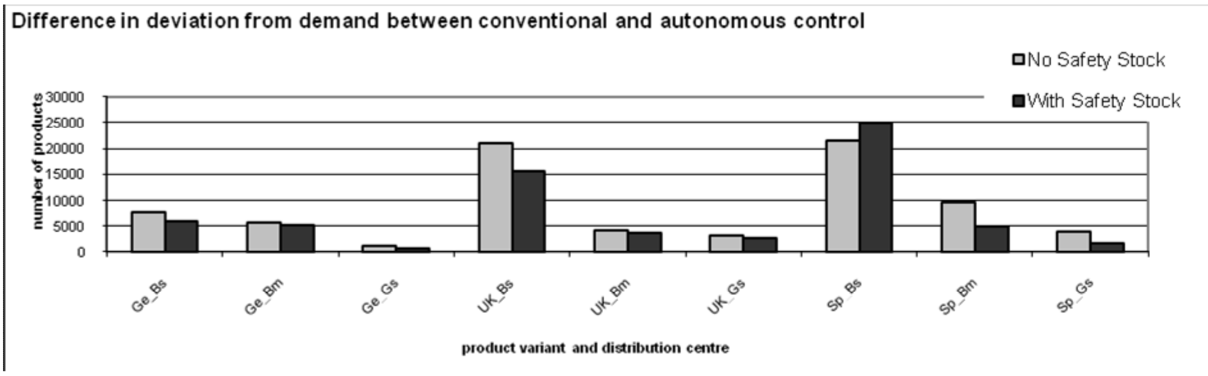

Figure 2 shows the difference between conventional and autonomous strategies in terms of their delivery deviation from demand. For each product variant and distribution centre two different coloured columns are depicted. The light grey columns show delivery deviation from demand without safety stocks in Dubai, the dark grey columns with safety stock at Dubai. Conventional planning performs worse than autonomous control, as delivery deviations from demands are considerably higher for conventional control for a number of products. In particular, the autonomous system with flexible destination and priority selection according to real-time demand situation meets current demand requirements more often.

CONCLUSION AND OUTLOOK

This paper outlined how problems related to time asymmetries and information gaps in global apparel supply chains relate to a case study of a garment supplier producing articles in China and selling them in Europe.

Coupling of enhanced RFID technology with other information and communication technologies may achieve intelligent objects, which are capable to control their own behaviour in logistic processes. Applications for such autonomous logistic objects in apparel supply chains are allocation of articles to customer orders and transport route selection. In discrete event simulations, application of autonomous control strategies could reduce delivery deviations from demand and thus out-of-stock situations at distribution centres.

Further research is necessary to refine and expand the model of the autonomous logistic objects within transport scenarios and to assign the objects fitting local objectives. The validity of the concept has to be checked by more complete simulations, taking into account differences in transport and storage costs.

ACKNOWLEDGEMENT

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BRINGING NEW PARADIGMS TO INTELLIGENT TRANSPORTATION SYSTEMS (ITS) IN LOGISTICS USING DEDICATED SHORT RANGE COMMUNICATION (DSRC) TECHNOLOGY IN MULTIMODAL OPERATIONS

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ABSTRACT
The growing complexity of logistics has raised the profile of Information and Communication Technology (ICT) as means to improve the levels of visibility and responsiveness in supply chains relying in multimodal operations. ICT-based initiatives supported in different countries have been looking at enabling Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications using technologies such as Dedicated Short Range Communications (DSRC) mainly for road traffic safety and control. However, the impact on logistics operations has not been fully addressed. The potential implications of DSRC to multimodal logistics are explored in a case comprising of tipping of bulk material carried by vessels, unloaded into haulage vehicles for transport to different depots within the port area. Event flow, mapping and simulation analysis lead to provide evidence on the suitability of adopting DSRC to meet the needs of multimodal logistics in terms of track and trace, security and visibility.

KEYWORDS
Multimodal logistics, Road Haulage, Intelligent Transport Systems, DSRC.

INTRODUCTION
Multimodal logistics have become an important component of logistics operations worldwide. Hence, in deep-sea and short-sea ports there is access to other modes of transportation including road, rail, pipeline and sometimes air. The use of multimodal logistics has been encouraged by government initiatives aiming at making operations more efficient. Examples of this in Europe include the European Commission's guidelines at developing short sea shipping as a sustainable part of the logistics chain at a time Europe's road congestion problems have been identified as major issue affecting the efficiency of sea transportation.

Ports represent ideal locations to investigate multimodal logistics operations and management. In Northern Europe, the growing importance of short sea shipping has generated regular liner services and ferries operating fast, reliable and flexible connections that carry a wide range of cargos in a wide range of vessels, including charter vessels for transport of bulk steel and construction materials between terminals in the region as well as Roll On-Roll Off (RO-RO) operations. According to the European Commission, in 2005 the total volume of tonnage moved in short sea shipping was in the order of 591 million tonnes. In Europe, road haulage and sea transportation combined represent 86% of the trend in market share of freight transport modes (Browne et al, 2003). On the other hand the complexity of multimodal logistics can result in serious inefficiencies in supply chain operations. Examples of inefficiencies include: penalties of thousand of Euros when a vessel has to spend an extra day docked in order to get fully discharged; container lorries missing the time slot when for loading on a ship; haulage vehicles remaining idle or moving discharged goods to a wrong depot/warehouse within the port.

The growing complexity of multimodal logistics operations in ports and in particular the interdependencies between sea transportation and road haulage represents a strong argument towards exploring efficient use of information and communication technology (ICT) and in particular technologies such as wireless vehicular networks to provide higher levels of visibility in the supply chain. The following sections introduces ICT-based concepts such as Intelligent

Transport Systems, wireless vehicular networks in the form of Dedicated Short Range Communication (DSRC) and then, a case comprising of event flow, mapping and simulation analysis to provide sufficient evidence on the suitability of adopting DSRC to meet the needs of multimodal logistics.

DEVELOPMENTS IN INTELLIGENT TRANSPORT SYSTEMS (ITS), PORTCENTRIC AND THE POTENTIAL TO AFFECT MULTIMODAL OPERATIONS

International logistics requires ICT systems that satisfy a diversity of needs (Leviäkangas et al., 2007). It has been agreed that international logistics is practically mostly multimodal and involves a number of different players that underline the challenge of implementing information services that work to serve the needs of the whole logistics chain (Leviäkangas et al., 2007). In recent years ICT has had a major role in logistics operations. Global Positioning Systems (GPS), cellular networks and Wi-Fi, are three major technologies that have enabled unprecedented levels of connectivity not available few years back. On the other hand, the use of heterogeneous technologies can represent a burden to business applications relying on them mainly because of problems related to reliability, connectivity, limited range, scalability and security.

In recent years, Intelligent Transport Systems (ITS) has emerged as an initiative that will not only transform transportation by enabling Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications but also the overall efficiency of logistics operations. Intelligent Transportation Systems (ITS) comprise the use of advanced ICT to achieve a reduction of congestion and accidents while making transport networks more secure by reducing their impact on the environment (ERTICO, 2008). In logistics, ITS plays an important role in achieving paperless information flows, efficient traffic management by the use of RFID and tracking and tracing by using satellite positioning services (Zomer and Anten, 2008); the crucial role that ITS plays in achieving reliable, flexible, green, sustainable, safe and secure logistics has not been fully recognised (Zomer and Anten, 2008).

The use of vehicular network technology such as Dedicated Short Range Communication (DSRC) technology @ 5.9 GHz promises to bring a new paradigm in the way ITS/ICT plays a critical role in logistics. For example, DSRC, based in the IEEE 802.11p draft, is designed to handle different types of service applications, including the transmission of both safety and non-safety messages into two modalities: V2V and V2I. DSRC has been developed to provide high-quality roadside-vehicle communication services for intelligent highways (Cai and Lin, 2008). The eventual deployment of this technology could address several needs including seamless information exchange, security and integrity of information exchanged or the capacity to forecast accurate travel times (Nyquist and Bergsten, 2008).

The elements of a DSRC vehicular network operating at 5.9 GHz, fundamental for developing the logistics capabilities of ITS, include On-Board Units (OBUs), Roadside Units (RSUs) and Message Switches. Other components include Network Management Units, Certification Authorities and Map Servers. An OBU comprises a hardware module installed within the vehicle which includes a 5.9 GHz DSRC transceiver; a GPS location system; a processor for application services; and a human machine interface (HMI). A wide range of applications generated at the OBU can be formatted as IP traffic and propagated by using an available DSRC service channel. The RSU is considered to be the gateway between the fixed infrastructure and vehicles. RSUs comprise a DSRC transceiver, a GPS location system, an application processor and a router that is attached to the fixed network. RSUs comprise roadway, toll collection, parking management and commercial vehicle check. The RSU periodically broadcasts advertisement messages within its radio transmission range to aware neighboring vehicles of its presence. The function of the message switch is to handle and parse all the data intended to reach any network element. It also performs message management and subscription operations according to the message's priority for efficient bandwidth distribution. Overall, for transport systems in a sea port DSRC application has the potential to become the background infrastructure where different multimodal logistics players can exchange data like as shown in figure 1.

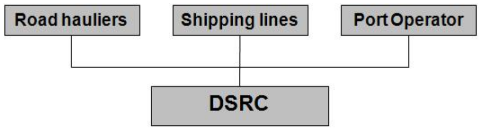


Figure 1. DSRC as the infrastructure that can be used to support data exchange among different users of the port

Another reason why technology such as DSRC could be adopted in major port operations is the emerging importance of port-centric operations and logistics. According to Neade (2008) Portcentric is seen as a way to rationalise the supply chain by driving down the delivery costs per unit. In port-centric operations it is expected that road hauliers, port/terminal operators and shipping companies rely on ICT at different levels. However, ports operate in a multi-faceted environment with an inadequate and delayed information exchange (Nyquist and Bergsten, 2008). According to the point of view expressed by PortCentric Logistics (2009), ports have traditionally been seen merely as points at which the transport mode changes from sea to road or rail. Ports are also viewed as a source of additional cost within the supply chain, a bit of a 'black-hole 'which swallows-up cash for quay rent and other idiosyncratic items like 'Lo-Lo' charges (PortCentric Logistics, 2009). In the UK, some ports are actively encouraging companies to locate distribution centres at ports rather than in their traditional locations, which tend to be in geographically central, inland locations. They argue that current patterns of (inland) distribution centre location ignore the fact that most of the freight that passes through these distribution centres first has to go through a port (Mangan et al. 2008).

The adoption of DSRC technology in multimodal logistics operations meets the criteria of other initiatives affecting multimodal logistics such as the "Motorways of the Sea programme" (2005) funded by the European Union which is looking at the increase of short sea shipping in the North Sea particularly on infrastructure (port, direct land and sea access as well as inland waterway and canal) and facilities (electronic logistics management systems, facilities to ensure and enhance safety and security, facilities to simplify administrative and customs procedures).

MULTIMODAL LOGISTICS OPERATIONS: SIMULATION AND APPLICATION OF DSRC IN A PORT

The adoption of technologies such as wireless vehicular networks in the form of DSRC would enable different applications used by road hauliers, shipping lines and terminal operators to get and send real-time data from/to haulage vehicles. In figure 2 where specific information systems applications such as daily operation plans or haulage unloading control could use DSRC to know the exact location of bulk material road hauliers.

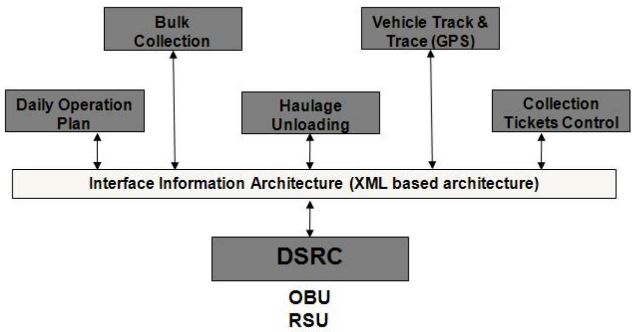


Figure 2. DSRC becoming the infrastructure that links vehicles and enterprise applications

The identification of logistical processes through mapping is a key activity in the deployment of a DSRC-based network within a port. A mapping activity requires the involvement of players such as road hauliers and port/terminal operators. Mapping has the purpose of identifying flow of information and flow of material. But in particular, mapping the flow of information involves identifying information needs, the applications used as well as identifying the capabilities of information exchange between vehicles and RSUs, and the possibility of updating enterprise systems of different players in the supply chain with its resulting increase in visibility levels.

The best way to test the feasibility of deploying a wireless vehicular network technology is to actually get involved with a port terminal operator and investigate the current state of the use of ICT to support running multimodal logistics operations. The work presented in this paper is based on a case study involving the participation of a port operator in North East England. There are several multimodal logistics operations within a port that could be improved by the adoption of wireless vehicle technologies such as DSRC. However, a practical example of where such network could be deployed is in the allocation of trucks to tipping operations involving bulk materials from a vessel docked in a given berth (point of discharge) to a number of depots/warehouses (open or closed) within the confinements of the perimeter of the port. Figure 3 depicts the tipping of bulk material using road haulage vehicles.

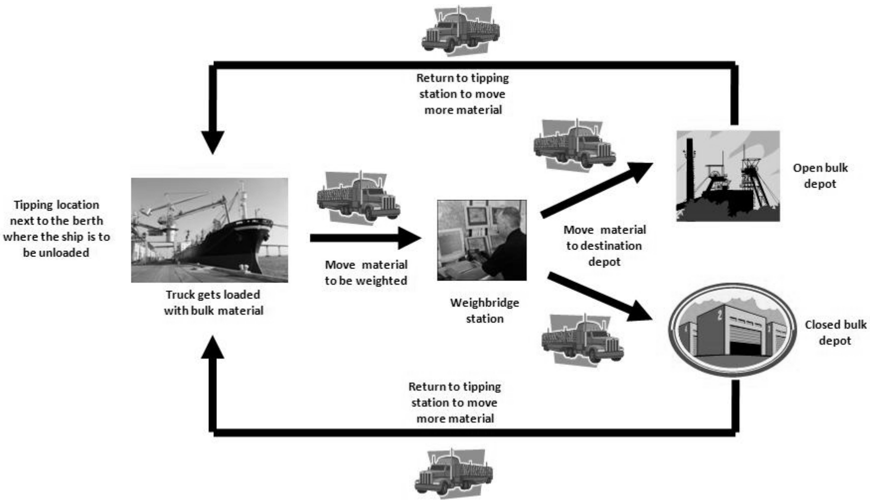


Figure 3. Multimodal logistics operation found in a port

In figure 3 the cycle of loading a truck, tare, discharging goods and returning to collect a new load normally takes 20 minutes. Materials handled can include coal, animal feed, fertilisers but also hazardous materials which demand close track and trace which can be achieved with vehicular networks such as DSRC and its IP capabilities. The same technology can also be applied to other multimodal operations such as handling of containers and Ro-Ro.

The identification of ICT capabilities has helped to set guidelines regarding the description of information and the size of files exchanged, the frequency of updates plus the capacity of the network to handle data traffic. Particularities of the tipping of bulk material process in the case study include: a contract number which is unique to the vessel to be unloaded and to the bulk material handled; up-to six vessels carrying bulk material can be docked and unloaded at any given time and several haulage vehicles can be allocated to a contract number involving unloading operations that can last up-to 36 hours. Errors and limitations that can take place during the tipping of bulk material include drivers unloading material in the wrong depot/warehouse; trucks remaining idle for long periods of time and limited monitoring capabilities of material moved. Table 1 shows the flow of events that have been identified for the operation of bulk material tipping in the case study of a wireless vehicular network such as DSRC is adopted to support multimodal operations. The physical representation of the DSRC-based network for bulk material tipping is shown in figure 4.

1. The Use Case starts when the driver of a haulage vehicle enters the Tipping Zone System (TZS) to unload bulk material from a vessel to a specific depot within the port area. The TZS is hosted in the servers of the Terminal Operator.
2. The TZS uses the Road Side Units (RSU) enabled with wireless interfaces to detect the presence of the haulage vehicles.
3. The haulage vehicle's On-board Unit sends its identification number to the TZS via the RSUs.
4. The haulage vehicle is authorised to move material after the TZS finds the vehicle identification number matched to a contract number.
5. Before being loaded with bulk material for the first time, the haulage vehicle needs to go to the weighbridge station to check the tare. The TZS registers the tare, issues a job number and sends the driver directions to the tipping point to load bulk material. The weighbridge station has an RSU with wireless interfaces and the haulage vehicle has an alphanumeric capable display.
6. When the haulage vehicle has arrived to the tipping point, the TZS checks that the truck is authorised to load that bulk material from that tipping point. The tipping point has RSUs with wireless capabilities.
7. If authorised, the vehicle is loaded and then it goes to the weighbridge station to tare, the weight is checked by the TZS.
8. If the weight is within the authorised allowances the TZS registers the weight and sends the driver instructions to proceed to the indicated port depot to unload the bulk material. There can be up to ten different depot sites in the port.
9. On arrival to the indicated depot the TZS identifies if the haulage vehicle is authorised to unload the bulk material in the site. If authorised, the material is unloaded. The depot has RSUs with wireless interfaces. After unloading the material the TZS calculates the total weight and total number of jobs handled by the haulage vehicle using the RSU.
10. Upon leaving the depot, the TZS requests the driver if a new job is to follow. If affirmative the TZS issues a new job number and sends instructions for the next load of bulk material.
11. Driver proceeds to the indicated tipping point to be loaded with more bulk material.
12. The use case ends when the driver declines to take a new job after unloading bulk material or the total weight for the contract number has been reached.

Table 1. Flow of events for a DSRC-based application used in tipping of bulk material

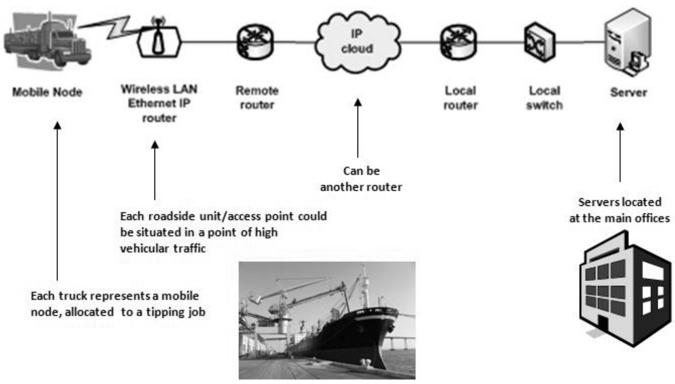
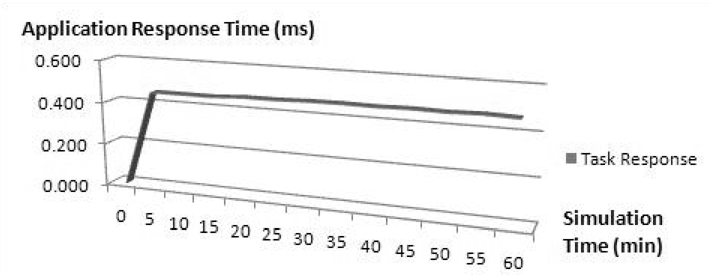


Figure 4. Deployment of a wireless vehicle network (DSRC-based) in a multimodal logistics environment

SIMULATION RESULTS

The data that need to be exchanged between the OBU inside the haulage vehicle and the RSUs where data flow to/from the corporate servers can include the following fields: date, contract, days, operation, destination, time, tonnage moved, operator identifier, road haulier id and current position. The size of such file would be relatively small (a few tenths Kbytes). The use of advanced modelling wireless tools such as OPNET's® (2009) Wireless Modeling Suite and Application Characterisation Environment (ACE®) can enable the analysis of the topology presented in figure 4 whilst simulating the exchange of data. The analysis of the DSRC-based wireless network for the flow of events described in table 1 shows that if there are 20 trucks allocated to a tipping job, only a slight delay in the network is experienced, making it suitable for the requirements of real-time control for the truck and track and trace for the cargo. A web service application that represents the application used by the truck to write/read data from the server has a response time of 0.455 ms. If 20 trucks happen to be allocated to a tipping job and running the web service application, the response time experienced would be in the order of 0.473 ms, a delay of 18 ms, which is reached and stabilised in that value after 28 minutes (for one hour of simulations) of the network starting to deal with truck data exchanges (see figure 5). Based on the events of table 1, the RSUs could be located in the point of tipping, the weighbridge or the depot areas. Trucks travel was assumed at 30 mph and the data traffic received is in the order of 30 Kbytes/sec.



Simulation Time (min)	0	5	10	15	20	25	30	35	40	45	50	55	60
Task Response (ms)	0.000	0.457	0.457	0.457	0.465	0.465	0.470	0.471	0.469	0.472	0.469	0.473	0.468

Figure 5. Results of simulating the exchange of messages between haulage vehicles and one RSU

CONCLUSIONS

Although the deployment of technologies such as Global Positioning Systems (GPS), cellular networks and Wi-Fi among others have had a significant impact on track and trace capabilities the fact is that the characteristics of multimodal transport need robust technologies such as DSRC for efficient operations. DSRC can become the infrastructure where data are exchanged between interested parties and hence, bring new paradigms to ITS in logistics.

The identification of information and material flows through mapping is an important step towards defining a methodology to implement DSRC to improve efficiency in logistics operations. Immediate benefits of a DSRC-based network include instant real-time tracking and tracing, which can reveal if goods are delivered/collected to/from the right place, as well as immediate update to corporate information systems, security, theft prevention, vehicle utilisation, driver/operator monitoring, etc. representing a change of paradigm on how the supply chain can be managed. A large scale deployment of a DSRC-based network would allow ubiquitous access to information. However, prior to large scale deployments taking place, testbeds will have to be deployed to run a number of trials and to know what sort of results will be achieved. A challenging scenario to deploy a DSRC testbed is represented by intermodal logistics comprising road and sea transport. The same methodology used in the analysis of bulk materials can be applied to other operations involving Ro-Ro and containers as well as liquid bulk.

In recent years and as part of their own ITS initiatives, the US, Japan and Europe have emphasised the future adoption and deployment of emerging wireless vehicle technology such as DSRC to enable vehicle integration with the possibility of achieving significant reduction in road congestion, traffic accidents and vehicle wear. The adoption of mobile communications in Internet Protocol (IP) based networks can have a major impact on improving the efficiency of multimodal logistics operations especially at a time where government agencies are engaged launching initiatives that will contribute towards efficient freight transportation and better use of resources.

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LOW-COST RFID FOR INDUSTRIAL APPLICATIONS

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ABSTRACT
This paper describes new opportunities of facilitating container management by the use of RFID technology. The authors approach the papers topic from different perspectives, resulting in entirely different points of view and foci. However, within the frame of interdisciplinary collaboration, it gets apparent a common goal exists, to develop strategies and tools facilitating the work of decision makers in logistics. For this purpose one part addresses the management of returnable containers for the automotive industry. The other part describes the improvement of its automatic and reliable identification by means of the development of a new antenna concept for passive UHF transponders.

INTRODUCTION
Logistic systems are getting more and more comprehensive, possess a variety of influencing factors and dependencies, and are also supposed to have the ability to react on changes with high flexibilities. To control these systems has become a central task for enterprises when considering the systems high complexity and high relevance for the overall efficiency at the same time. The role of the container management has consistently been gaining importance over the last few years. The container being considered as a valuable resource has raised the awareness of decision makers in logistics. It has been recognised that a lack of management for this resource might impact the supply availability or may cause significant additional work and expenses respectively. Reasons for the increasing interest in an active container management are among others:

- the enormous costs of special load carriers, which are identified as a potential for further savings.
- guaranteed security of supply, which is the basic requirement for a successful container management and which leads to an active supply chain management
- positive impact on the whole field of logistics and prevention of waste in supply chains and supply networks by means of a systematic management of the resource containers.

INITIAL SITUATION
It is a central demand in the management of the resource container to secure smooth logistics, in particular in production or assembly environments. This does not only require a high but also an efficient security of supply having the right containers at the right place at the right time. High planning and controlling requirements regarding the container loops result from that.

However, enterprises often have difficulties in planning their need for containers. The prevailing problem is that container loops are not planned and controlled systematically in most cases. Commonly large container stocks are created throughout the whole supply chain, which results in an enormous capital commitment (warehouse, container) and which nevertheless cannot guarantee the desired security of supply due to a lack of transparency.

However, high process reliability requires that the containers, which are expensive in production, are always available at a sufficient quantity in the logistic loop. Due to missing containers, shortage within the logistics chains occurs, which can hardly be compensated as a result of the manufacturing time of the special containers. In this case, alternative containers are often used leading to a higher number of damages and efforts in repacking. [1] In addition to that, the provision of alternative containers represents an emergency strategy being particularly cost-intensive. Even more, missing containers or alternative containers also mean high transport costs due to detours or extra tours.

Enterprises, which plan their container demand regularly, have the opportunity to reduce considerably the volume of their container stocks and therefore the fixed capital! [2] However, these firms lack a reliable tool for this purpose, which is easily to handle and which quickly creates a respective planning result, in particular on the basis of current parts requirements and availabilities of containers. The control of containers is very complex in most cases. In the majority of cases the exact location, the content and the storage period of the containers is unknown, so that product data, location data etc. can hardly be used for controlling the production. Therefore enormous controlling efforts result from the demand to assure the required quality of the logistics chains. It is indispensable to create transparency of both, container stocks and costs for the improvement of the container management.

Radio Frequency Identification (RFID) is a technology, which has already been utilized to support the control of logistic processes successfully. A variety of RFID tagged objects can automatically identified within a very short period of time and based on these data retraceability becomes possible. However, extensive application of this technique is not feasible in a lot of scenarios. At this point, identification problems of the RFID transponders in metallic surroundings and for metallic objects must be highlighted in particular. These problems are based on the physical fact that metallic or metallised surfaces strongly reflect electromagnetic waves and are therefore a source of obstruction with regard to RFID technology. Currently a handful of methods for get over these obstructive properties of metallic objects in the field of transponders exists. This includes application of absorber materials between transponder and metallic object. Furthermore, there are also approaches to take advantage of the given properties of metallic objects to guarantee the functionality of the transponder. However, the mentioned techniques are often characterised by limited profitability resulting from high production costs of the transponders and a limited effectiveness at the same time. To counter the latter, it has become necessary to develop a new antenna concept, which has been optimised for a printing-based manufacture of transponder antennae and which can ensure a very high functionality in the UHF frequency range in and for metallic surroundings.

METHODICAL APPROACH

Management of special containers

One of the prerequisites for an efficient planning and control of container loops is the transparency of the material flow, i.e. the availability of information relating to actual stocks, storage periods of containers, levels of utilisation and a lot more in real time.

More attention has to be paid to the container function "information carrier", especially in the planning period of logistics systems. Based on the respective logistics strategy and the respective information demand for the functional planning and controlling of the container, points of origin and points of consumption of the information flow have to be determined as conducted in material flow planning, and data acquisition is to be supported by the appropriate auto-ID technique. The highest potential for automatic identification of containers has been seen in the RFID technology so far. For the selection of the RFID hard- and software, concrete application goals and conditions need to be considered. Consideration of all relevant determining factors is guaranteed when applying the planning method "easyRFID" [3].

However, the improved basis of information regarding the state of container loops has to be used in an appropriate way. Already in the stage of planning, evaluations, reports and alarm messages need to be defined among others, which in turn prompts the responsible personnel to structured acting and taking corrective action relating to the container flow, if required. Besides this kind of "machine-human" communication, there is a variety of approaches for the "machine-machine" communication, which realise visions of a partial to automatic control of logistics systems.

Development of technology
Within the frame of this paper, development of technology means direct impact of function parameters of the RFID technology. As the automatic identification of special containers via RFID takes place under the strong influence of metallic materials, it is the goal of the development of technology to guarantee secure Identification on metallic ground without cost-intensive damping of obstructive properties. The starting point for this is the development of a new antenna concept, which is being optimised for a printing-based production.

The new antenna concept is an arrangement of layers lying upon each other containing printed conductive antennae (see Fig. 1 for illustration of layers). Here, conductive layer 1 is contacted with the RFID chip and therefore it is the feeding element. Conductive layer 2 (director) and the metallic surface (reflector) are absolutely passive. [4]

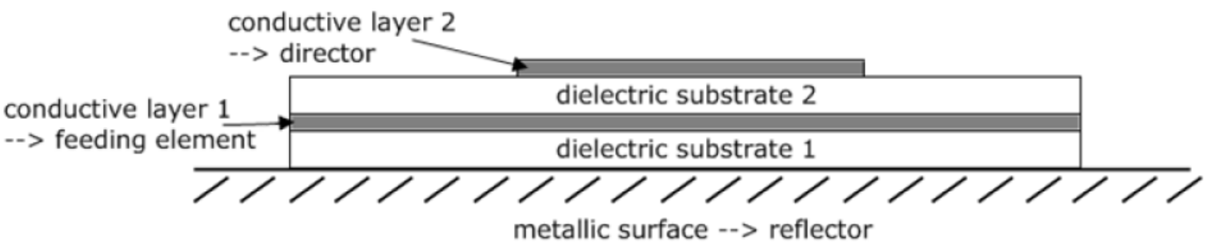

Figure 1: Schematic illustration of layers of a transponder antenna according to the new RF antenna principle

The functioning of the antenna concept is based on electromagnetic interaction between the feeding element, the reflector and the director. In consequence of this interaction, a directed and bundled directional characteristic vertical to the reflector layer is created. In turn, this makes an increased reading and writing range possible and minimises environmental effects. It has to be noted that the antenna principle can only function if a metallic surface is provided as reflector.

FINDINGS
Management of special containers
Within the frame of the cooperative project "iBox", a control cockpit for special container loops is created, which gives persons responsible in logistics the opportunity to recognise the container loop and therefore to plan the parts flow in a better way to detect shortage in an early stage and to intervene for corrective action.

Planning and control are based on current data, which are recorded by means of RFID technology and which are then transferred to the cockpit. To achieve this goal, a planning method including tool, controlling approaches on the basis of RFID data and various aspects regarding the RFID technology to be applied are examined and a respective software prototype is developed.

The system iBox to be developed serves the tracing of containers in defined loops. For this purpose, the containers have to be detected at selected points by means of the RFID technology. The iBox cockpit, which will be developed by our associate partner Carnet GmbH, serves as a link to the end user. It visualises the process of the container loops and offers different possibilities for tracing of the containers (tracking) and evaluation (reporting).
A prototypical realisation of the results takes place within a pilot project. Here, the container loop is considered for the transport of automotive parts from the assembly of a supplier to an automobile manufacturer.

ARCHITECTURE AND COMPONENTS OF THE SYSTEM IBOX FOR THE PILOT AREA:
The basic architecture of the system iBox is displayed in the figure below.

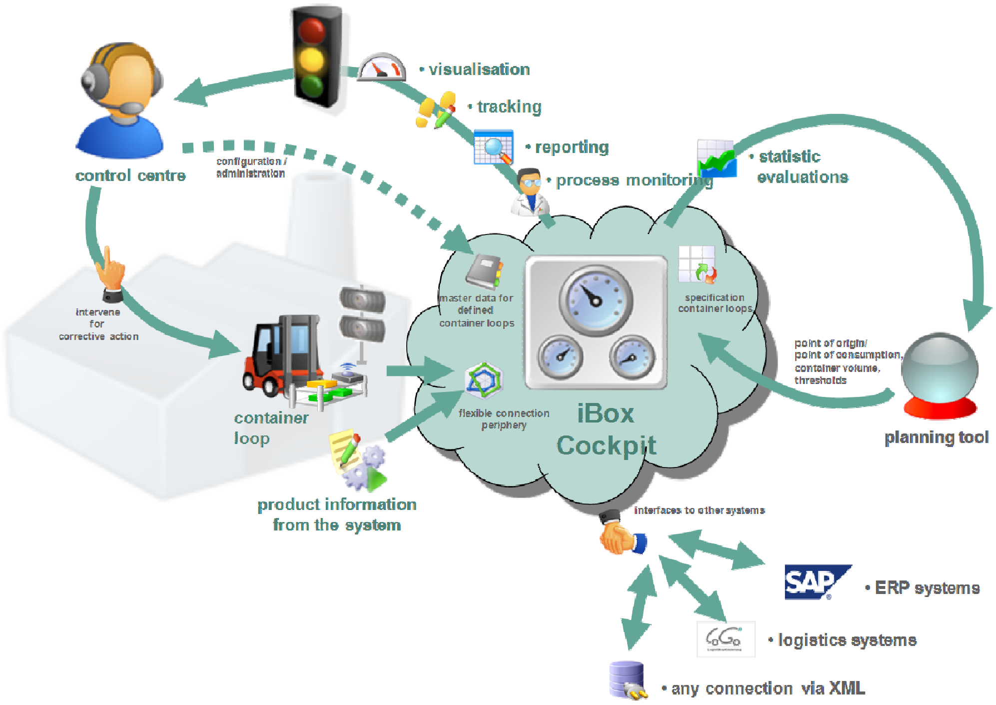

Figure 2: iBox architecture

The clear identifications of the RFID tags at the containers are read at different points in the process chain and are transmitted to the central data base. There the read identifications are assigned to the container by help of master data, which can be maintained by key users. The container content (variant) is determined from the assembly system.

The cockpit front end serves as visualisation of the container movements and flows transmitted to the data base. In addition to that, the cockpit offers different evaluations and statistics. It also includes monitoring of the whole process chain. Moreover, the system iBox provides various interfaces for the connection of superordinate systems (e.g. SAP R3). A flexible connection of further systems is possible by means of a universal XML interface.

The cooperative project "iBox" is funded within the framework of the European Regional Development Fund (EFRE) and with funds from the Free State of Saxony.

Technology development
Development work was conducted by the Fraunhofer Research Institution for Electronic Nano Systems (ENAS) in the field of RFID transponder technology being independent from the current cooperative project "iBox".

Constructive realisation of the new antenna concept [4]
With regard to the arrangement of layers of printed conductive antenna structures, (see Figure 1) different constructive solutions of the new antenna concept may be implemented. The dielectric substrates can be realised by various papers and PET films. Here, coordination of the antenna performance strongly depends on the substrate properties (relative permittivity, substrate thickness, surface roughness) and on the conductivity of the printed layers 1 and 2, so that afterwards an optimised antenna design of layers 1 and 2 must be realised in a planar form with respect to the operating frequency band. In addition to that, the antenna design of layers 1 and 2 has to be adapted subject to the relative position of layer 1 to layer 2. The new antenna concept

has been developed for a substrate layer thickness starting from 130µm. Therefore, the transponder can take a flexible and thin shape.

For the implementation of a printed RFID transponder antenna in the frequency range of 868MHz, an adjusted design (Figure 4) and its properties have been simulated as an example. The following layer parameters were implemented.

Layer	Material	Layer thickness
a) dielectric substrate 3	PET	50µm
b) conductive layer 2	silver ink	1µm
c) dielectric substrate 2	PET	130µm
d) conductive layer 1	silver ink	1µm
e) dielectric substrate 1	PET	130µm
	paper	175µm
a) dielectric substrate 3	aluminium	5mm

Table 1: Layer parameters

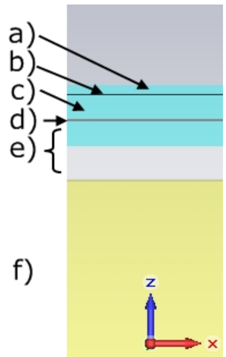

Figure 3: Sectional view of the design

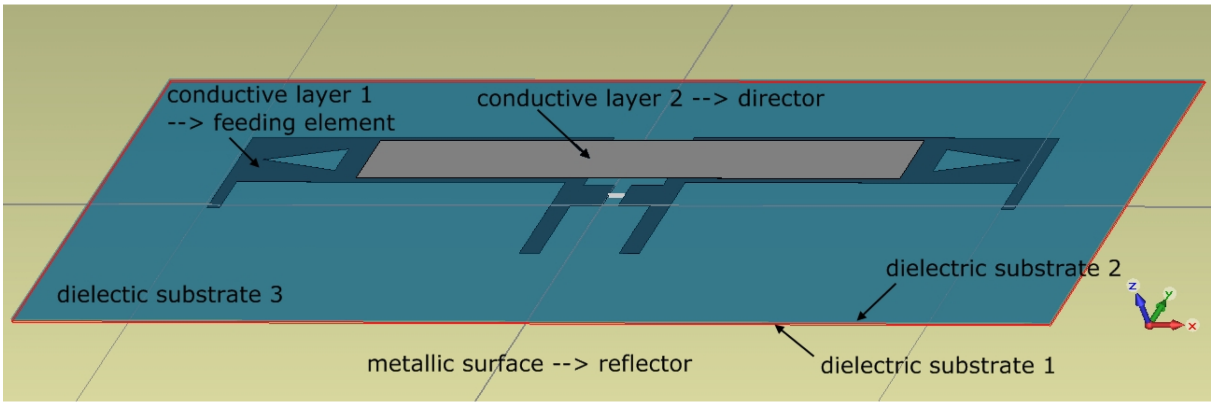

Figure 4: Spatial arrangement of an exemplary antenna design on basis of the RF antenna concept

Depending on the print method (roll-to-roll: screen printing, flexo, inkjet), modifications have to be made at the antenna design to obtain the desired functionality. This results from the fact that parameters, which underlie typography, as for instance layer thickness, edge structure and surface texture of the printed conductive layers, strongly depend on the particular printing process.

The antenna concept in form of the exemplary antenna design is characterised by a good adaptive behaviour (see Figure 5) in the frequency range of 868MHz, a good Voltage Standing Wave Ratio (see Figure 5) and an adjusted directional characteristic (see Figure 6) vertical to the metallic surface. These properties make a large reading and writing range possible and therefore also a high reading and writing reliability of the passive transponder. According to the Friis radio link formula, the reading range R is determined as follows.[5],[6]

Friis radio link formula: $$P_r = \frac{G_t G_r \lambda^2}{(4\pi R)^2} P_t \qquad (1)$$

- Frequency: $f = 868\,MHz$ → wave length: $\lambda = \frac{c}{f} = \frac{2{,}998 \cdot 10^8\, m/s}{868 \cdot 10^6\, 1/s} \cong 0{,}345m$ (2)

- Directivity of transmitting antenna (Reader): $G_t = 9dBi$

- Directivity of receiving antenna (exemplary antenna design): $G_t = 7{,}125\, dBi$

- Transmitting power of RFID reader: $P_t = 1W$

- RFID Chip (NXP UCODE G2XM) Minimum Operation Power: $P_{\min} = -15 dBm$

- RFID Chip (NXP UCODE G2XM) approximated normal Operation Power:
$P_r = -12 dBm$

$$\rightarrow \quad R = \sqrt{\frac{G_t G_r \lambda^2 P_t}{(4\pi)^2 P_r}} = \sqrt{\frac{10^{0,9} \cdot 10^{0,7125} \cdot (0{,}345m)^2 \cdot 1W}{(4\pi)^2 \cdot 63{,}1\mu W}} \approx \underline{22m} \qquad (3)$$

As a consequence of the adjusted directional antenna characteristic, environmental perturbations are additionally minimised. Therefore, application in metallic environments like metal boxes or racks is especially suitable.

Besides the benefits of the antenna concept in respect of its application possibility and high functionality on metals, it can also be produced in a cost-efficient way by means of the roll-to-roll print method. This ensures high efficiency having high functionality at the same time.

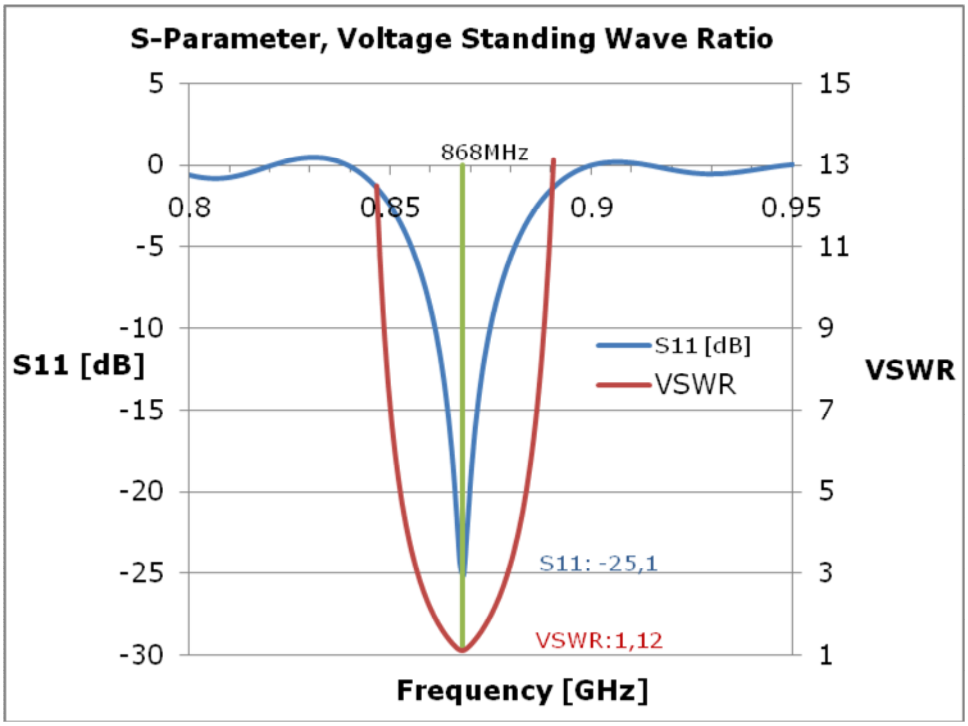

Figure 5: S11 Scattering Parameter, Voltage Standing Wave Ratio

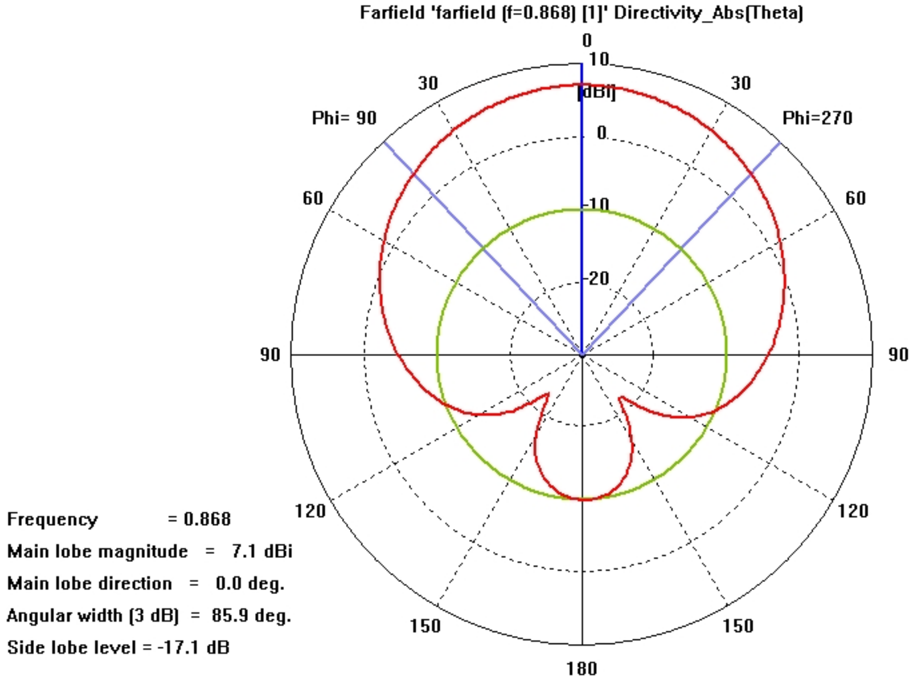

Figure 6: Far field polar plot in x-plane

The described antenna concept has primarily been developed for passive RFID transponders, but it may also be applied for active RFID transponders for increased performance concerning reading and writing ranges and reliability. Moreover, it is possible to utilise the required metallic surface (reflector) in a printing-based manufacturing process to be able to apply the RFID transponder antenna in a functional way to materials having high permittivity, if taken as an example. This can be done due to the fact that the electromagnetic waves coming from the transponder are emitted directional and therefore they enter the subjacent material in the back lobe area of the transponder antenna only slightly (see Figure 6). Thus, the obstructive properties of the immediate vicinity are extremely minimised.

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A STUDY OF THE SMART CONTAINER MONITORING SYSTEM IN THE OCEAN SHIPPING INDUSTRY

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ABSTRACT:
There are more than 146,172,823 TEUs containers handled through the top ten container ports in 2006. With such a large amount of container throughput, how to accurately read the container I.D. at the gate during their entering into and leaving from a container yard is a major issue. An appropriate monitoring system can not only improve the yard's operation efficiency but also reduce the yard's operation cost.

There are two types of technology currently employed to help identify the container external markings with detailed cargo information, namely, (1) Optical Character Recognition (OCR) and (2) Radio Frequency Identification Tag (RFID). According to the author's knowledge, there is no academic study to compare the cost and benefit of the two container monitoring technologies systematically. This research employed the AHP methodology to find out the major criteria influence the container yards' monitoring system selection decision by distributing AHP expert questionnaires to major stakeholders in the ocean container shipping industry in Taiwan.

The initial finding indicates using an OCR system could result in a higher benefit /cost ratio, which means OCR is perceived to be the better container monitoring systems by most of the major carriers in Taiwan.

Key Words: AHP, OCR, RFID.

INTRODUCTION

There are more than 4600 container vessels serve the 4000 container terminal. More than 80% of international general cargo trade is shipped by containers, and there is around 72 million containers fleet available in the maritime transportation industry (The Economist, 2002). Each container has its own serial number which is similar to a citizen's social security card number in the United States. The container serial number is also used by shipper, carriers, custom, and consignees to identify the cargo content and track the container flow. The container serial number is shown in six different positions of the container, thus the users can have convenient access to identify the serial number. Currently, most serial number of the container is identified manually in most container terminals. In another word, it is read by the container inspector without resorting to any automation gadget. Misread number could be occurred due to the distance, angle, insufficient intensity of light, and poor container position in the yard between the inspector and the container. Reading errors could be also resulted from the inspectors' oversight. These omissions and errors usually result in lengthy delivery delay and extra expenses.

To avoid the risk of inspectors' omission and negligence, two types of techniques are normally suggested to improve the container identification process, namely, Optical Character Recognition (OCR) and Radio Frequency Identification (RFID). Some modern container vessels have reserved spaces for installing RFID readers, but RFID is not used currently by any major ocean container carriers to identify container numbers. APL was the pioneer to invest several million US dollars to install RFID tag (the so called Auto Equipment Identification tag, AEI tag) on its containers fleet around the 1990s. The AEI tag scheme was abandoned by the APL because of the emergence of alliance operation. The AEI tag cannot function in a terminal operated by the APL's alliance carriers because the AEI reader was just not available in APL's alliance carriers' terminals.

Optical character recognition (OCR) is the technology to translate the printed or handwritten text and images into a machine-readable data, transfer information from a non-computer-retrievable medium into computer retrievable ones (Sun et al., 1992), and it was used by the United States

Postal Service in as early as 1965. The OCR is also employed by many professionals in the semiconductor, automotive, and pharmaceutical industries to track and control cargo flows (Menard, 2008). Printing and image quality of an OCR code will influence its reliability. In addition, OCR is usually used in a harsh environment where the image quality is not easily obtained by the OCR reader.

The commercial application of RFID was firstly initiated by the Raytheon Corporation by releasing its 'Raytag' product, and similar RFID tag were produced by RCA, Fairchild Semiconductor, and Schlage Electronics (Shepard, 2005). A typical RFID system should include three major components, the transponder (can be active/passive transponder), the reader, and the data collection application. An active RFID transponder is battery powered and has a read range as much as 15 meters. Thus it can be used to identify individual containers in a shipping environment. For highway toll-collection and container shipping applications, a typical RFID device is operated in the ultra high frequency or microwave range (e.g. 900 MHz or 2.45 GHz in the U.S.A., or 5.8 GHz in Europe). The function of RFID can be adversely affected by moisture, and the UHF and microwave range RFID device is not licensed in Japan and parts of Europe respectively (Shepard, 2005). RFID cannot be used globally without a universal standard, the electronic product code (EPC), for immediate, automatic, and accurate product identification. The EPC was firstly developed by MIT to establish an internet-based system to identify products anywhere in the world in the early 2000s.

STRENGTH AND WEAKNESS OF THE RFID AND OCR TECHNIQUES

Ocean container carrier is a third party logistics service provider, it take cargo from the shippers and use trains or trailers to move container to a container depot or a container terminal to await the container vessel's loading operation. Without the cargo manifest, truckers, container carriers, and terminal operators cannot acquire the cargo information they need. Supply chain management is strived to pursue the integrated logistics management (Blanchard, 2006). Manufacturers and suppliers embedded the RFID tags into their products during the manufacturing processes, and stored their products information in the active RFID tag on the containers during their loading and discharging stage. Thereafter, the container and cargoes can be traced ubiquitously by the RFID reader. Information of container number, shippers, cargo contents, quantity, booking number, loading/discharging ports, and consignee etc. can be easily obtained and managed. The RFID tag used in the container shipping industry is normally an active, and microwave-length tag, class 2 RFID tag is potentially to be used by the carriers to track their containers. With a unique container serial number, it is reported the RFID reader can almost 100% obtain the container information correctly (Kima, 2007). However, there are problems in using RFID to monitor container movement. Firstly, the active RFID tag is more expensive than the OCR, and the battery in an active RFID tag can only be used up to 6 years. Secondly, the industry wisely prevalence of RFID reader in container terminals is not available.

Most literatures on the OCR are limited to the static character recognition. According to the authors' knowledge, extant academic research on the OCR application in container shipping industry is not available. Post 911 catastrophe in 2002, ISPS (International Ship and Port Facility Security Code) demand foreign containers destined for USA have to be inspected by the Integrated Container Inspect System(ICIS). ICIS includes vehicle and cargo inspection, radiation portal monitor, optical character recognition, and pulsed-neutron elemental analysis subsystems. Containers with OCR serial number can be recognized by the OCR reader if the trailer speed is below 40 kilometers per hour (Orphan et al., 2005). Nonetheless, there are still two problems to be overcome by using the OCR in container shipping industry. Firstly, container OCR serial number is printed on a long-effect sticker and the image quality of the characters on the containers would be deteriorated over a long traveling between continents. Damage of the sticker can be occurred due to container collision, scratch, and seawater erosion. Secondly, OCR reader is normally installed in a fixed place without moving it around. Thus, the reliability of OCR reader installed on the gantry cranes, transtainer cranes, and straddle carriers is greatly reduced.

The pros and cons of the application of OCR and RFID techniques in container shipping industry is summarized in the Table 1, and the authors also use them to build the AHP decision-making structure as shown in the Figure 1.

Table 1. Comparing OCR and RFID application in the Container Shipping Industry

Criteria \ Alternatives		OCR	RFID
Start-up Cost	Equipment Cost	Long-effect OCR sticker cost below US$2 each	US$20~30 for each active RFID tag
	Facility Cost	US$100k ~400k for an OCR reader	US$400~500 for each RFID reader
Repair & Maintenance Cost	Facilities	**Low**	**High**
	Equipment	OCR has longer product life without paying extra maintenance cost	Each active RFID can be used up to 6 years before the battery is run out. RFID tag is likely to be damaged during loading and discharging operation.
Information Quality	Accuracy	90%~98%	Near 100% (Kima, 2007)
	Data Capacity	Only the container serial numbers are identified to be used to link with a container database in the yard or terminal.	Information can be stored in the RFID tag up to 256 bytes (Wamba, 2007).
	Information Addibility		
Processing Time	Time needed for Container positioning	High: OCR readers can be easily installed in most container ports.	Low: RFID tag can only be functioned in a port with the RFID reader (Nagi et al., 2005).
	Gateway Inspection Time /Tallying Time	Low: Reader can only be installed in a fixed position, and the OCR containers can only recognized if its speed is less than 40km/hr.	High: Active RFID tag can be installed on a moving container, and the reader can be installed anywhere in the terminal.

Note: Facilities includes infrastructure and readers of the OCR and RFID data acquisition system. Equipment cost includes the RFID tag cost and the OCR printing cost.
Source: this research.

RESEARCH STRUCTURE AND METHODOLOGY

Analytical hierarchic process is firstly proposed by Saaty (1978) and is widely used as a decision-making technique. It can be used to take quantitative and qualitative criteria into consideration at the same time. The basis of an AHP structure includes the goal, criteria, sub-criteria, and the alternatives. The sub-criteria and criteria are usually obtained from previous literatures or the interview with managers in an industry. AHP is use the questionnaire to extract the respondents' perception, and human beings are said to be used to evaluate the performance of system in semantic wordings (Tsaur et al., 1997 & 2002). Thus, the fuzzy logics can be applied in this research to make the fuzzy semantic wordings into a crispy numerical number. In addition, Saaty (2001)pointed out often the alternatives are associated with both costs and benefits, thus it is appropriate to construct separate costs and benefits hierarchies and make the benefit/cost analysis (BCA) to choose a project with the highest BCA ratio.

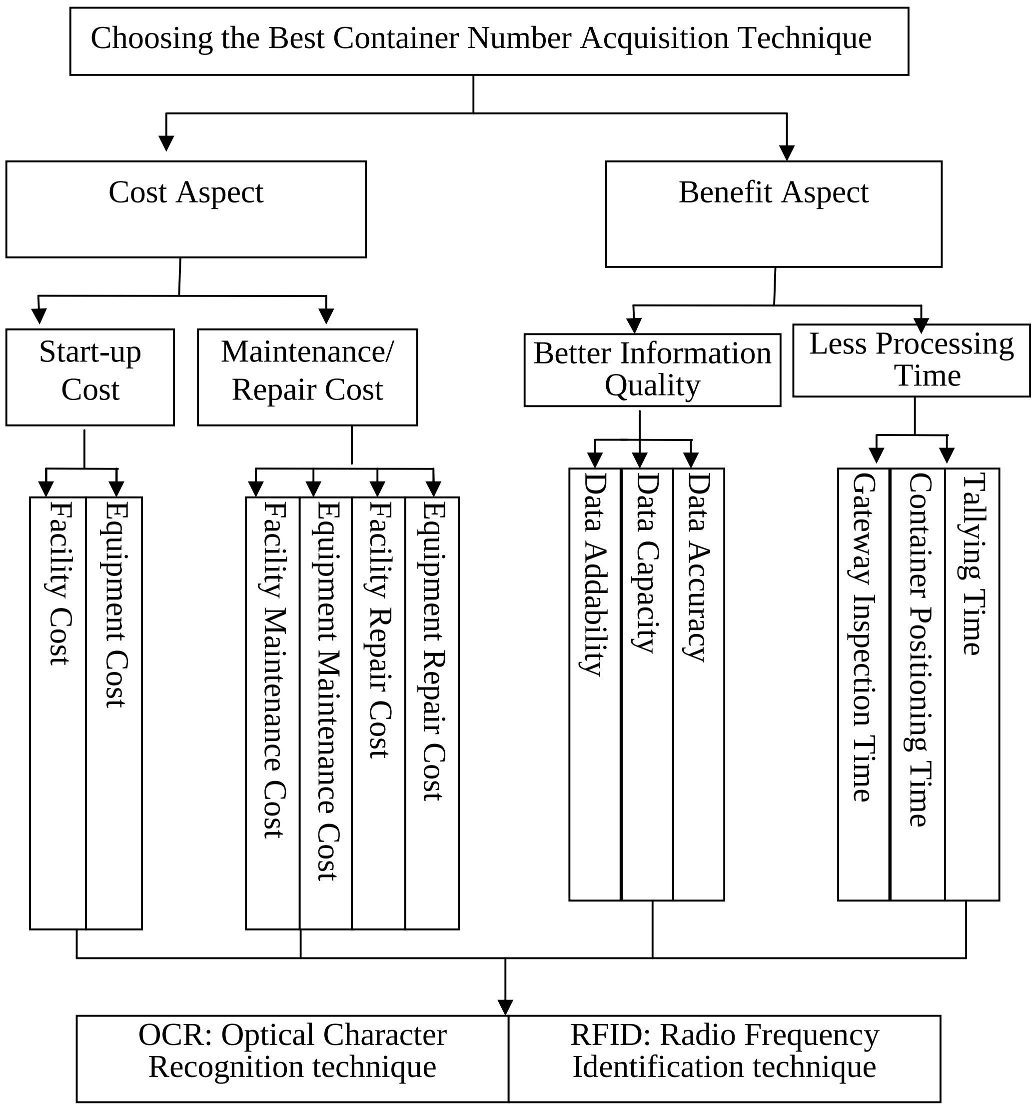

Figure 1 Cost Structure and Benefit Structure of the container monitoring system

PILOT STUDY IN TAIWAN

Pilot study questionnaires were send to four ocean container carriers in Taiwan. There are three major container shipping companies in Taiwan, they are ranked as the top twenty container carriers in terms of their container fleet capacity. Another major regional container carriers in Taiwan is also surveyed. This research employs the fuzzy AHP methodology to survey these carriers' perception on the relative importance of criteria influencing their selection of the two container number recognition system. Responses from the four managers of the four major Taiwanese ocean container carriers were obtained and analyzed by the fuzzy AHP technique and Expert Choice software[23]. The fuzzy AHP technique compare the relative importance of two criteria pairwisely, and the sub-criteria priorities of the benefit and cost aspects in using the RFID and OCR system are shown in Figure 2 and Figure 3 respectively.

[23] As one of the carrier is very conservative and it is almost impossible to collect the replied questionnaire from the carrier. Thus, a questionnaire was send to a senior manager recently retired from that carrier.

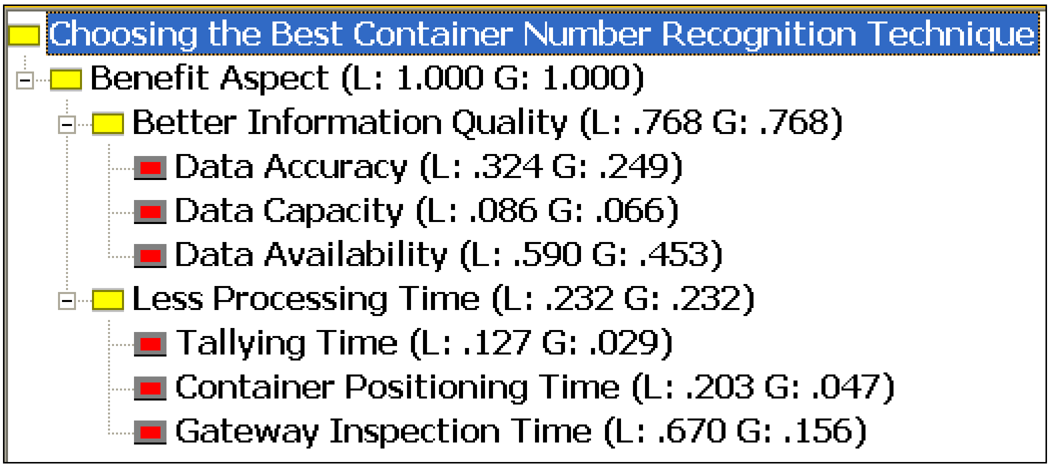

Figure 2. Importance of different sub-criteria in benefit aspect

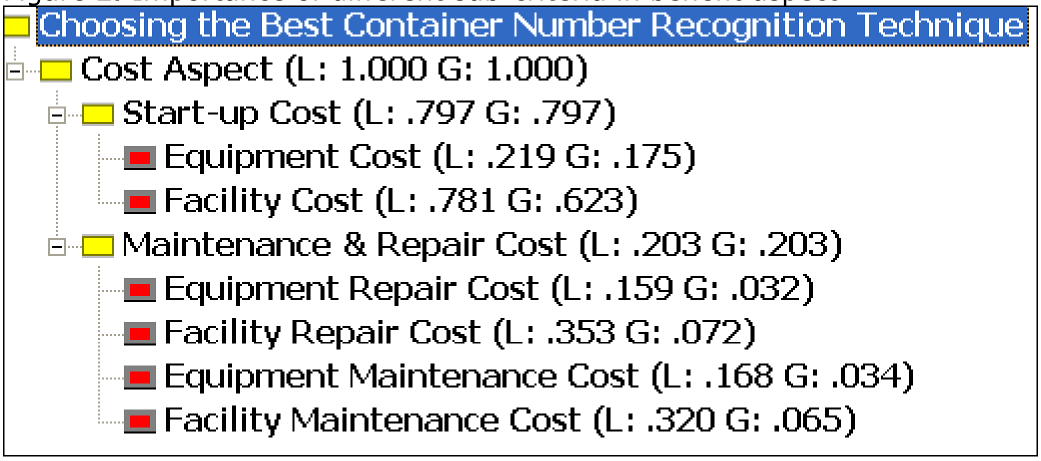

Figure 3. Importance of different sub-criteria in cost aspect

RESEARCH FINDINGS AND SUGGESTIONS

Using Tsaur's (2002) defuzzying formula, different degree of semantic wordings on benefit and cost aspects are become crispy numbers (see Figure 4). Although RFID system has a better overall benefit scores (358.71), its overall cost score is even higher (364.89). Thus the BCA (Benefit/Cost Analysis) ratio of the RFID system is approximated 0.983, and similar ratio for the OCR system is 1.05 (see Figure 5) . The higher the BCA ratio, the better the container monitoring system perceived by the ocean container carriers.

The RFID system has a very outstanding performance over OCR system on the "Data Availability" sub-criteria. RFID system has a comparatively poor cost structure to the OCR system on the 'Start up cost of the RFID equipment' sub-criteria. Future cost reduction on the active RFID tag could possibly make the RFID system become a more attractive container monitoring system from major Taiwan container carriers' viewpoint.

As security issue is the most important factor influencing the passengers' transportation mode choice behaviour, a study on the historical development of OCR and RFID's applications in the passenger transportation industry can be another possible avenue for future research.

Table 4 Defuzzyfication of Semantic Wordings

Degree of Benefit	Respondent 1	Resp. 2	Resp. 3	Resp. 4
Very Good = VG	88.00	89.33	92.67	95.33
Good = G	85.33	85.33	86.00	88.00
Fair = F	80.00	82.33	82.00	84.00
Poor = P	76.67	76.00	74.67	75.00
Very Poor = VP	65.00	60.00	43.33	43.00
Degree of Cost	Respondent 1	Resp. 2	Resp. 3	Resp. 4
Very Costy = VC	88.00	89.33	92.67	95.33
Costy = C	85.33	85.33	86.00	88.00
Fair = F	80.00	82.33	82.00	84.00
Less Costy = LC	76.67	76.00	74.67	75.00
Least Costy = LTC	65.00	60.00	43.33	43.00

Source: this research.

Table 5. Comparison of Benefit/Cost Ratio between OCR and RFID techniques

Benefit		OCR Performance perceived by the respondents						
			Importance	Resp. 1	Resp. 2	Resp. 3	Resp. 4	Total Benefit Score of the OCR
	Benefit Aspect	**Better information Quality**			0.768			
		Data Accuracy	0.249	88.00 VG	85.33 G	86.00 G	88.00 G	86.48517
		Data Capacity	0.066	80.00 F	85.33 G	82.00 F	84.00 F	21.86778
		Data Availability	0.453	76.67 P	82.33 F	82.00 F	75.00 P	143.148
		Less Processing Time			0.232			
		Tallying Time	0.029	80.00 F	85.33 G	82.00 F	75.00 P	9.34757
		Container Positioning Time	0.047	85.33 G	82.33 F	86.00 G	84.00 F	15.87002
		Gateway Inspection Time	0.156	76.67 P	82.33 F	86.00 G	88.00 G	51.948
								328.66654
		RFID Performance perceived by the respondents						
			Importance	Resp. 1	Resp. 2	Resp. 3	Resp. 4	Total Benefit Score of the RFID
	Benefit Aspect	**Better information Quality**			0.768			
		Data Accuracy	0.249	88.00 VG	89.33 VG	92.67 VG	95.33 VG	90.96717
		Data Capacity	0.066	88.00 VG	89.33 VG	86.00 G	95.33 VG	23.67156
		Data Availability	0.453	88.00 VG	85.33 G	92.67 VG	88.00 G	160.362
		Less Processing Time						
		Tallying Time	0.029	88.00 VG	89.33 VG	92.67 VG	88.00 G	10.382
		Container Positioning Time	0.047	85.33 G	89.33 VG	92.67 VG	88.00 G	16.70051
		Gateway Inspection Time	0.156	85.33 G	89.33 VG	92.67 VG	95.67 VG	56.628
								358.71124
Cost		OCR Performance perceived by the respondents						
	Cost Aspect		Importance	Resp. 1	Resp. 2	Resp. 3	Resp. 4	Total Cost Score of OCR
		Start-up Cost			0.797			
		Equipment Cost	0.175	76.67 LC	76.00 LC	82.00 F	75.00 LC	54.19225
		Facility Cost	0.623	80.00 F	76.00 LC	82.00 F	75.00 LC	194.999
		Maintenance & Repair Cost			0.203			
		Equipment Repair Cost	0.032	76.67 LC	82.33 F	74.67 LC	84.00 F	10.16544
		Facility Repair Cost	0.072	80.00 F	82.33 F	74.67 LC	84.00 F	23.112
		Equipment Maintenance Cost	0.034	76.67 LC	82.33 F	74.67 LC	75.00 LC	10.49478
		Facility Maintenance Cost	0.065	76.67 LC	76.00 LC	74.67 LC	75.00 LC	19.6521
								312.61557
		RFID Performance perceived by the respondents						
	Cost Aspect		Importance	Resp. 1	Resp. 2	Resp. 3	Resp. 4	
		Start-up Cost	0.797					Total Cost Score of RFID
		Equipment Cost	0.175	88.00 VC	89.33 VC	92.67 VC	95.33 VC	63.93275
		Facility Cost	0.623	88.00 VC	89.33 VC	92.67 VC	95.33 VC	227.60059
		Maintenance & Repair Cost	0.203					
		Equipment Repair Cost	0.032	88.00 VC	82.33 F	92.67 VC	95.33 VC	11.46656
		Facility Repair Cost	0.072	80.00 F	89.33 VC	92.67 VC	95.33 VC	25.72776
		Equipment Maintenance Cost	0.034	88.00 VC	89.33 VC	92.67 VC	95.33 VC	12.42122
		Facility Maintenance Cost	0.065	88.00 VC	89.33 VC	92.67 VC	95.33 VC	23.74645
								364.89533
		OCR Benefit/Cost =	1.051344116					
		RFID Benefit/Cost =	0.983052428					

Source: this research.

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OPTIMAL CONTRACTS AND INFORMATION DISTORTION

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ABSTRACT
This paper examines optimal contracts in a principal-agent model with both moral hazard and adverse selection in which the agent can choose a costly signal to falsify her private information. We consider an environment in which a risk-neutral manufacturer (agent) supplies a product to a risk-neutral retailer (principal). The manufacturer is assumed to have private information about her production cost. It is also assumed that the manufacturer can signal her type by incurring costs and exert efforts for increasing the probability of being efficient. We examine the effects of the manufacturer's costly signals and efforts on the level of production and characterize the optimal contract. We demonstrate that the optimal contract exhibits different regimes depending on the costs of signals and those of exerting efforts and that there exists a case in which the agent sends costly signals to the principal.

INTRODUCTION
In many principal-agent relationships, agents often have incentives to distort their private information. This paper examines the optimal contract in a principal-agent model with both moral hazard and adverse selection in which the agent can choose a costly signal to falsify her private information. We consider a supply chain setting between a retailer (principal) and a manufacturer (agent) in which the retailer contracts with the manufacturer for purchasing her product. The manufacturer is assumed to have private information about her production cost. We also assume that the manufacturer can signal her type by incurring costs and exert an effort for increasing the probability of being the efficient type.

Specifically, we consider a contracting game in which first, the retailer offers a contract to the manufacturer, and then the manufacturer accepts or rejects the contract. If the manufacturer accepts the contract, she chooses an effort for increasing the probability of being the efficient type and then the cost state is realized. Then the manufacturer chooses a costly signal. Finally, transfers take place. We analyze this contracting game to examine the effects of the manufacturer's costly signal and efforts on production. We demonstrate that the optimal contract exhibits different regimes depending on the costs of signals and those of exerting efforts and that the manufacturer sends the retailer a costly signal regarding the production cost.

Our paper is related to a number of papers regarding information distortion. Maggi and Rodriguez-Clare (1995a) examine the falsification of information in a principal agent model. They show that costly information distortion can arise at the equilibrium. Lacker and Weinberg (1989) examine the problem of costly falsification in a model of an exchange economy in which a risk adverse agent can misrepresent her own endowment and characterize the optimal contract with no falsification. Dye (1988) considers an overlapping generation model under costless falsification and show that information distortion may be optimal. Crocker and Morgan (1998) show that optimal insurance contracts induce falsification in an environment in which the insureds can falsify actual losses. Our paper is different from those papers in that we consider a principal-agent model in the presence of both adverse selection and moral hazard.

Crocker and Slemrod (2007) examine the optimal contract with costly falsification in a model with private information and hidden action. We focus on the effects of limited liability constraints on the optimal contract while they do not consider limited liability constraints. Besides their setting is based on the relationship between shareholders and a manager while our model considers a supply chain between a manufacturer and a retailer. Furthermore we discuss a case in which the manufacturer's fixed costs depend upon her type, that is, upon the asymmetric information parameter.

The paper is organized as follows. Section 2 describes the basic model. In Section 3, we characterize the optimal contract. In Section 4, we consider a case in which fixed production costs depend on private information and discuss the role of signaling costs and fixed costs on the possibility of countervailing incentives. Section 5 concludes.

THE MODEL

Let us consider a setting in which a risk-neutral manufacturer (agent) supplies a product to a risk-neutral retailer (principal). Let q denote the quantity of the product. The manufacturer is assumed to have private information on the constant marginal cost of production, β, either low β_L or high β_H, with respective probabilities λ and $1-\lambda$, and $0<\beta_L<\beta_H$. We also assume that these probabilities depend on the manufacturer's effort or action e, that is, $\lambda(e)$ and $1-\lambda(e)$, and that $\lambda'(e)>0$ and $\lambda''(e)<0$. Thus the manufacturer can exert an effort to increase the probability of being efficient. Let $\varphi(e)$ denote the disutility of exerting an effort. We further assume that the manufacturer can signal her type by incurring costs. Let $c(\beta,\theta)$ denote the cost of a signal, where θ denotes a signal by the manufacturer. We assume that $c_\theta(\beta,\theta)>0$, where $c_\theta(\beta,\theta)$ is a partial derivative with respect to θ. Let $B(q)$ denote the retailer's revenue and satisfy $B'(q)>0$ and $B''(q)<0$. Let t denote the payment from the retailer to the manufacturer. Then the manufacturer's payoff U is given by $U=t-\beta\cdot q-c(\beta,\theta)-\varphi(e)$. The retailer's payoff π is given by $\pi=B(q)-t$.

The timing of the contracting game is as follows. First, the retailer offers a contract to the manufacturer. Second, the manufacturer exerts an effort to increase the probability of being efficient. Third, the efficiency parameter is realized and only the manufacturer learns it. Fourth, the manufacturer chooses a costly signal. Finally, transfers between the retailer and the manufacturer take place.

CHARACTERIZATION OF OPTIMAL CONTRACTS

In this section, we derive the optimal contract under both asymmetric information and moral hazard. First let us consider a benchmark case in which marginal cost β and the manufacturer's effort e are known to both the retailer and the manufacturer.

We assume that the manufacturer is protected by the following limited liability constraints: For the efficient type,

$$U_L=t_L-\beta_L\cdot q_L-c(\beta_L,\theta_L)\geq 0 \qquad (1)$$

and for the inefficient type,

$$U_H=t_H-\beta_H\cdot q_H-c(\beta_H,\theta_H)\geq 0. \qquad (2)$$

The retailer's problem under complete information is

$$\max_{t,q,e}\lambda(e)\{B(q_L)-t_L\}+\{1-\lambda(e)\}\{B(q_H)-t_H\}$$

subject to (1) and (2).

Thus the manufacturer's outputs under complete information are given by

$$B'(q_L^{FB})=\beta_L$$

and

$B'(q_H^{FB}) = \beta_H$.

The manufacturer chooses the first best output for each of the two states.

Next we examine the optimal contract under both asymmetric information and moral hazard. Suppose that both β and e are known only to the manufacturer. Then the optimal contract has to satisfy the following incentive compatibility constraints. For the efficient type, the incentive compatibility constraint is

$$\begin{aligned} U_L &= t_L - \beta_L \cdot q_L - c(\beta_L, \theta_L) \\ &\geq t_H - \beta_L \cdot q_H - c(\beta_L, \theta_H) \\ &= U_H + (\beta_H - \beta_L) q_H + c(\beta_H, \theta_H) - c(\beta_L, \theta_H). \end{aligned} \tag{3}$$

For the inefficient type, the incentive compatibility constraint is

$$\begin{aligned} U_H &= t_H - \beta_H \cdot q_H - c(\beta_H, \theta_H) \\ &\geq t_L - \beta_H \cdot q_L - c(\beta_H, \theta_L) \\ &= U_L - (\beta_H - \beta_L) q_L + c(\beta_L, \theta_L) - c(\beta_H, \theta_L). \end{aligned} \tag{4}$$

In the model we assume that the manufacturer can exert efforts to increase the probability of being efficient. Then the manufacturer chooses her effort level to maximize her expected payoff. Thus the moral hazard incentive constraint is given by

$$\max_e \lambda(e) U_L + \{1 - \lambda(e)\} U_H - \varphi(e). \tag{5}$$

The first order condition with respect to e is

$$\lambda'(e)(U_L - U_H) - \varphi'(e) = 0. \tag{6}$$

Since the contract is offered before the agent's types are chosen, the ex ante participation constraint is given by

$$\lambda(e) U_L + \{1 - \lambda(e)\} U_H - \varphi(e) \geq 0. \tag{7}$$

Hence when the cost state β and the manufacturer's effort e are known only to the manufacturer, the retailer's problem is given as

$$\max_{t, q, e} \lambda(e) \{B(q_L) - t_L\} + \{1 - \lambda(e)\} \{B(q_H) - t_H\}$$

subject to (1), (2), (3), (4), (6) and (7).

Depending on which constraints are binding, we need to distinguish the following two cases. For simplicity, we assume that $\lambda(e) = e$ and $0 \leq e \leq 1$.

Case 1: Suppose that the constraints (2), (3) and (6) are binding.

Since the limited liability constraint (2) is binding, we have

$$t_H = \beta_H \cdot q_H + c(\beta_H, \theta_H).$$

Since the incentive compatibility constraint (3) is binding, we have

$$U_L = t_L - \beta_L \cdot q_L - c(\beta_L, \theta_L) = (\beta_H - \beta_L) q_H + c(\beta_H, \theta_H) - c(\beta_L, \theta_H).$$

It follows that

$$t_L = (\beta_H - \beta_L) q_H + \beta_L q_L + c(\beta_H, \theta_H) + c(\beta_L, \theta_L) - c(\beta_L, \theta_H).$$

By (6) and $\lambda'(e) = 1$, we have

$$U_L = \varphi'(e) = (\beta_H - \beta_L) q_L.$$

Hence the retailer's problem can be rewritten as

$$\max_{q,e,\theta} \lambda(e)\left[B(q_L)-t_L\right]+\{1-\lambda(e)\}\left[(B(q_H)-t_H\right]$$
$$= \lambda(e)[B(q_L)-\{((\beta_H-\beta_L)q_H+\beta_L q_L+c(\beta_H,\theta_H)+c(\beta_L,\theta_L)-c(\beta_L,\theta_H))\}]$$
$$+\{1-\lambda(e)\}[B(q_H)-\{\beta_H q_H+c(\beta_H,\theta_H)\}].$$

The first order condition with respect to q_L is

$$B'(q_L)=\beta_L.$$

Thus for the efficient agent, the second best output is given by

$$q_L^{SB}=q_L^{FB}.$$

The optimal output of the efficient agent is the same as the complete information case.
The first order condition with respect to q_H is

$$\lambda(e)[-(\beta_H-\beta_L)]+\{1-\lambda(e)\}[B'(q_H)-\beta_H]=0.$$

Thus for the inefficient agent, the second best output satisfies

$$B'(q_H^{SB})=\beta_H+\frac{\lambda(e)}{1-\lambda(e)}(\beta_H-\beta_L).$$

Therefore we have

$$q_H^{SB}<q_H^{FB}.$$

For the inefficient agent, the second best output level is lower than that of the complete information case.

Next we derive the optimal signals. Then for the efficient agent, we have

$$\lambda(e)\left[-c_{\theta_L}(\beta_L,\theta_L)\right]<0.$$

Thus $\theta_L^{SB}=0$. For the inefficient agent, we have

$\lambda(e)c_{\theta_H}(\beta_L,\theta_H)-c_{\theta_H}(\beta_H,\theta_H)\le 0$ or $\lambda(e)c_{\theta_H}(\beta_L,\theta_H)-c_{\theta_H}(\beta_H,\theta_H)\ge 0$.

Therefore if $\lambda(e)c_{\theta_H}(\beta_L,\theta_H)-c_{\theta_H}(\beta_H,\theta_H)>0$, then we may have $\theta_H^{SB}>0$ provided that there exists an upper bound on θ such that $\theta\le\bar{\theta}$.

Case 2: Suppose that the constraints (2) and (6) are binding. Then we have

$$\lambda'(e)[U_L-U_H]=\varphi'(e).$$

Hence the retailer's problem can be written as

$$\max_{q,e,\theta} \lambda(e)\left[B(q_L)-t_L\right]+\{1-\lambda(e)\}\left[(B(q_H)-t_H\right]$$
$$= \lambda(e)\left[B(q_L)-\{\beta_L q_L+c(\beta_L,\theta_L)\}-U_L\right]+\{1-\lambda(e)\}[B(q_H)-\{\beta_H\cdot q_H+c(\beta_H,\theta_H)\}].$$

Then the first order condition with respect to q_L is

$$B'(q_L)=\beta_L$$

Thus for the efficient agent, the second best output is given by

$$q_L^{SB}=q_L^{FB}.$$

The first order condition with respect to q_H is

$B'(q_H) = \beta_H$.
Thus for the inefficient agent, the second best output is given by
$q_H^{SB} = q_H^{FB}$.
The second best outputs are the same as those under the complete information case.

Next we derive the optimal signals. For the efficient agent, we have
$\lambda(e)\left[-c_{\theta_L}(\beta_L, \theta_L)\right] < 0$.
Thus we have $\theta_L^{SB} = 0$. For the inefficient agent, we have
$[1-\lambda(e)][-c_{\theta_H}(\beta_H, \theta_H)] < 0$.
Hence we also have $\theta_H^{SB} = 0$. Therefore the optimal contract induces no falsification. We summarize these results in the following proposition.

Proposition *The optimal contract has the following features. If binding constraints are* (2), (3) *and* (6)*, then we have, for the efficient agent,*
$q_L^{SB} = q_L^{FB}$
and for the inefficient agent,
$q_H^{SB} < q_H^{FB}$.
Moreover the inefficient agent chooses costly signals provided that $\lambda(e)c_{\theta_H}(\beta_L, \theta_H) - c_{\theta_H}(\beta_H, \theta_H) > 0$. *If binding constraints are* (2) *and* (6)*, then we have, for the efficient agent,*
$q_L^{SB} = q_L^{FB}$
and for the inefficient agent,
$q_H^{SB} = q_H^{FB}$.

DISCUSSION
In the previous section, we have examined optimal contracts when the manufacturer has private information on the cost of production and can send a costly signal to the retailer. We have shown that the efficient type of the agent obtains information rents and that there exists a case in which the manufacture sends a costly signal to the retailer. In this section, we discuss a setting in which the manufacture's production cost is given by $\beta q + C(\beta)$, where $C(\beta)$ denotes fixed costs, which depend upon the agent's type. In this case, the limited liability constraints become

$$U_L = t_L - \beta_L \cdot q_L - c(\beta_L, \theta_L) - C(\beta_L) \geq 0 \tag{8}$$

and

$$U_H = t_H - \beta_H \cdot q_H - c(\beta_H, \theta_H) - C(\beta_H) \geq 0. \tag{9}$$

The ex ante participation constraint is given by

$$\lambda(e)\}U_H + \{1-\lambda(e)\}U_L - \varphi(e) \geq 0. \tag{10}$$

The incentive compatibility constraints become
for the efficient type,

$$\begin{aligned} U_L &= t_L - \beta_L \cdot q_L - C(\beta_L) - c(\beta_L, \theta_L) \\ &\geq t_H - \beta_L \cdot q_H - C(\beta_L) - c(\beta_L, \theta_H) \\ &= U_H + (\beta_H - \beta_L)q_H + C(\beta_H) - C(\beta_L) + c(\beta_H, \theta_H) - c(\beta_L, \theta_H) \end{aligned} \tag{11}$$

and for the inefficient type,

$$U_H = t_H - \beta_H \cdot q_H - C(\beta_H) - c(\beta_H, \theta_H)$$
$$\geq t_L - \beta_H \cdot q_L - C(\beta_H) - c(\beta_H, \theta_L) \quad (12)$$
$$= U_L - (\beta_H - \beta_L) q_L - C(\beta_H) + C(\beta_L) + c(\beta_L, \theta_L) - c(\beta_H, \theta_L).$$

The moral hazard incentive constraint is given by

$$U_H - U_L - \varphi'(e) = 0. \quad (13)$$

Thus the retailer's problem can be written as

$$\max_{q,e,\theta} \lambda(e)\{B(q_L) - t_L\} + \{1 - \lambda(e)\}\{B(q_H) - t_H\}$$

subject to (8), (9), (10), (11), (12) and (13).

The optimal contract in this case also depends on $C(\beta)$ and $c(\beta, \theta)$. Then it would be possible that countervailing incentives arise in this case. For countervailing incentives, see for instance, Lewis and Sappington (1989) and Maggi and Rodriguez-Clare (1995b). The efficient agent's second best output may become larger than the complete information level of output. It is also possible that the inefficient agent's second best output is larger than the complete information level of output.

CONCLUSION

This paper has studied optimal contracts in the model of a supply chain between the risk-neutral manufacturer and the risk-neutral retailer in the presence of both moral hazard and adverse selection in which the manufacturer can choose a costly signal to falsify her private information. We have shown that the optimal contract exhibits different regimes depending on the costs of signals and those of exerting efforts and that there exists a case in which the manufacturer sends a costly signal to the retailer.

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USING MOBILE AGENT TECHNOLOGY FOR FULFILLING THE VISION OF INTELLIGENT CARGO

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ABSTRACT
The Logistics area has seen a huge growth in the last few years. This growth is on the one hand a result of the globalization which has led to international supply chains which require sophisticate logistics concepts. On the other hand the development of ecommerce has additionally boosted the need for logistics concept. Here it is also interesting to note that while the overall consignment number has increased the consignment size has decreased, leading to more and smaller consignments that need to be transported to different locations. The smaller consignments pose a huge problem to the logistics service providers and their goal to keep the bundling of the consignments as long as possible in order to enable the best usage of the transport vehicles with as much consignments as possible. This goal hasn't been reached so far and thus e.g. the utilization of trucks is in some countries is lower than 60%. This rather weak utilization of the transport vehicles does not only pose a problem to the logistics providers as well as forwarders, but also poses a substantial problem to our environment. The emissions caused by the transport sector are still one of the highest. The ultimate goal therefore has to be to increase the utilization of the transport vehicles in logistic while maintaining and developing the integration of the developing countries.

One of the main objectives of the EU funded project EURIDICE [1] is the development of a platform with distributed business process intelligence relying on the vision of intelligent cargo. The final paper will provide a short overview how the concepts of mobile agents are utilized for fulfilling this vision, and how the agents are organized.

By using existing or new information and communication infrastructures (e.g. GPS, Galileo, UMTS) it is possible to define a uniform Information triple Item (time, place and status) for all transported goods in Europe. The use of these data limits itself currently, nevertheless, in primarily to easy "tracking and tracing"-functionalities. In the project EURIDICE, based on this information, added value services should be defined, allowing an individual control of the transport goods in the European home market. For an effective implementation the data acquisition and decision-making should result to a very great extent on mobile devices, being able to react on one hand without delays to logistic events and on the other hand to reduce communication expenditures.

The mobile devices within EURIDICE therefore offer services for accessing different data by any authorized party in the logistics chain utilizing the platform built around these mobile services for integrating them with legacy systems and orchestrating them to build whole new logistic processes. To fulfill these requirements two main concepts of the project are SOA in combination with web services and mobile agents.

In this paper we will concentrate on a possible architecture for the mobile services using mobile agents, modern mobile communication infrastructures and the capabilities of today's available devices. We would like to discuss some design decisions for the mobile application running on different mobile devices, installed within containers or cargo items. The EURIDICE agent application architecture was designed to ensure flexibility, scalability, robustness and maintainability in and mobile, resource-limited environment.

INTRODUCTION

The Internet of things has seen a huge interest since more and more companies would like to adapt technologies like RFID in order to improve their processes. The possibility to individually track & trace goods on their way through the supply chain promises much better control mechanisms as well as an improved quality assurance. This is obviously of particular interest for the logistics sector which, by definition, is concerned to physically move and store goods. Here the most notable technology RFID promises a better transparency of the physical goods as they move through the different logistics operations. In the project EURIDICE RFID is conducted with the software concept of mobile agents to achieve a better representation of these processes and their actual status now also in the virtual world. The new possibilities that are enabled by the virtual representation of real-world goods in the logistics sector will be described in this paper.

OVERVIEW

To identify the opportunities that in the transport sector are unleashed with the availability of low & high cost RFID chips the European Commission has launched the "EURIDICE"-project under the Framework Programme 7. The goal of this project is to realise, with the help of the technologies and services provided, a section of the Internet of Things and Services, which enables the long-term deployment of intelligent cargo for the different stakeholders involved in the transport sector. This includes e.g. customs, ports, terminals, shippers, forwarders etc. Overall the EURIDICE project consists of more than 20 partners from different business sectors and authorities, which ensure that the project will provide an open platform, where services form different stakeholders as well as service providers, can be integrated. The platform will enable the service providers to combine different transport related services e.g. for dangerous or high value transport in an open and freely customisable manner. For the evaluation of the project companies and authorities from the transportation sector are integrated in the design process of the platform and pilots will be installed for them showing the applicability of the system.

VISION INTELLIGENT CARGO

The fundamental question that is related to this issue is whether bit is worthwhile to hold onto to the structured processes or whether it would be better to define a new self-controlled process regarding future logistics operations. The European Project EURIDICE opted for the later approach. The project is based on the assumption that in the future the usage of passive and active RFID will increase and as such the availability of intelligent mobile devices will likewise also increase. This will lead to a situation where more and more local intelligence is available and thus also the capability to process locally information and take local decisions on the basis of this information. EURIDICE predicts a future where the computing capabilities will be more and more decentralized, and thus will lead to a situation where the distributed computing capabilities will be used on the spot to make local decisions within the local environment, rather than taking the typical client server approach of today's service infrastructures into account.

However this approach requires certain pre-requisites that need to be fulfilled.

a) Intelligent Local Capabilities

As already mentioned above one major prerequisite is the availability of computing capabilities on different levels in the transport chain. With the advent of active RFID chips and the drop of prices for these kinds of chips, but also with the affordable prices of smart devices in the future, it is obvious that this requirement will be fulfilled in the upcoming years. Currently information is available either via the transport vehicle or the transport container which enables decision making in the respective level. However in the future it will get more and more common to have such capabilities also attached to e.g. palettes or the 'to be shipped' product itself, as it is done currently e.g. at book retailers, allowing a much greater flexibility to control and steer the transportation of a good.

b) Detaching product and Process view

A fundamental change that has to be implemented in order to allow for a better decentralized steering of goods flow it is necessary to decouple the goods from the existing planning systems. While there is obviously a clear need to further plan and control the transport vehicles on a central bases, the individual cargo items like goods, palettes and containers should be enabled to choose their mode of transport on their own, leading to a chaotic planning system which will better utilize the existing resources and infrastructures.

c) A pure service oriented Architecture

In order to allow the system to act autonomously, services that can be used by the different transport units have to be easily identifiable and usable. Since all these services will be represented by software this appropriate infrastructure is required to enable the service discovery, authentication, usage and accounting. Thus the new system for intelligent cargo has to have a clear Service Oriented Architecture (SOA).

Figure 3 describes the vision of intelligent cargo in EURIDICE based on value added services involving different stakeholders, centered on the cargo.

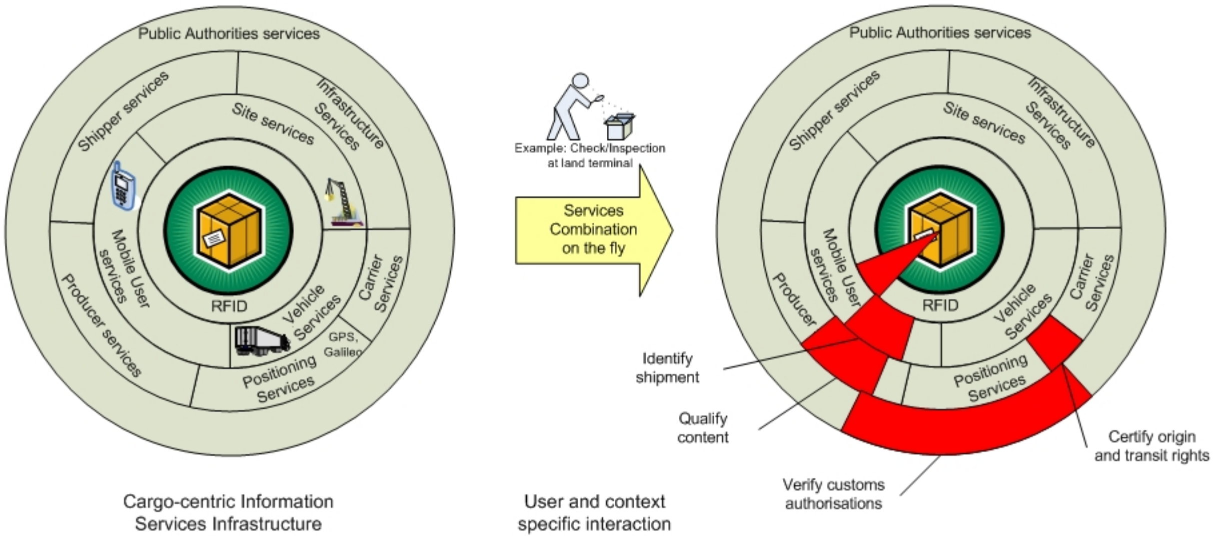


Figure 3: EURIDICE vision of intelligent cargo and value added services for different stakeholders

MOBILE AGNETS

Basically a mobile agent [2] is the same as a software agent [3]. That means, that a mobile agent is just a piece of software which does one job, acts as a delegate for someone else and this without any user interaction. Agents communicate with other agents, other processes and their environment. Because of the fact that one agent is designed to execute only one simple job there have to be other agents or communication partners to build up an agent network. With this network the agent system becomes intelligent [4] and flexible. Intelligent because the agents can interact and share information, resources and computation power within this network of agents and other communication partners (e.g. sensors) and react on changes in it. Flexible because the agent network can be tailored to its exact needs. An agent has also the ability to decide autonomously how to reach its objectives. They have the capability to take actions on their own to achieve their responsibilities. And an agent has the ability of adaption, which means they are able to adapt their strategies to react on changes inside of the agent network by learning from their experiences. The difference between a mobile agent and a software agent is that mobile agents can move from one host to another. To do that, they stop their current execution and transform themselves to a byte-stream and move over a network to another host to continue their execution.

EURIDICE will use a large number of mobile agents. These agents can be installed on several devices spread on several transportation vehicles like trucks, ships, etc. The goal of the agent network is to observe the cargo, the business state and to offer real time information for business process optimization.

A problem is the limited power supply and resources on the transporting vehicles, inside of a container or inside of a packet. But there will be different power supplies and resources between these three environments. To benefit from this fact, EURIDICE will use an agent hierarchy where the different levels of the hierarchy will handle different tasks. The basic agent hierarchy of EURIDICE is shown in Figure 4.

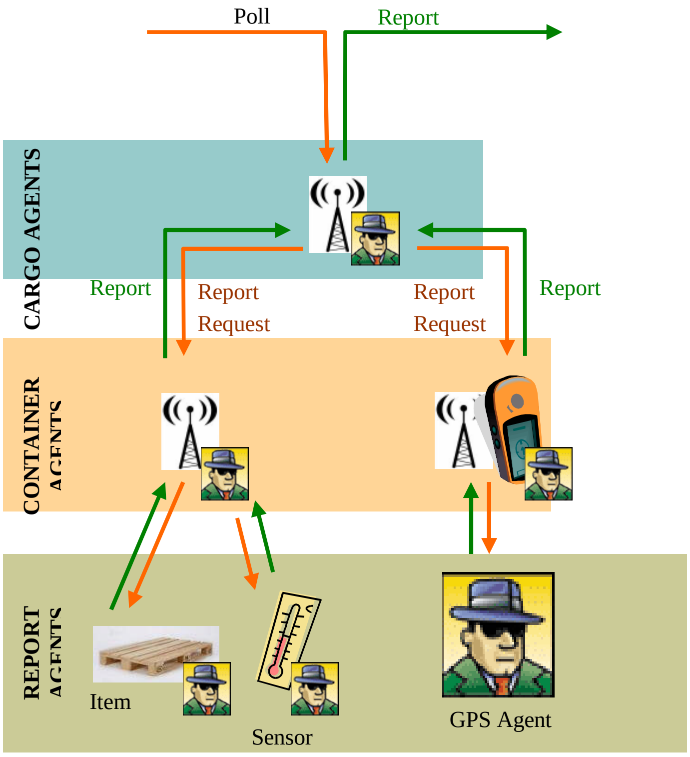
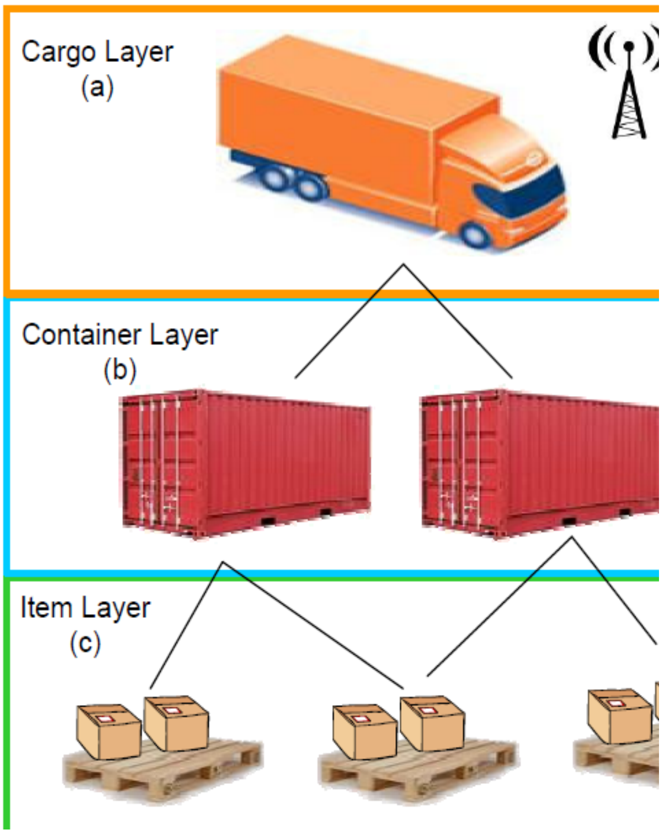


Figure 4: Basic agent hierarchy in EURIDICE

DESCRIPTION OF MOBILE AGENT ARCHITECTURE

The EURIDICE Agent application organizes its agents in a hierarchical approach. Higher level agents offer common tasks used by the whole network. Lower levels are responsible for very specific tasks.



The cargo Layer (Figure 5-a) manages all lower levels. It acts as a gateway for the outside world. Cargo Layer agents are installed on quite sophisticated devices which have a very powerful battery or a permanent power supply.

The Container Layer (Figure 5-b) manages the item layer. Its main tasks concern the integration of Item Layer agents and devices entering the container at runtime. They also offer sensors responsible for the whole container like RFID readers, positioning sensors, temperature sensors or eruption sensors.

The Item Layer (Figure 5-c) consists of agents representing single cargo items. They are responsible of sensors attached to single items. Those devices can enter and leave containers at runtime. They continue their observatory work, even when they are not connected to a Container Layer – for example if an item is moved temporally to a stock.

The layered System is designed to be very flexible regarding scalability and robustness. New agents/devices can be integrated very easily without affecting the whole system. If a higher-level device fails, a lower-level device can raise and assume the work done by the crashed device.

INFRASTRUCTURE

The EURIDICE Agent application defines a set of agent types that offer some basic services for a whole agent network running within a container. There are agents offering management of participation and integration of new agents and devices at runtime, offering some routing of message to and from the outside world and finally agents that offer some yellow-page services for inter-agent shared resources.

Cargo Agent

The cargo agent acts as a proxy for the outside world. It is installed on a device offering some wide range and some short range communication capabilities. It offers routing of messages from and to the outside world. The Cargo agent keeps track of all participating agents and devices within the container. New or non connected agents periodically search for cargo agents. If a device enters a container it will find the installed cargo agent where it will be registered. Now it is integrated within the agent network and can be reached using the agent communication facilities. If somebody wants to communicate with a participating agent, it sends a message to the cargo agent where a receiver field indicates the final receiver. The cargo agent routes messages to the mentioned agent if it participates within its container. If an agent wants to communicate with the outside world it uses the cargo agent as a gateway.

Yellow Page agent

The Yellow Page agent offers a yellow page service for the agent network of a container. An agent offering some services registers them at the yellow page agent. Agents looking for some type of service query the yellow page agent. The yellow page agent returns the address of an agent offering the requested service (Figure 6). Such services could be: storage space, outside world communication routing, RFID-reader, sensors like temperature sensors, humidity sensors, eruption sensors... To keep the Yellow Page agent's catalogue of service up to date, it periodically broadcasts a service-discovery message. If an agent receives this message it declares all its offered service (Figure 6).

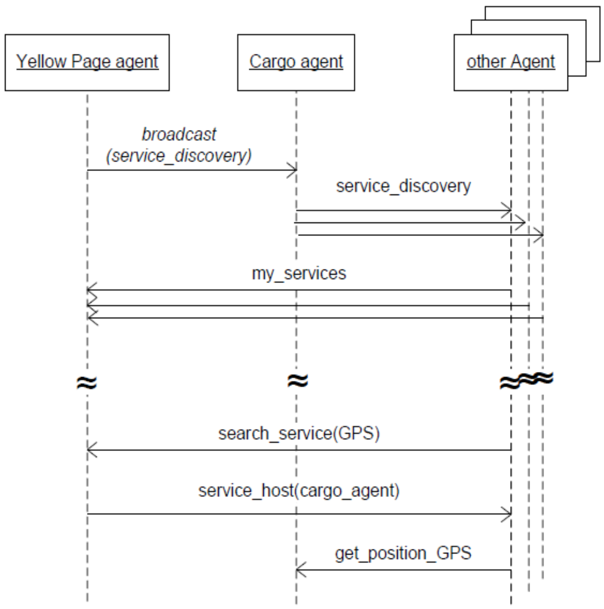


Figure 6: ***Service discovery within a container***

The Yellow Page agent also periodically scans the environment for new Bluetooth sensors. If it found a new device and it is able to classify it (e.g. GPS-device) it tries to delegate the responsibilities to another device participating within the same container. The concerning device starts a new agent called Service Proxy Agent. This agent offers virtual access to non permanent installed sensors like sensors connected via Bluetooth.

Sensor Proxy Agent

Sensor Proxy Agents offer virtual access to sensors installed on or controlled by a device. Such sensors could be a fixed installed GPS module, a camera or any sensor connected via Bluetooth. One Sensor Proxy Agent is responsible for exactly one sensor. Therefore usually multiple instances of that agent type will run on a device. Sensor Proxy Agents can be configured to observer sensors. This means that one can subscribe for events (e.g. a sensor value reaches a critical value). The Sensor Proxy Agent will inform the subscribers if the particular event occurs.

SUMMARY MOBILE AGENTS ARCHITECTURE

The EURIDICE Agents application architecture supports different types of hardware to be used within the application. Due to the fact that the application is written in JAVA, any device hosting an agent needs to offer a Java Virtual Machine. The requirements for the Device are specified by the MIDP2.0 [5] Profile and the CLDC1.1 [6] Configuration. Of course, more sophisticated devices can be integrated very easily.

To participate within the Agent network, the device needs to offer some wireless communication facilities like Wi-Fi or Bluetooth. Within a first reference implementation of the system we used standard mobile phones offering Bluetooth as communication service.

Besides fixed installed sensors like cameras, the system is able to use wireless sensors connected via Bluetooth like GPS-Devices or Temperature sensors.

CONCLUSION AND OUTLOOK

The EURIDICE project is planned for duration of 3.5 years. It started with 1st of February 2008 and will last until 31st of July 2011. Thus it is still in the beginning stages mostly dealing with user requirements and domain modelling, architecture design, definitions and service descriptions. The described high level architecture and used technologies are acknowledged by the consortium. The next steps in the project will be the software implementation of the platform and the adoption of it for the usage within the pilots and the business cases in the project. For regularly updates on the project progress have a look on the website of the project, as it is the first and most up-to-date information source about EURIDICE.

ACKNOWLEDGEMENT FOR PUBLICATIONS

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DEVELOPING A DECISION SUPPORT FRAMEWORK FOR IDENTIFYING KEY EXTERNAL FACTORS FOR POSTPONEMENT IMPLEMENTATION

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ABSTRACT
Postponement is an increasingly used and effective supply chain strategy for mass customization of products i.e. increasing operational flexibility, reducing costs and lead times. This paper makes a clearly defined contribution to the field by directly extending earlier work by Graman and Magazine (2006), by considering the external factors required for postponement decision making. The framework allows practicing operations managers to identify and understand criteria, which are external to the boundary of the firm, and essential for guiding strategic decisions regarding postponement. Key issues involve outsourcing, the need to protect intellectual property (intelligence postponement) and also environmental uncertainty.

INTRODUCTION
Postponement is an increasingly used and effective supply chain strategy for mass customization of products i.e. increasing operational flexibility, reducing costs and lead times (Reichhart and Holweg, 2007). It has been a well known concept in both industrial applications as well as academic literature (van Hoek 2001, Yang and Burns 2003). Large, well known organisations such as Hewlett Packard, Dell and Fujitsu have all tried to implement postponement in various ways: form postponement and time postponement, for example. In order to implement postponement successfully in a firm, various issues need to be considered. Importantly, both external and internal factors to the firm should be taken into account for its successful implementation. Literature in the areas of supply chain management and mass customisation (Feitzinger and Lee, 1997) is established, however, work on factors critical for successful postponement implementation appears to be lacking. Graman & Magazine (2006) considered the internal factors that centred on scheduling as well as raising the strategic issue of organisation readiness, although any conditions for organisational readiness were not elaborated upon.

The work presented in this paper makes a clearly defined contribution to the field by directly extending earlier work by Graman and Magazine (2006), who identified a requirement for formal definition of the factors, which would enable decisions regarding whether or not an organisations' particular external operating environment suited a postponement strategy. This study considers factors such as uncertainty in the business environment, particularly relevant today as companies experience unprecedented challenges during the current Global economic downturn. The issue that postponement strategies are specific to each business and not generic, are not considered here, but it is acknowledged that industrial variation will likely be of influence.

The paper is exploratory and conceptual in nature. The research methodology employed reviews the extant literature from supply chain management, mass customisation, operations management and strategy domains. Relevant and critical factors and issues are considered, with regards to practical postponement implementation. The relevant factors are then formulated into an appropriate framework structure that would provide practical value to practitioners. Key issues are related to the nature of outsourcing, the need to protect intellectual property (intelligence postponement) and also environmental uncertainty.

BACKGROUND

According to Swaminathan and Lee (2003), the concept of postponement appeared to originate first, as a mechanism that might reduce uncertainty (and costs) in marketing operations, as introduced by Alderson (1950). Alderson (1950) stated that postponement "the most general method which can be applied in promoting the efficiency of a marketing system is the *postponement* of differentiation, ..., postpone changes in form and identity to the latest possible point in the marketing flow; postpone change in inventory location to the latest possible point in time". Bucklin (1965) went on to consider issues of time and the arrangement of processes within this structure.

In their seminal paper, Zinn and Bowersox (1988) classified five distinct types of postponement: labelling postponement, packaging postponement, assembly postponement, manufacturing postponement and time postponement. In broad terms, these classifications are sometimes referred to simply as postponement in form and postponement in time. Pagh and Cooper (1998) built on these earlier concepts by introducing their conceptual tool called the P/S matrix. This simple but effective matrix considered trade-offs between manufacturing postponement and speculation against logistics manufacturing and speculation and pointed towards generic supply chain strategies. Skipworth and Harrison (2004) noted, postponement has been widely acknowledged as a means to delivering superior supply chains (Jones and Riley as early as 1985, Scott and Westbrook 1991). Doran *et al* (2007), highlight that modularisation and its control necessitates mastering the management of complexity associated with products.

Graman & Magazine (2006) looked at the organisational and managerial issues raised during a process of considering partial postponement (only a portion of the product is postponed) as part of a supply chain strategy exercise. Their findings raised centrally strategic questions regarding the operation such as, if a particular was product suitable for postponement, impact on planning and scheduling, issue of late delivery and even employees perceived threat to their job security. Graman and Magazine (2006) noted that work was still required in the area of understanding the operating environmental conditions, in particular definition of factors that for decision making. The most recent work regarding postponement decision frameworks has come from Kumar and Wilson (2009), who sought to assess inventory costs as a means to aiding a postponement decision. Kumar and Wilson's (2009) work is relevant but they do accept that other factors (not included in their simplified product model analysis) such as culture and external influences would need to be considered. Mills et al (2004) suggested that the supply chain management field could be considered from a number of different perspectives based on the position of the researcher or manager: upstream, downstream, static network and dynamic network. Our position as strategists however, can be seen to actually sit across both static and dynamic network perspectives, with a view to both understand the present situation, and also to consider longer-term implications of decisions.

With regard to the benefits offered by postponement, namely cost reduction, delivery response to customer and organisational flexibility, Swaminathan and Lee (2003) identified three key factors which influence the postponement outcome, these being market factors, process factors and product factors. As with many things, ones viewpoint is crucial to what ones sees and understands, in this paper, the Authors adopt the simpler, strategic management view of factors which lie within the 'boundary of the firm' and those which lie outside the boundary of the firm. The subsequent strategy of postponement is emergent (Mintzberg and Waters, 1985), through the process which can begin at the product design stage and continue through manufacturing, assembly, inventory and distribution to the customer.

In considering postponement external (environmental) factors, these factors will lie outside the control or the boundary of the firm. These factors are not dissimilar to those to consider during a review for strategic outsourcing or offshoring (Liker and Choi, 2004). Indeed the considerations of product integrity and intellectual property are equally important. Further, 'hollowing-out' (the loss of key organisational skills and knowledge) may also be an issue for consideration.

KEY EXTERNAL FACTORS

The key factors are based on the position that any intention to consider postponement for a particular product, whose control extends beyond the boundary of the firm, must involve both production and logistics related postponement factors. For this reason, postponement considering external factors should view postponement as an organisational or business process (Hammer and Champy, 1993)and the decision making should be strategic in its approach. In the list of external factors as set out below, the issue of cost is inherent.

For complete postponement options to be possible there is a key prerequisite that the product must be modular in its design form. This modularity of form increases the scope of possible postponement strategy options and importantly, the positioning of a decoupling point (Ulrich, 1995), downstream towards the customer. The clear linkage here between the responsiveness and flexibility within a supply chain is recognised (Reichhart and Holweg, 2007).

The key external factors are:

1. Legal – intelligence/IP security, licensing, incoterms, guarantee of delivery
2. Supply chain partner - selection - partner organisation dependability, relationship/trust, control, product quality integrity, third party logistics
3. Market factors – currency, trade tariffs, incentives
4. Foresight and uncertainty – what likely to happen in future, political environment, geographical constraints, terrorism
5. Customer – does it compromise service/product/support
6. Contingency policy
7. Competitor awareness – what are your competitors doing, are they using your potential supply partners?

DECISION SUPPORT FRAMEWORK

The seven key factors below head a numbers of issues that should be considered in further detail during a postponement decision making process. Each issue is assessed for confidence in how negative or positive the issue is for the business, with respect to postponement. This assessment is rated on a scale ranging from 1 to 5, where 1 signifies low confidence and 5 signifies high confidence against a particular issue. At the end of the process, the scores are totalled to provide an indication of a management teams confidence in dealing with factors outside the boundary of the firm.

External Factors for Postponement

Low ← Neutral → High

1	**Legal**	1	2	3	4	5
	Intelligence/IP security					
	Licensing					
	Incoterms					
	Delivery guarantees					

2	**Supply Chain Partner Selection**	**1**	**2**	**3**	**4**	**5**
	Dependability					
	Relationship/trust					
	Product quality integrity					
	Third party logistics					
	Control					

3	**Market Factors**	**1**	**2**	**3**	**4**	**5**
	Currency					
	Trade tariffs					
	Incentives					

4	**Foresight and Uncertainty**	**1**	**2**	**3**	**4**	**5**
	Product lifecycle					
	Political environment					
	Geographical constraints					
	Civil instability					
	Economic infrastructure					

5	**Customer Issues - compromise**	**1**	**2**	**3**	**4**	**5**
	Product					
	Service					
	Support					

6	**Contingency**	**1**	**2**	**3**	**4**	**5**
	Alternative channels					
	Rapid & safe extraction from postponement					

7	**Competitor Awareness**	**1**	**2**	**3**	**4**	**5**
	Postponement related behaviour					
	Common supply chain					
	Competitive partnering (e.g. broadband)					

	Total Score (max 25)					

DISCUSSION AND CONCLUSIONS

Postponement implementation potentially has deep rooted implications for an organisation because of its innate questioning of fundamental business strategy and business direction. The decision can ultimately be viewed as one that defines an organisations structure and competitive space. Conventional views may consider separately the strategies of say manufacturing postponement and logistics postponement. However, one can not be distinct or separated from the other – a process view should be taken since the decision making effort and factors for consideration are linked closely to each other and tied to the core of the business strategy itself.

As noted in the introduction, the issue of whether postponement strategies can be generic or specific has not been directly addressed here. However, it may be implicit in the nature of strategic decision making that each business will have its own manner to address its issues – perhaps akin to fingerprints where we all possess them but they all differ in small details. The framework presented in this paper, can also be viewed as providing a current perception of the outside world, by a manager or management team.

This framework is intended to provide a strategic decision making aid for practitioners considering postponement opportunities. This paper takes steps to address the need for an integrating construct as raised by both Graman & Magazine (2006) and van Hoek (2001). Further work in the extension and refinement of this framework process should be considered as well as validation of the framework within an industrial setting. It would prove interesting to conduct testing amongst a range of different organisation types; selected on the basis of industry sector, business size or postponement type. Additionally, the consideration of external factors must compliment the consideration of factors internal to the firm, and ultimately provide a holistic approach to postponement strategy decision making. More broadly, there is a need within the postponement research area to investigate whether there are particular types of companies which are better suited to postponement, and also to investigate the nature of consequences of poor decisions. Postponement strategies should be designed to deliver clear performance objectives that relate to cost, flexibility, product integrity without damaging customer perceptions if not enhancing customer value. How postponement fits in with established strategic concepts and operational practices of outsourcing is also of interest.

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ENHANCING THE OPERATIONAL EFFICIENCY OF THE GLOBAL SUPPLY CHAIN THROUGH THE DEVELOPMENT OF AN E-BUSINESS MODEL: A CASE STUDY OF ALEXANDRIA PORT OF EGYPT

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ABSTRACT
The purpose of this research is to investigate the efficiency of global supply chain information and operations and to examine the importance of enhancing global supply chain management and operations through using electronic business transactions for the case study of Alexandria port of Egypt. The research addresses the issue of the feasibility of introducing a tailored e-business model to enhance global supply chain operations in Alexandria port with a view to increasing the competitiveness of the port. The code name for the proposed model is **GEMA** Model i.e., **G**lobal **E**-Business **M**odel for **A**lexandria will be presented here to emphasize the necessity of each element included that suit the Egyptian environmental particularities.An analysis of the current systems applied in Alexandria port will be also presented here with the view to highlight critical issues and emphasize the need for a system change. Alexandria port is the largest port in Egypt and the only port that deals with all types of cargo. They currently operate with two systems. One is a manual documentary system that has been proved to be obstacle due to the long procedures required to finalize an operation. The other one is a web-based semi-automated system, which has been recently adopted by Alexandria port recently. This second system is considered semi-automated as it concentrates only on customs procedures. The use of the two systems is sometimes challenging for the users. The research reveals that a system change is needed which should consider elements such as: securities, strategies, policies, cultures, and skills that suit the local environment leading to improved port performance.

INTRODUCTION
Globalisation has involved greater opportunities and changes in international business, a combination and integration of markets on a global basis, and a movement toward a world that has no barriers or even borders increasing the need for global flows (Mearsheimer, 2003). *Technological advances* have been one of these sources that have considerably lowered the costs of transportation, communication, data processing and information storage and recovery. *Liberalization* of trade has resulted in decrease the protection of trade and security of data due to a more liberal trading system. Liberalization has also led to changes in the capital and labour distributions and increases the technological innovations. These new issues of international trade have led to a different international economy of the last century in terms of quality of producing goods or services (Habermas, 2001). *Organizations* and the changes among them have a wider reach of different countries and markets, partially due to the technological changes and to another wide-ranging perspective of their managers, who have been influenced by advanced aids in communications. Thus, companies that had been mainly focused on a local market have, have extended their business activities to a global reach (Pogge, 2002). These changes in the industrial formation have led to increases in profits and productivity of those organizations but they needed a quick adjustment due to the quick and rapid changes in the markets conditions. *Cultural development* is the fifth source of globalisation, with a move to a globalised pattern and popular culture and with the worldwide use of the English language for global communication. Partly as a result of these cultural developments, some developed countries see globalisation as a new form of privatization and a chance for investment in electronics.Meanwhile, Global supply chain management became an important matter for many companies and businesses as a result of globalisation. Efficient global supply chain management reduces costs, decreases risks, and minimizes related time and procedures.

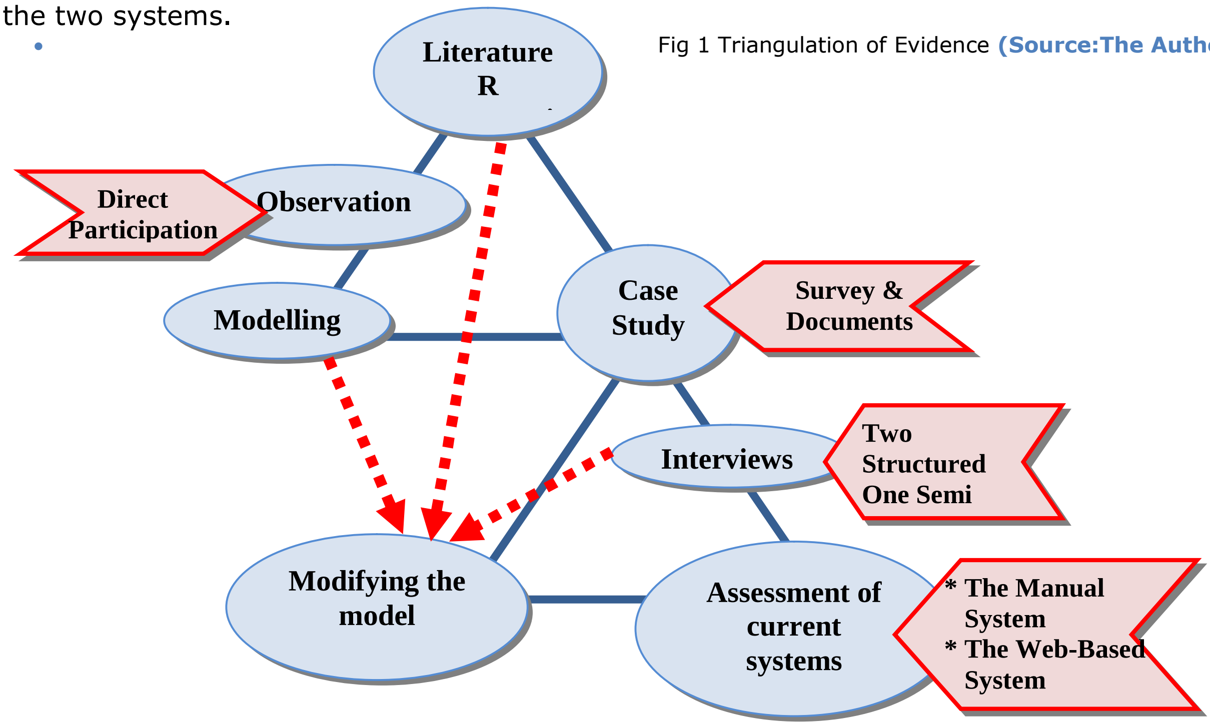
RESEARCH PURPOSE AND METHODOLOGY

The research proposes a fully automated model for Alexandria port. The code name for the proposed model is **GEMA** which stands for **G**lobal **E**-business **M**odel for **A**lexandria Port. Several elements should be taken into consideration to apply the e-business technology in the local environment of Alexandria port that is included in GEMA Model. This research aims to analyze issues that relate to the design of a tailored e-business model for Alexandria port community. It is not appropriate to apply ready-made models to Alexandria port since culture, strategies and policies, training and skills, trust and security issues need to be taken into account in order to match the e-business model with the local environment. Reference to the failure of the PORTIC agreement is of relevance at this point[24]. Although the PORTIC system is considered one of the successful models in the port of Barcelona, it did not work for Alexandria port due to its environmental particularities which were not taken into consideration (A.P.A, unpublished report). Other perspectives such as the legal aspect and legislation are to be addressed in further research. The research investigates the current systems used in Alexandria port to evaluate their effectiveness and usefulness and to confirm the requirement for a system change. Therefore, an introduction of a new e-business model (GEMA Model) is the main aim of the research to enhance the global supply chain operations in the port. A comprehensive literature review to verify the originality of the GEMA elements and the importance of each element has been previously undertaken. Alexandria port as a case study has been chosen due to the significance of its geographical location in the Mediterranean Sea. It is the largest port in Egypt and the only port that deals with all types of cargo.

DATA COLLECTION AND TRIANGULATION OF EVIDENCE

Data has been selected from multiple sources and triangulation of evidences has been used as a process of verifying the validity of the research findings. The way in which data has been collected and analysed is highlighted in Figure 1. The triangulation of the case study; modelling, observation, and assessment of the applied systems at the port, the literature review and the original interviews will all serve as integrated methods of collecting data for this case study research. Direct observation took place by visiting Alexandria port many times to note and write down the actual processes, step-by-step for the two systems applied in the port. Two semi-structured and one structured interview were conducted to collect more data about the case study and the two systems.

Fig 1 Triangulation of Evidence **(Source:The Author)**



[24] PORTIC, which stands for "Port Information and Communication System", was an agreement between Alexandria Port Authority and Barcelona Port Authority to apply Barcelona's E-Business Model in Alexandria Port Community which is successful in Barcelona.

The manual documentation system and the Web-Based system and the data collected from the observation and the interviews were analyzed and assessed. However, the double triangulation along with the extensive literature review lead to modifying the GEMA Model by adding Infrastructure management and its related cost as an additional element to the model.

Interviews were selected as the appropriate data collection for this research; there were two structured interview; one to investigate the manual documentation flow system in the port and the second structured interview were to examine the changes among the procedures after the implementation of the Web-Based new system. A semi-structured interview were carried out to assess the effectiveness of this new system and to verify the GEMA elements. The target survey population was professional people from international companies drawn from Alexandria community working in the field of maritime transport and logistics and involved in international trade. Accordingly, they are engaged in global businesses which have Alexandria port as a link in their transportation chain and fully aware of the situation.

1. Shipping lines in Egypt (7 different companies).
2. Shipping agents and the customs clearance agents in Egypt (15 different companies).
3. Freight forwarders in Egypt (8 different companies).
4. Key persons in Alexandria Port Authority.

Reaching this sample from the port community was by personal contact as they were the only ones that responded to the request of holding face-to-face interviews with them.

The first interview conducted was in the form of a structured interview with one central question:

Q. Please specify the documents handled right from the moment of the ship's arrival at, until the final clearance of cargo from, Alexandria port.

The question aims to investigate the manual documentation flow system of Alexandria Port and evaluate its suitability. The interview was conducted with one company from each category because it was investigating the existing system used for many years and the processes would not change from one company to another. The shipping line was represented by Maersk – Sealand Company which is considered one of the biggest shipping lines worldwide. They own 500 container vessels and more than 1,900,000 containers (Moller, A.P. – Maersk Group web site) and have 5 branches in Egypt, one of which is in Alexandria. The shipping agent was represented by Abu Simbel & Tiba Shipping Agencies in the Shipping Agents Sector. It is owned by the public sector (The Egyptian Government) and is considered the biggest shipping agent in Alexandria community. This agent has an office inside the port which makes them more involved than others. The freight forwarder was represented by Cargo Express Company that is considered one of the most famous freight forwarders and has the largest market share in Alexandria community. El Mohamady Customs Clearance Company was chosen to represent the customs clearance sector that has the majority of the market share in this business sector in Alexandria.

The second interview was again in the form of a structured interview using the same central question with the aim to investigate the newly adopted Web-Based Semi-Automated System. This interview was conducted with the freight forwarders companies (8 companies). The reason for choosing this category of organizations is that they are the only category which carries out the procedures and provides door–to– door service which involves all procedures and authorities. Accordingly, they are the most appropriate organizations to judge the changes which occurred by using the Web-Based System and they will be able to describe the actual procedures right from the beginning to the very end.

The third interview was in the form of a semi-structured interview with respondents covering three main objectives: (1) knowing the views of the respondents concerning the importance of having a fully automated E-system; (2) assessing the Web-Based customs system (semi automated system) recently used by Alexandria port; and (3) verifying each of the elements of the GEMA system. This interview was conducted with the thirty companies mentioned earlier.

DATA ANALYSIS

The interviews have produced the following criticisms for the ***manual documentation flow system*** procedures: long procedures, noticeable red-tape, many signatures and too many stamps.

This criticism highlights the following weaknesses: wasting of time, repeated steps, increasing costs and reducing port productivity. The manual documentation flow system is a time consuming process influenced by a history of corporate culture and orientation that need to change. It hinders the global supply chain operation in the port from being efficient operations chain. The long procedures negatively affect the entire operations that detract from the global competitiveness of Alexandria port.

The customer is required to carry out 13 steps by himself if not hiring a Customs clearance agent. The starting point is when the customer pays the charges required to the shipping agent and receives the delivery report that declares the arrival of his cargo. The customer has to go through all the inspections processes and settle all Customs dues until he gets the release letter to receive the cargo. These processes and all documents exchanged between different departments and authorities take days to be completed. This delay is considered a waste of time and money for both the customer and the port. With respect to the increasing importance of globalization and the increasing need for faster and more flexible communication, a system change is required. The challenge the port faces is how to achieve quality, accurate and faster services. The port should consider automating processes and integrating global supply chain services through the implementation of an e-system in order to streamline procedures and minimise documentation flow.

The GEMA model seeks to address this need.

As for the ***Web-Based semi-automated system***, the interviews and the analysis of data collected showed the following criticisms:

The majority of the three categories of respondents interviewed stated that a system change is required and essential. They were in favour of a tailored fully automated e-system to deal with the Egyptian environment particularities. They also insisted to have not only a tailored system but also tailored training courses.
Their exact responses were as follows:

- Tailored system is the best solution for Egypt.
- Alexandria Port failed in the past to adopt the Spanish e-business system due to the fact that system was not tailored or customized for the Egyptian environment and accordingly could not deal with its particularities. (It was what they successfully applied in Barcelona ports).
- There are some factors related to the Egyptian environment that should be considered right from the beginning.
- Customized training courses are essential before the implementation phase.

They also raised the question of why a semi-automated system is applied. The port is in need for a fully automated e-business system in order to avoid using the manual system. The majority of respondents believed that a fully automated e-business model could meet their requirements and achieve the port objectives. The GEMA proposed model addresses these needs.
Alexandria Port has various international trade barriers. One of these barriers is the documentation flow. The above data analysis indicates that the port's manual documentation flow reduces its global competitiveness.
The newly introduced Web-Based Semi Automated System of the port has its own difficulties and deficiencies. Lack of collaboration during the preparation phase created software and other problems during the implementation phase. Awareness, different skills at all levels and sufficient training are required. A system change is needed to support the introduction of the GEMA model. The majority of the respondents agreed to the suggested model elements. They all agreed to giving priority to culture and training elements to cope with the particularities of the Egyptian environment. The Web-Based did not achieve the expected or planed objectives. The system users are sometimes confused by using the old manual system and the new Web-Based System

together. It is to be noted that most of the companies surveyed were well aware of the importance of the tailored e-business implementation to the Egyptian environment.

THE PROPOSED E-BUSINESS MODEL

The research focuses on having a tailored e-business model to overcome any environmental particularities. However, the basic elements of the proposed e-business model are e-security, strategies and policies in compliance with the local culture, the logistics skills, and in conformity with the local regulations.

IDDENTIFYING GEMA MODEL ELEMENTS

GEMA Model has been divided into three zones and it is presented in Figure 2.

The first zone is the customer zone and consists of three major parts such as external customers, internal customers and customer relationship. The external customer contains shipping lines, agents, shipowners, exporters and importers. While the internal customers include shipping lines and agents, freight forwarders, importers and exporters and cargo owners. The main purpose of applying e-business is to enhance customer services by reducing the procedures time and decrease costs through improving the quality of services provided and increase interaction and integration between the involved parties.

The second zone is the infrastructure and the related costs zone.
Infrastructure management is the normal requirement for any business model like; *software requirements:* technical personal and specialist programmers, *hardware requirements:* the data and information centre, and *human resources requirements:* information technology staff, support personnel, and operators. While the related costs to these requirements are *direct costs:* in-house costs which represented by buying all equipment and developing software or outsourcing costs if the port refers to a third party provider. The *indirect costs:* these costs resulting from having communication aids, networks, mobile business management, technical maintenance, creating IT department and the costs of providing the services itself. The *preparation and implementation costs:* some of these indirect costs could be considered as the preparation costs while the implementation costs are the software purchase price which depends on the software options, ongoing maintenance cost, communication expenses which also depends on the nature of the connections and the e-business personnel which depends on having the system running in-house or not.

Finaly, the third zone is the tailored components zone.
The tailored components zone contains of e-security which includes software, security IDs, e-security strategy and e-trust strategy. Local strategies and policies consists change management, real-time services, effective e-business process and IT strategy. Local culture reflects in red-tape, lack of team work, reluctant to change, collaboration and integration and uncertainty. ICT and Logistics skills contain ICT training for employees, logistics training for operators and awareness training for both employees and operators.

E-security is one of the critical elements in any e-business model. It is essential to ensure that only the authorised persons have access to the system and to ensure that all documents sent or received are not altered or changed in any way. Specific strategies and policies should be part of the development plan for any e-business model to suit each local culture. In Alexandria port, the workforce has held the same jobs responsibilities for many years and there is a reluctance to change. The strategy should gain the acceptance of such employees to achieve the set objectives. This implies taking into consideration the local culture which, as an element, did not have much value in most of the existing models applied elsewhere. Logistics and Information and Communications Technologies skills are important elements which should be part of the e-business model. Training is seen as vital at this stage to upgrade the skills of the present employees, operators who will run this system and workers to cope with the new way of adapting the business and to have professional technicians and workers to maintain it. Additional factors concerning country specific implementations for e-business and e-commerce should also be considered in the development stage of an e-business model for example, the regulations that govern the e-business transactions in Egypt.The proposed model is expected to reduce both time and cost to the minimum level and accordingly support efficient global supply chain operations that lead to increase the port productivity and revenues.

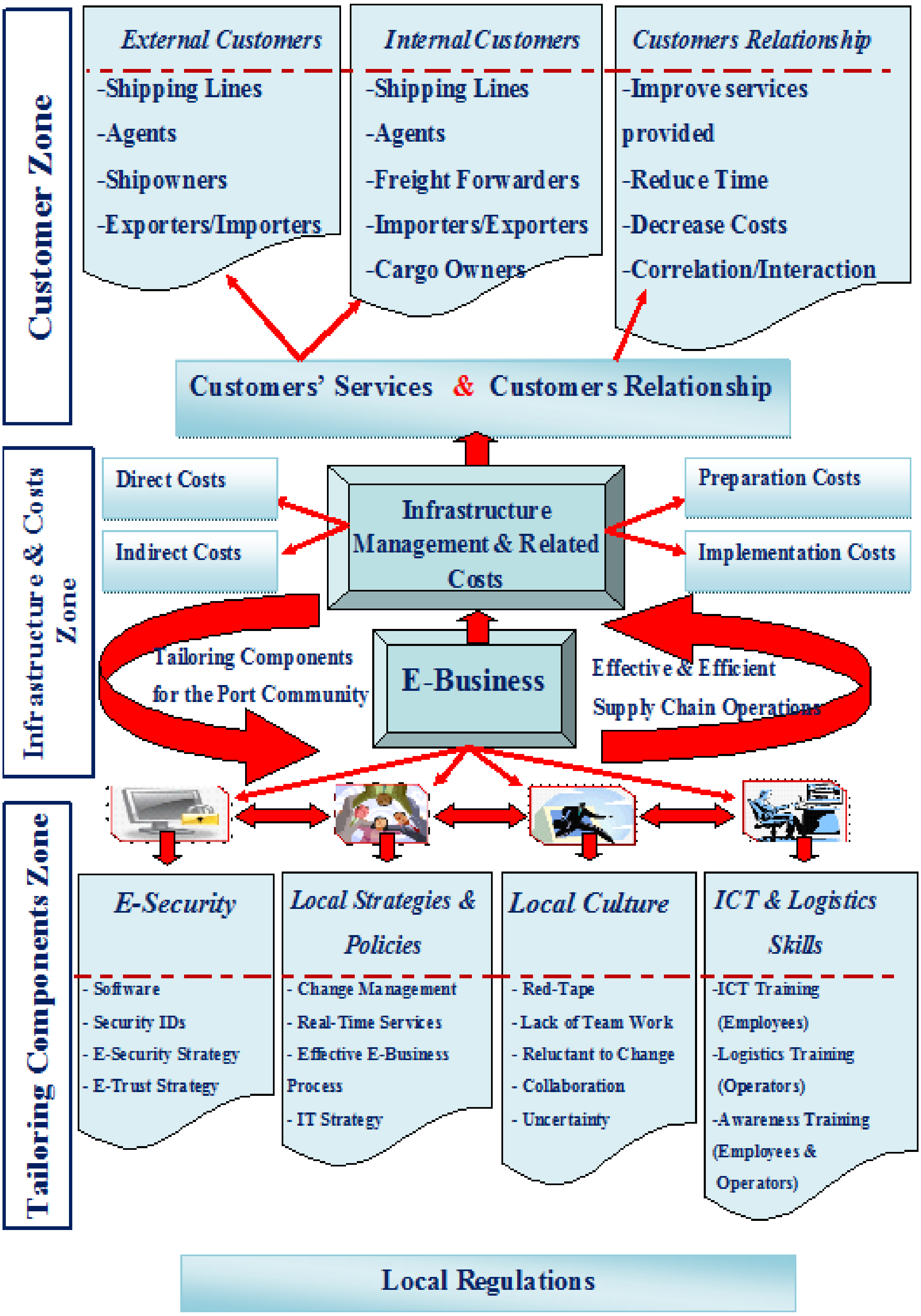


Figure 2 - The Proposed E-Business (GEMA Model) for Alexandria Port
(Source: The Author)

CONCLUSION AND FURTHER WORK

GEMA model aims to be a fully automated system that will enable the port to operate with only one system. By adopting this system no duplication of works or procedures will be created. Preparation and training can assist in overcoming any problems associated with the incorporation of the software. The lack of collaboration during the preparation phase of the web-based system created software problems and other problems like delay, error messages and failure of sending or receiving any e-transactions during the implementation phase. A highly qualified and professional host company has to be chosen through a national bid and not through the direct order as the latter caused a lot of problems with the web-based system application mentioned earlier. GEMA model is also a tailored model that takes into account and studies the Egyptian environment particularities which is something not offered by any readymade e-business model. E-services centre is established and logging into it is exclusive for the employees through issuing security IDs. E-Security is offered and guaranteed to encourage the parties involved to use the e-transaction and to overcome two issues; 1) hesitating to apply the e-technology, 2) being reluctant to change. However, tailored strategies and polices are designed to outweigh all negative attitudes; like routine and red-tape, duplication of works and delays. Awareness of the importance of e-business and the benefit of using it is created when the employees and the port worker are always kept informed and have the sufficient knowledge to minimize the issue of being reluctant to change. Different skills at all levels and sufficient training are offered to have skilled personnel and workers to cope with the system. Hiring professional IT team to run the system is highly recommended to apply GEMA model to minimize the operators' deficiencies which was one of the obstacles of applying the web based system that the data analysis showed.

Areas for further works include:

More light will be shed on how the proposed e-model would enhance overall operational efficiency in Alexandria Port global supply chain through the description of an actual transaction done by the current new system at the container terminal, pointing out how the application of GEMA Model would have resulted in time and cost savings and highlighting in what ways GEMA will overcomes the various difficulties among the current adopted system with a recommended problem solving steps.

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MANAGING LOGISTIC SYSTEMS FOR THE CREATION OF SUSTAINABLE TOURISM ON KOH LAN CORAL ISLAND

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ABSTRACT
Nowadays, tourism has become a significant industry in Thailand's economy. Tourism generates high revenues, as compared to the revenues from exporting. Koh Lan is a beautiful example of Thai tourism today. It is an island just out from the beaches of Pattaya City, in Chonburi province. Koh Lan has become an important tourist destination. However, ever-increasing tourism has created problems there related to the sufficiency of its infrastructure systems and facilities. These problems include growing demand on natural resources and an escalation of environmental pollutants. Further, these problems are pointing to an urgent lack of effective logistical planning and management.

This study applied principles of logistics management to the tourism industry under the hypothesis that moving tourists from Pattaya to Koh Lan more efficiently and effectively, including providing an effective transport networking system, would increase and support tourism on Koh Lan. A demand forecast for tourism into the next decade was statistically calculated in order to provide recommendations for the improvement of infrastructure systems and facilities.

An objective was to examine an appropriate demand forecast model for tourism on Koh Lan. The results could be used for planning infrastructure systems and facilities, including strategies for transport networks and logistics systems to support the future growth. Data was collected from secondary and primary sources, e.g. questionnaire and in-depth interview. The questionnaire was distributed to 270 potential participants, with 245 questionnaires being returned, for a 90.74 % return rate. Validity and reliability were examined.

The result showed that a time series would be an appropriate model for a demand forecast. It found that tourism to Koh Lan would double in the next decade. This result should be used for designing transport and logistics systems from Pattaya City to Koh Lan. Today, more than 1,500 trips a day by ferry and speed-boats are used for tourist travel from Pattaya City to Koh Lan. Effectively designed infrastructure systems and facilities are required to support sustainable tourism on Koh Lan. Further, this study learned that new and fantastic tourist facilities would be increasingly built on the island, underscoring the need for an appropriate plan for managing environmental pollution.

Finally, this study pointed out that a reverse logistics system for garbage management would need to be effectively utilized. Rapidly increasing garbage is a problematic issue for logistics related to a sustainable, green, eco-friendly environment. This study concluded that strategic and integrated logistical management is necessary, with participation from all stakeholders.

Keywords: Tourism, Logistics, strategy, demand forecasting, Island, Thailand

1.0 INTRODUCTION

Nowadays, tourism has become a significant industry to Thailand's economy growth. It generates high revenues as compared with the revenues from exporting. The paper focuses on adoption of logistics management to eco-friendly tourism on the island in Thailand. Koh Lan coral island (commonly known as Koh Lan) is an important and popular tourist destination, just out from the beaches of Pattaya City, in Chonburi province. However, ever-increasing tourism has created problems in Koh Lan related to the sufficiency of its infrastructure systems and facilities. These problems include growing demand on natural resources and an escalation of environmental pollutants. Further, these problems are pointing to a lack of effective logistical planning and management.

This study applies principles of logistics management to the tourism industry under the hypothesis that moving tourists from Pattaya to Koh Lan more efficiently and effectively, including providing an effective transport networking system, would increase and support the tourism on Koh Lan. A demand forecast was statistically calculated in order to provide recommendations for the improvement of infrastructure systems and facilities. The use of logistics in the tourism industry is currently recognized as a strategic tool for enhancing tourist satisfaction in relation to lower travel costs, one-stop services, other conveniences and safety.

However, the research study (Briguglio 1995; Bryden 1973) shows that traveling places, especially in islands, typically fail to understand how to apply a logistics concepts as well as how to put logistics strategies into action. Therefore, the aim of this study is to examine an appropriate demand forecast model for tourism on Koh Lan. The findings are used for planning and developing infrastructure systems and facilities, including formulating strategies for transport networking and logistics systems to support the future sustainable growth of tourism industry. It also examines other logistical issues (i.e. role of demand forecasting and managing reverse logistics system for garbage).

2.0 LITERATURE REVIEW

This study reviews the literature related to the role of tourism (and in particular, eco-friendly tourism) to the economic growth of Thailand. It also considers the adoption of logistics management in the tourism industry, especially island tourism. Two relevant sources (Acharya 1995; Briguglio 1995; Bryden 1973) point out that logistics management contributes to the success of sustainable tourism development. These sources also review definitions of logistics and logistics management as they pertain to sustainable development of tourism, but no one provides what is tourism logistics and how it contributes to tourism success.

It is important to understand a clear and concise concept of logistics from a tourism perspective. Logistics is mostly understood in term of business industries, with only a few research studies done exclusively in relation to tourism (Briguglio, Butler, Harrison and Filko 1996). People typically relate logistics (Bowersox & Closs 1996; Lambert, et al. 1998) to transportation or warehousing, particularly connecting it to aspects of material goods or information flow (Butler 1980; Theppitak 2006). As such, logistics is understood as a service-oriented process related to movement of physical and information flow. To apply logistics to tourism, people, or tourists, shall be considered as physical flow from one point to another, and examined in terms of lower costs, higher safety and more convenience through excellent coordination and collaboration (Bowersox & Closs 1996).

The authors (Butler 1980; Briguglio 1996) points out that before logistical planning for tourism infrastructure and facilities can be achieved, there needs to be an accurate demand forecast developed. Demand forecasting for tourism into the next decade is statistically calculated in order to provide improvement for infrastructure systems and facilities, which can in turn support growth and expansion. However, very few researches have been done in area of tourism logistics (Butler 1980; Conlin and Baum 1995). It also reveals patterns of tourist behavior and other factors influencing travel decisions, as well as identifies problematic issues with tourist destinations (Conlin and Baum 1995).

Conlin and Baum (1995) states that there is a relationship between adoption of logistics management in the tourism industry and the success of sustainable tourism development. For instance, logistics management can be used to consider moving people, or tourists, from one point to another point (Theppitak, 2006). It provides tools for facilitating how to prepare accommodations, how to build transport networks between and within locations to support sustainable tourism (see Figure 1). However, it found that there is the gap for application logistics in tourism. This study applies a logistical approach to the tourism industry under the hypothesis that moving tourists from Pattaya to Koh Lan more efficiently and effectively, including providing an effective transport networking system, would increase tourist satisfaction on Koh Lan. Tourism is qualitatively different from the other domains within the cultural sector, as it cannot be readily classified as a sector in the traditional sense, i.e. as measured by either particular markets or industrial outputs. Therefore, it is better understood as a demand-driven, consumer-defined activity.

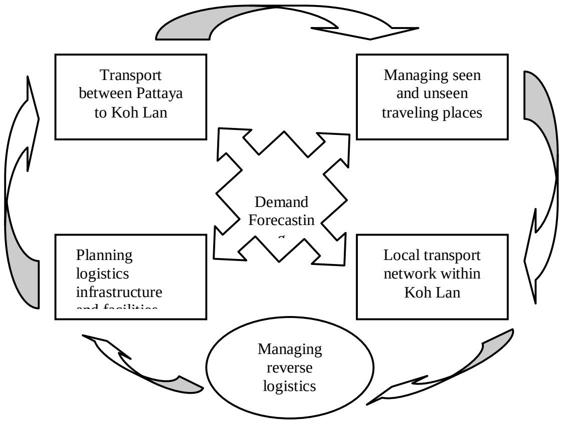

Figure 1 Relationships between activities in tourism logistics

When considering the factors affecting logistics management adoption and implementation in tourism, particularly, tourism on islands, the literature points out the major factors are economic and political realities (Thor 1994). The research (Conlin and Baum, 1995) highlights the relationship between such factors and the adoption of logistics management, like fluctuating tourist counts and tourist satisfaction.

It concludes there is a literature gap related to the examination of issues related to adoption of logistics management (and its effectiveness) within the tourism industry, and specifically for islands. In particular, there needs to be an examination of the factors contributing to the logistics adoption phase and the factors influencing sustainable tourism development. This study therefore proposes a theoretical framework (Figure 2) derived from a previous study (Theppitak 2006).

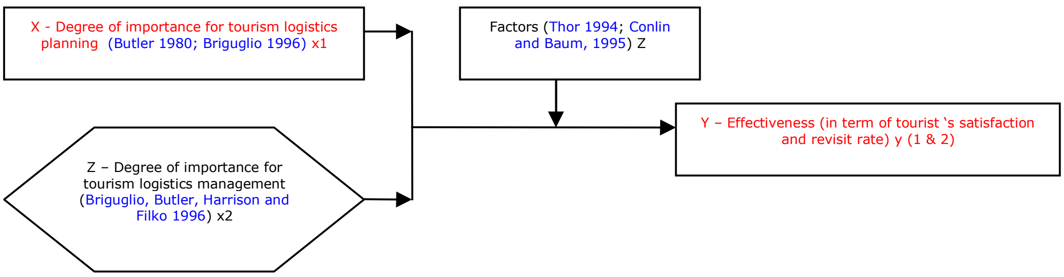

Figure 2 Theoretical Framework of the study

Figure 2 shows the theoretical framework of variables in this study. The literature review revealed that building a sustainable tourism industry, especially tourism on islands, required widely applied logistics concept and strategies. Success of sustainable tourism development requires a high priority of importance on adoption of logistic planning. The research showed that the more importance placed on the logistics planning, the more effectiveness is gained for developing tourism (on an island) in term of tourist satisfaction. A main objective is to find ways to improve tourist satisfaction.

This study examines relationship between variables (*X*, *Y, Z*), defining degree of importance to the adoption of logistics planning and logistics management as *an independent variable* (V*ariable X1* and X2) and defining the effectiveness of logistics management to tourism on Koh Lan, in terms of tourist satisfaction (i.e. convenience, safety for transport network, infrastructure and facilities on Koh Lan), and return rate of tourist as *a dependent variable* (*Variable Y1 and Y2*).

Furthermore, this study discovered that other influential factors, such as economic and political realities, were significant to the adoption (or non-adoption) of logistics management that could develop or enhance tourism on the island. These influential factors are defined in the framework as *an intervening variable,* (Variable Z), which influences both the independent variable (V*ariable X*) and the dependent variable (V*ariable Y)*. It was therefore assumed that the level of such influencing factors would have a direct correlation to the degree of importance placed on the adoption of logistics management, as well as to the effectiveness of any logistics used on the island.

3.0 RESEARCH METHODOLOGY
This study initially conducted *a literature review* related to the role and patterns of tourism on islands from a logistics perspective, including the examination of problems and obstacles that occur while traveling on an island. It also explored the use of logistics management in the tourism industry. The objective of this study was to investigate the relationship between variables related to the adoption of tourism logistics management on Koh Lan, as well as the effectiveness of logistics management for building sustainable eco-friendly tourism.

An interview technique was used jointly with questionnaire surveys in order to obtain relevant and in-depth information from tourists on Koh Lan. To obtain the data, the study used a sample of 270 randomly selected tourists, which included both Thai and foreign tourists traveling on Koh Lan. This number of face-to-face questionnaires was based on a randomly stratified sampling. The rate of response was very good, with 245 respondents, or 90.74 percent of the total questionnaires. The data collection period took two months.

3.1 Research Questions
To answer the above issues, the study sought to define the following questions:

1. What is the definition of tourism logistics?
2. How can behaviors of tourists be used to design infrastructure and facilities on Koh Lan?
3. What are factors influencing the design and implementation of tourism logistics strategy on Koh Lan?
4. What are efficiencies and effectiveness of tourism logistics management?

3.2 Research Hypotheses
Based on these research questions, hypotheses were established in order to examine a relationship between tourism logistics planning and management and the effectiveness of improving tourism on Koh Lan. This study therefore examined a relationship of the variables under following hypotheses.

H_1 = There is a relationship between tourism logistic planning and a degree of tourist satisfaction.

H_2 = There is a relationship between tourism logistic management and increasing return rate of tourists to Koh Lan.

3.3 Population & Sampling Procedure
This study used the number of tourists who traveled to Koh Lan during January through April 2008. 270 questionnaires were randomly distributed for the sampling. After several months, there were 245 questionnaires returned, for a response rate of 90.74 per cent. This study also interviewed 50 tourists to gain their opinions related to tourism logistics on Koh Lan.

3.4 Data Collection
This study collected data in *two* following dimensions: first, a *literature review* was conducted in various fields related to tourism logistics management. Secondly, *questionnaire survey and in-depth interview method* was used. Two pre-testing were conducted with Cronbach's alpha (α) at 0.91 and 0.92 respectively.

4.0 RESEARCH FINDING

The survey briefly explains demographical information related to attitudes and behaviors of tourists when visiting Koh Lan, including examining hypotheses. It showed that male and single tourists made up the greatest number of respondents in the sample at 56.8 percent, followed by female tourists at 43.2 percent. It showed that 63.9 percent were between the ages of 13 to 28 years. Most of them, or 38.9 percent, had an age between 21 and 28 years. Secondly, 25.2 percent had an age between 13 and 20 years. The major targeted groups of tourists on Koh Lan are now adolescent and young adult. The most tourists (86.2 percent) came from Asian countries (e.g. Thai, China, Taiwan, and South Korea).

The greatest percentage of tourists, or 71.2 percent, traveled with their friends. Only 19.8 percent came with family, and their group was less than 5 persons (58.6 percent). Most of them or 33.3 percent, traveled to Pattaya City by personal car, 30.6 percent of them visited by bus, and 17.1 percent by tourist bus, respectively during October – December (67.8 percent). Most of tourists or 87 percent identified that they did not stay overnight on Koh Lan because of improper and inconvenient infrastructure and facilities.

Table 1 Summary of testing hypothesis and relationship between variables

Variable		Correlation	p-value
Independent	Dependent		
X1	Y1	0.860	0.000
Z	Y2	0.650	0.020
X2	Y2	0.770	0.000

Table 1 shows summary of hypothesis testing. It tested that adopting tourism logistics planning (X_1) would have relationship with tourist satisfaction (Y_1). Further, effective tourism logistics management (X_2) would increasingly encourage and promote increasing tourists' return rate to Koh Lan (Y_2). In term of tourism Logistics planning covers properly matching demand of tourists and services supply on the island, including organizing logistics networks (e.g. linking between seen and unseen traveling places, transport, accommodation) within the island. Tourism logistics management covers how well logistics management is used to create and promote tourism industry on Koh Lan, including providing reasonable costs, satisfying tourist need.

The result shows that adopting tourism logistics planning (X_1) has strongly relationship with generating tourist satisfaction (Y_1). It also reveals that tourism logistics management (X_2) has also moderately relationship with increasingly promoting tourists' return rate to Koh Lan (Y_2).

5.0 DISCUSSION AND IMPLICATIONS

5.1 What is the definition of tourism logistics?

The findings revealed relevant patterns and trends of tourism on Koh Lan. It identified that the direction for development of eco-friendly tourism on Koh Lan are unclear. There needs to be an application of logistics principles to create and develop sustainable tourism. The key question is that what is the definition of logistics in the context of tourism? Authors (Bowersox & Closs 1996; Lambert, et al. 1998; and Knox 1982) provide much definition but no one discusses what tourism logistics is.

Theppitak (2005) states in a definition that logistics is "the process of planning, organizing and controlling the flow of physical and information from origin to the end point to satisfy all stakeholders." Therefore, logistics in the context of tourism would be defined as "the management of the flow of physical (including tourists or vehicles) and information (information related tourism)." In this definition, tourists are being considered as "goods," being moved from point to point. Transport system(s), between mainland and the island, as well as within the island, would need to be designed to support the move of tourists in terms of lower costs, safety, comfort and convenience. Therefore, scope of tourism logistics also covers functions i.e. transport, infrastructure and facilities. (in Figure 1)

To support and foster more and better tourism on the island, infrastructure (e.g. electricity, water and telephone) must be readily available. Also, future tourist facilities (for all travel activities and including currently undeveloped areas) must be well planned and organized. These facilities should include hotels and other accommodations. If tourists are the goods, then hotels and resorts can be considered as warehouses or distribution centers. Proper demand forecasts of tourist behaviors and lifestyles are critical. In-depth and accurate logistics is the only proper way to prepare for future tourist accommodations, facilities and traveling activities.

Tourism logistics also includes reverse logistics activities. Reverse logistics can be defined as the management of the flow of materials or information back to a desired point. This methodology covers the management of garbage, or unusable materials, by tourists. Normally, there are many methods to manage garbage, with different costs occurring, including non-monetary costs like pollution. This study can also be used logistically to incentive and support sustainable, more eco-friendly tourism on Koh Lan.

5.2 Tourists' behaviors and designing logistics infrastructure on Koh Lan

When consider levels of importance and satisfaction with various transports systems between Pattaya City and Koh Lan (an eight kilometer distance), it reveals normally, tourists have two choices of transport to the island: ferry or speed boat. It showed that tourists have intermediate expectation levels of service quality (e.g. convenience, safety and fee) for speed boats and ferries. After actually traveling to Koh Lan, they had satisfactory levels lower than their expectation levels. It reflected that with speed boat services, fees and safety were the main sources of dissatisfaction. For ferry boat services, convenience and safety were the main sources of dissatisfaction. Tourists are satisfied when their perceptions equal or above their expectations. Therefore, the gap between tourists' expectation and perception needs to be closed.

To improve transport systems between Pattaya City and Koh Lan, it would improve in two ways. First, reengineering existing transport systems by focusing on hardware (i.e. vehicle and harbors), software (i.e. information to tourists) and peopleware (i.e. training crew with service minded). Second, new efficient and friendly environmental transport system (i.e. cable car and underwater car) would be considered.

The result shows the levels of importance and satisfaction tourists have for travel destinations within Koh Lan. Surveyed tourists revealed they had high expectation for travel destinations in respect to beauty and atmosphere, cleanliness and safety, and that they were satisfied with these aspects of the island. However, they indicated some dissatisfaction with cleanliness and sanitary system, as well as some concern for the safety of security systems used at some travel destinations.

Managing tourism logistics in term of existing travel places is not considered only lower costs and higher services level, but it also means to manage all travel destinations in routes and vehicles. Unseen travel places would be effectively established and promoted. Obvious and clear signs between destinations become a source of satisfier.

When considering the levels of importance and satisfaction tourists place on transport (and related logistics) while visiting on Koh Lan. This study asked the tourists to rate the transport systems from Pattaya City to Koh Lan, as well as the transport systems within Koh Lan, in various relevant areas. Most of the tourists indicated high expectations related to safety and the expense of transportation. The study also found that they were mostly satisfied with the availability and comfort of transport systems to Koh Lan. However, they were somewhat dissatisfied with the safety of transport systems to Koh Lan.

When considering the transport system within Koh Lan, tourists had high expectations for price standardization, as well as for comfort and availability of transport. But, they were dissatisfied to actually find a lack of price standardization of transport within Koh Lan. Logistical implication would consider in a whole system, and then set standard prices in each destination. The difficulty is how to communicate and motivate to local people for following to same standard without their resistance and conflict.

The interesting issue for infrastructure required for supporting tourism on the island, it included electricity, road, water, and telephone systems. Survey results revealed that most of the tourists (more than 75 percent) did not stay overnight in Koh Lan, but rather returned to stay overnight in Pattaya City. The question is that why tourists did not stay overnight on Koh Lan. the interviewed results showed that most of tourists identified to unavailability and inconvenience in term of shortage, including high prices compared with earned services. They had high expectations for the costs and availability of tourism infrastructure in Koh Lan. But, they were dissatisfied with the actual fees charged for services and the availability of infrastructure.

These results reflect that there is a need to think and analyse a whole system. It would commence with forecasting future demand to provide properly infrastructure and facilities. The study examine an appropriate methods and found that seasonal time series would be the demand forecasting model which fits to tourism on Koh Lan.

One of serious problems is garbage and pollutions occurring from tourism (appropriate 6-12 tons a day). Nowadays, the garbage is moved by 2 boats to Pattaya for disposal. Now the issue is increasingly becoming serious problems to friendly environmental tourism. It needs to apply concept of effective reverse logistics for creating and enhancing sustainable, eco-friendly tourism on Koh Lan.

In summary, the *main research finding* reveals that:

- Tourism logistics planning (X_1) has a strong and positive relationship to tourist satisfaction (Y_1).
- Tourism logistics management (X_2) has a strong and positive relationship to return rate of tourist to Koh Lan (Y_2)
- Factors (Z) (i.e. economic, and political) have a moderate and negative relationship to tourist satisfaction (Y_1 and Y_2) and they influence to decision making for traveling at Koh Lan.
- Lacking of effective demand forecast method creates problems in mismatching between supply and demand, preparing infrastructure and facilities.
- Transport (between Pattaya City and Koh Lan, and within Koh Lan) contributes to tourism's satisfaction and success.
- Koh Lan effectively lacks tourism logistics planning and management.
- Garbage from tourists is increasingly becoming serious problem, it needs to design effective and efficient reverse logistics systems.
- Finally, it concludes that effective tourism logistics management is a key success to tourism on Koh Lan.

6.0 CONCLUSION

The results show that using a logistics concept for tourism, especially on an island, would increase effective, sustainable, eco-friendly tourism. A demand forecast of tourism for the next ten years must be considered to effectively design and develop smooth flow patterns for future tourists, along with providing sufficient and appropriate infrastructure and facilities. It points out that a seasonal time series would be an appropriate model of demand forecasting. It revealed that in the next decade, tourism in Koh Lan would increase to twice its current level. This result must be taken into consideration for designing transport (and related logistics systems) from Pattaya City to Koh Lan.

Today, more than 1,500 trips a day, by ferry and speed-boats, are used in travel to Koh Lan. Effective design for future infrastructure systems and facilities must support sustainable tourism in Koh Lan. Likewise, development plans for new travel destinations must include an appropriate plan for managing environmental pollution. Finally, garbage management could be effectively planned using a reverse logistics system, as rapidly increasing garbage has become a problematic issue related to the logistics of maintaining a green, eco-friendly environment.

It provides valuable information for stakeholders, especially top management of Pattaya City and the Tourism Authority of Thailand, as to the planning and development of infrastructures and facilities for islands, and specifically Koh Lan. Logistically planned transport management can facilitate growing tourist travel to and from Koh Lan, providing hotel, resort and residential-accommodation owners with consistently increasing demand, while also preventing the unrestrained destruction of natural resources and environments on the island. This study leads to the conclusion that strategic and integrated logistics management is required, with active participation from all relevant stakeholders.

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SCOR MODELLING OF AN RFID ENABLED SUPPLY CHAIN FOR ROI ANALYSIS

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ABSTRACT
Purpose – To support the uptake of RFID (Radio Frequency Identification) technology amongst supply chain partners, a framework has been developed to quickly model positive business benefits arising from RFID adoption and to facilitate ROI (Return on Investment) analysis.
Design/methodology/approach – This paper describes a business process modelling tool that is based on the SCOR (Supply-Chain Operations Reference) model and IDEF0 (ICAM Definition language), which is extended to include time and cost weightings for ROI analysis. This is to provide a quantitative analysis of labour costs and productivity gains achieved through RFID data and process automation within business processes. The method described encompasses business process and data modelling concepts, as RFID implementation has an impact on the business operations and information architectures.
Findings – The business process modelling at SCOR model level 4 or higher levels provides an excellent start for process modelling and process re-engineering in order to perform ROI analysis. RFID implementation can increase data-entry accuracy so that mis-shipments, lost inventory and redundant data reads can be reduced.
Practical implications – The SCOR modelling tool and ROI calculator developed in this research can be applied to other cases where "as-is" and "to-be" scenarios can be constructed. While the SCOR concepts provide a perfect start point for process representation, the feature of allowing user customization of the tool enhances the flexibility of business process modelling.
Originality/Value – This research constructs a visual business process modelling tool based on the SCOR concept and provides a spreadsheet based ROI calculator for justification of adopting new technology and additional investment to projects.

INTRODUCTION
Adoption of RFID technology is a significant business investment for most organizations, requiring a commitment to a particular solution and the dedication of resources and funding to implement the project. The use of a technology enhanced system offers advantages in terms of supply chain automation, making the processes efficient, providing accuracy of information and reliability in the handling of any shipment from make to delivery.

For any organization considering RFID implementation in their supply chain, a formal business case justification will help gain project implementation approval from management. Our intention is to provide a modelling tool for these "early adopters", with an approach that can quickly identify whether the RFID project will generate positive business benefits and a tangible ROI. Our approach is to provide a quantitative analysis of labour costs and productivity gains achieved through RFID data and process automation, and better use of manpower resources within business processes.

RFID implementation involves an opportunity to critically examine business processes and re-engineered them with the goals of increased data-capture automation and data-entry error-reduction to reduce mis-shipments, lost inventory and redundant data reads. One of the many benefits is the reduction in manual processes through automated data capture to improve productivity, thus allowing manpower resources to be reallocated to higher value adding activities.

The approach described in this paper applies the SCOR model for business process modelling with the ability to capture the data elements used in the process. The use of SCOR as a reference model provides an opportunity to model the related business processes across the whole supply chain in a panoramic way and enables business processes to be analyzed at different levels; moreover, it also offers an opportunity for business process re-engineering.

LITERATURE SURVEY

There is no lack of articles and white papers appear in the literature reporting the qualitative benefits and potential applications of RFID, such as, Thiesse et al. (2006) describe a real-time identification and localization system uses RFID and ultrasound sensor technologies to improve tracking visibility for inbound logistics in a wafer fabrication cleanroom; Legner and Thiesse (2006) report that the Frankfurt Airport’s operating company integrated RFID and a mobile application with its asset management systems; Prater et al. (2005) examine market drivers that are leading to RFID implementation in the grocery industry and Roussos (2006) discusses benefits of RFID at item-level; to name just a few. However, there is deficiency of literature regarding quantitative analysis of RFID benefits.

Lee et al. (2004) and Lee et al. (2005) investigate how RFID advantages can contribute to the performance of a supply chain and hence to business value. Simulation is used to model the impact of RFID in a manufacture-retailer supply chain. The studies provide a comprehensive view and a quantitative analysis on how to demonstrate the potential benefits of RFID in terms of inventory reduction and service level improvement. Lee and Özer (2005) argue that the value of RFID should be analyzed with detailed models and compare the cost benefits of visibility and prevention for models with and without RFID. Leung et al. (2006a) and Leung et al. (2006b) develop a tool set to show the business value of RFID to different parties in a manufacturing-retail supply chain. The tool set consists of two tools which are linked: a business value model and a business process model. The former consists of the benefit model, the cost model and the data sets and is implemented as an in-house application using spreadsheet. The latter is implemented through a commercial discrete-event simulation package and computes certain supply chain performance metrics.

Gaukler (2005) investigates the impact of RFID on supply chain management in strategic, tactical and operational dimensions in his PhD thesis. Mathematical frameworks are proposed for evaluating some of the pertinent issues that have arisen with the availability of RFID technology in the broad field of supply chain management. Extracting value for supply chain with the traceability characteristic of RFID is also discussed. Gaukler et al. (2007) consider a supply chain with one manufacturer and one retailer and present analytic models of the benefits of item-level RFID to both supply chain partners within the context. Situations of a dominant manufacturer and a dominant retailer are examined respectively and the results indicate an introduction of item-level RFID to such a supply chain depending on partners’ market power characteristics. How the cost of item-level RFID should be allocated among partners is also analyzed so that supply chain profit can be optimized under different scenarios.

Overby et al. (2005) focus on a specific business process — order-to-cash to uncover how RFID data significantly improves the process. Order capture, shipping, billing and payment receipt are the most obvious beneficiaries out the improvement over order-to-cash process. The study suggests two basic questions (whether the process can benefit from automated data capture and whether the process can benefit from serialization) for RFID adopters to analyze their business processes.

SCOR MODEL

The Supply-Chain Operations Reference-model (SCOR) is a process reference model that has been developed and endorsed by the Supply-Chain Council. As it has gained acceptability, the supply chain models developed in this paper were based on the SCOR model in order to provide a common language for disseminating the results among supply-chain partners. The Model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return as defined in SCOR (Supply-Chain Council, 2008). SCOR is a hierarchical model with specific boundaries in regard to the supply chain management processes.

In terms of process decomposition, it contains three levels of process detail. The hierarchical decomposition, using the Deliver management process as an example is illustrated in Figure 1.

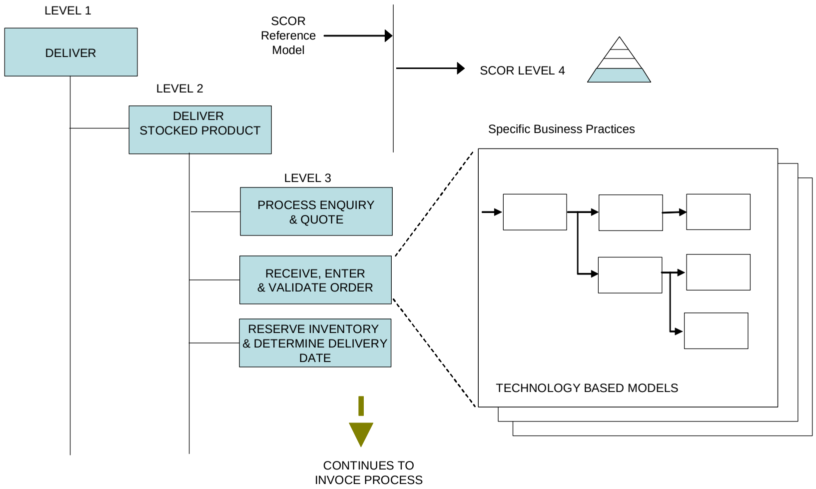

Figure 1: Modelling of specific business processes at SCOR Level 4

The primary management processes are defined at Level 1. Within the Deliver process, there are other Level 2 processes such as "Deliver Stocked Product" and "Deliver Make to Order", etc. Each Level 2 process is further decomposed into "Configuration Processes", which are at Level 3. This research, implemented supply chain improvements using the SCOR-model, by extended the Model, at least to Level 4, using specific processes to reflect how the supply chain costs and savings would be affected with the incorporation of RFID technology. The definition of the reference model to Level 3 provided a reusable framework of supply chain processes, which avoids the wastage of re-invention.

ROI ANALYSIS OF AN RFID ENABLED SUPPLY CHAIN

Many organizations that produce, distribute, handle or sell goods are researching what RFID can do to improve operating efficiency, reduce business risk and drive additional revenue opportunities. The proposed framework for this research is illustrated in Figure 2. The SCOR model is used as the foundation which also enables portability of the resulting technology models. Business processes are mapped based on the SCOR Level 3 processes and from there, the resources, inputs, outputs and triggers of each process are identified, collected and output to a spreadsheet. The ROI calculator is embedded in the spreadsheet and computes based on the data provided. In modelling SCOR activities, particular attention was given to factors such as the costs and time that are consumed by individual activities. Certain investment in technology allows business process re-design and improvements; the inclusion of cost and time factors enabled ROI analysis to be propagated across the process chain.

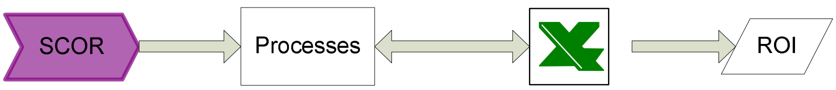

Figure 2: The approach to modelling ROI

RFID technology enhances visibility and accuracy of information throughout the supply chain via the automated data collection, as well as data associated with product movement. The study of the supply chain therefore progressed from the business process layer into the data layer. This was to focus on the modelling of data elements that could benefit from RFID automation and quantifying the associated cost and time weightings for subsequent ROI analysis.

IDEF0 is a descriptive method that shows the activities of a process. It is a notation for specifying the input, control, output, and mechanisms (ICOM) associated with each activity. Figure 3 is an abstract view of the IDEF0 notation. In addition to the activity, arrows represent the "data" associated with the ICOMs. Inputs are the typical artifacts such as resources consumed or transformed by a process. Output(s) are the results of the transformations of the inputs by the process. Controls are the standards, policies, guidelines, etc., that guide the process. Mechanisms are the resources (people, manual tools, automated tools, etc.) that accomplish the actions delineated within the process.

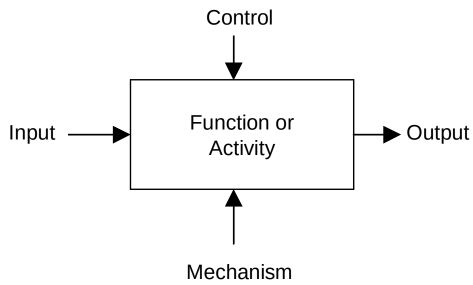

Figure 3: The IDEF0 Notation for Function or Activity Modelling

The concept of cost penalties is introduced at the stage where the activities are analysed and where the artifacts are identified. The transition from process modelling to data analysis was made by examining the process artifacts. At this stage, the authors were concerned with associating a "penalty" against the artifact, such as the time or cost taken to populate the element of data. This approach was taken with a view to weighting the overheads of data redundancy in systems.

In relation to the global supply chain, in addition to the approach of collecting cost and time weightings to measure ROI at the data-element level, it is likely that inefficiencies will exist in its operations. Examining the process in terms of the business process chains should be done in anticipation of achieving savings in labour, operational efficiencies. Significant opportunities for improvement are likely to exist in these areas and major improvements can be achieved prior to applying RFID through business process re-engineering. Cost and time implications also exist at the data level, when RFID technology is used to automate data entry, e.g. product location as opposed to collecting the data via bar-code technology, or even manually with pen and paper. Automated collection of data enables a smoother throughput of shipments by reducing manual operations and the accuracy of information is improved.

SCOR MODELLING TOOL

To benefit a cross section of the industry and to make the SCOR model readily usable, a visual modelling tool was developed. The tool was based on the SCOR process hierarchy and incorporated the IDEF0 modelling method for describing the individual activity. The modelling tool can be distributed to supply chain partners as a means to increase the uptake of SCOR. The tool provides two instances of the SCOR hierarchy in terms of the "as-is" and "to-be" models.

The software perspective of the tool is shown in Figure 4, which presents the UML model that the logic of the tool was based on.

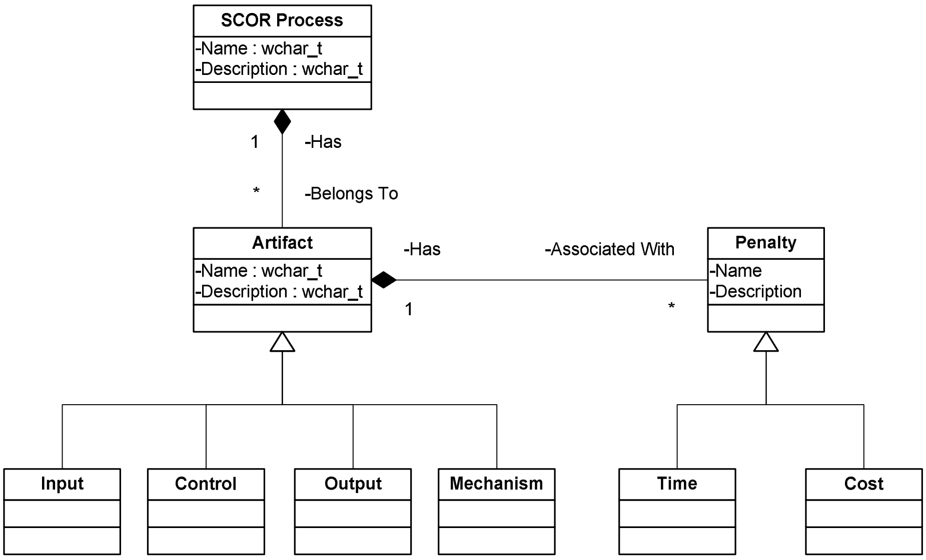

Figure 4: UML representation of the SCOR activity model

The model implements the IDEF0 constructs and extends the modelling notation to capture cost and time overheads. The SCOR process hierarchy is implemented using a tree-control (Figure 5), which is a type of control that provides the ability to show the hierarchical relationships of the SCOR processes, indenting the child processes and showing the sibling processes at the same level.

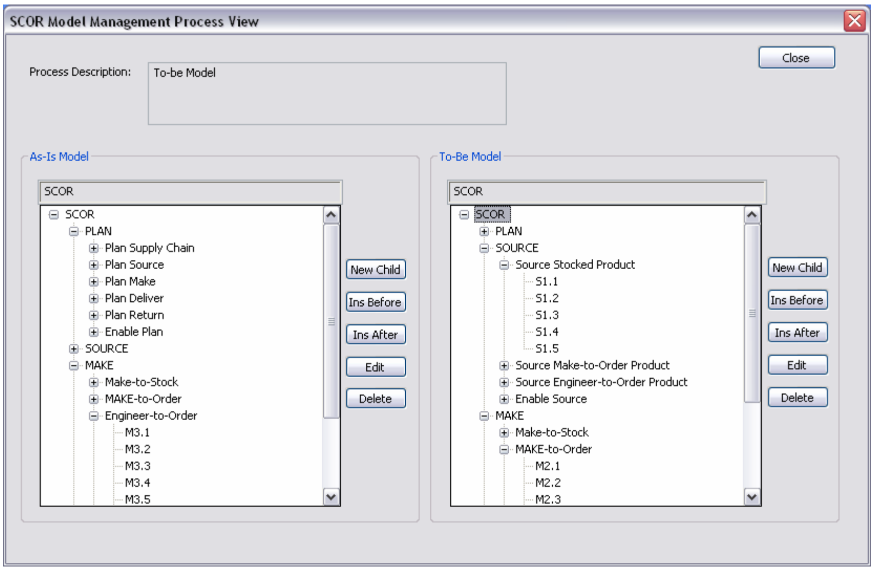

Figure 5: Using the SCOR process hierarchy

The “as-is” model is presented in the left pane and the “to-be” model is presented in the right pane. The SCOR model is fully implemented, providing end-users with a suitable basis for tailoring their models. End users may insert or delete new processes as appropriate, in order to create the configuration of specific business processes at SCOR Level 4. A particular study tends to be focused on specific processes, for example, the Make-to-Order branch. It is possible therefore, for other branches of the hierarchy to be deleted where appropriate. The most important feature is the ability to create two models (“as-is” and “to-be”) for comparative studies. The time and cost data associated with each process can be captured through the constructs of the IDEF0 notation.

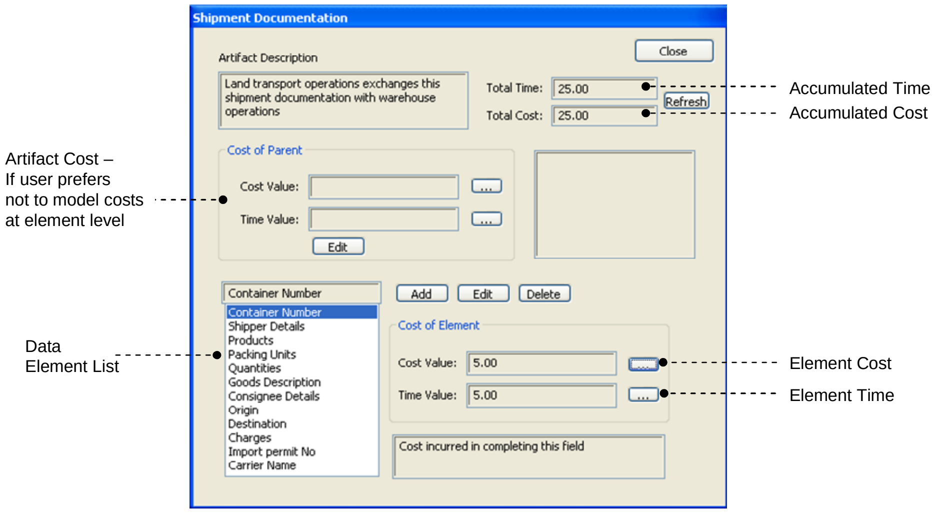

Figure 6: View of a process artifact

Cost and time are accumulated and displayed for individual ICOM(s), and accumulated in terms of a total cost and time for the activity itself. The user may view either the cost or time. The view into an individual artifact may be expanded to show the overheads and further data elements if relevant. This is achieved by the modelling tool using the detailed view of the process artifact, shown in Figure 6. The expansion of the artifact view demonstrates how an item is modelled using the extended SCOR concept.

ROI ANALYSIS

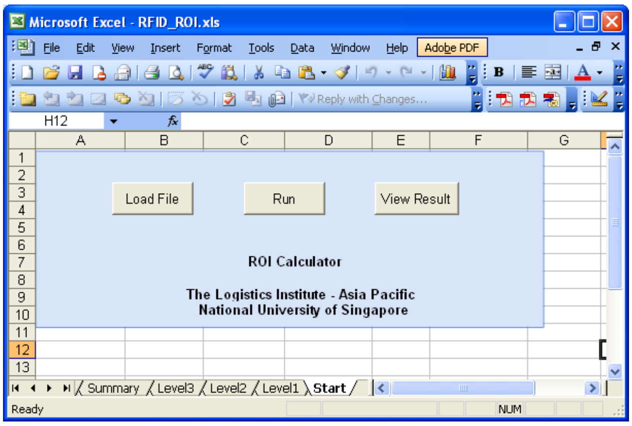

Figure 7: Interface of the ROI Calculator

ROI analysis is important for investment justification where the investment is evaluated by comparing the magnitude and timing of expected gains to the costs. To involve a wider number of stake-holders, the details of the Cost and Time data collected by the SCOR modelling tool are exported into a spreadsheet for subsequent analysis. The ROI calculator developed in this research bases on Excel spreadsheet and uses VBA to aggregate and analyse all data collected. Figure 7 shows the interface of the ROI calculator. The "Load File" button is used to import the data file. The "Run" button initiates the aggregation of data and calculates the summations at SCOR Level 1, 2 and 3 and put the overall cost and time into the "Summary" worksheet. The aggregation of cost and time is made in a way that all cost and time happen at a particular level and all subordinate levels are summarized up to that level. Therefore, comparison can be made for different processes at different level.

CASE STUDY

The case study investigates an IT product assembly line, where the RFID technology is used for assembling and handling over to a 3PL provider. The assembly process needs to associate part A and part B serial numbers with the box which they are packed into so that tracking of products can be achieved. The "As-Is" scenario is supported by barcode technology; while the "To-Be" scenario is supported by RFID technology. Parts are assembled to order and dispatched to the 3PL after assembly and testing.

In the "As-Is" scenario, the operator needs to switch operations between packing equipment and scanning barcodes to associate part serial numbers with box serial number. Following the final packaging, the shipment of several cartons is consolidated into a pallet and physically handed over to the designated 3PL. At the hand-over, the barcodes of the several cartons on a pallet are scanned to generate the hand-over document. From the perspective of the manufacturer, one person is required to hand-over the consignment of pallets; from the perspective of the 3PL, one handler is required to accomplish the confirmation scanning and take over of the pallet consignment.

In the "To-Be" scenario, RFID tags are printed and applied to the carton instead of using barcodes. Therefore, all serial number association can be done automatically through the RFID technology. The operator only needs to concentrate on the packing activities. This considerably reduces the manual handling activities and consequently speeds up the packaging rate. Furthermore, the person who handles the packaging is alerted when a wrong part is packed. The shipment is consolidated following the packaging and each pallet (on a pallet truck) is physically handed over to the designated 3PL. A total of four RFID antennas are installed (facing two opposite sides of the pallet) and these read the RFID tags as the pallets are pushed between them. The whole process of handing-over and consignment document generation can be finished after the pallet truck is pushed pass the RFID tag readers. Although in the case study this is still processed by the handlers, the process can actually be automated.

The whole process is recorded using the SCOR modelling tool, the output is processed by the ROI Calculator. The results of this cast study, which is a pilot implementation of RFID, show a negative ROI; however, this is acceptable by the manufacturer, as they realized other benefits in areas beyond the limits of the assembly line and that with full-scale implementation, the economy of scale spread the hardware and software cost, thus much reducing the cost per unit associated with this RFID implementation.

CONCLUSIONS

To increase the uptake of RFID technology in the supply chain, "early adopters" need an approach that can quickly identify positive business benefits and a tangible ROI. The use of the SCOR model has provided the framework of business processes for modelling supply chain scenarios for ROI analysis. The SCOR model is applicable across the supply chain industry and avoids re-invention of process models. The use of the SCOR model to underpin a modelling tool is to provide a method for ROI analysis that can be readily used, in this case, for studies involving RFID enabled supply chains. Specific business processes may be modelled in detail at SCOR Level 4 through process decomposition and a number of candidate "to-be" processes can be evaluated.

The constructs of the SCOR process framework has been extended, where cost and time penalties are included in the model via process artifacts. Invariably, RFID implementation also has an impact on the information system architecture in terms of data and application integration. The SCOR modelling tool involves the first step of data analysis by introducing activity artifacts and their data elements into the SCOR model. Associated costs and time are captured and accumulated to enable a comparison between the "as-is" and the RFID enabled ("to-be") models. This enables the ROI to be calculated on the basis of the running costs and technology investment. The development of a visual based interface to represent the SCOR and IDEF0 constructs offers a tangible and intuitive method for end-users to specify process artifacts and associated cost and time weightings.

The SCOR modelling tool and ROI calculator developed in this research can be applied to other cases where "as-is" and "to-be" scenarios can be constructed to justify adoption of new technology or additional investment in projects. While the SCOR concepts provide a good start point for process representation, the feature of allowing user customization of the tool enhances the flexibility of business process modelling.

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THE HUMAN SIDE OF LEAN LOGISTICS[1)]

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ABSTRACT
Logistics is a highly competitive industry, hence logistic service providers (LSP) generally tend to get small margins on their activities. This promotes a managerial tendency to see labor as a source of costs that needs to be disciplined and controlled, rather than a source of added value that needs to be fostered. As a consequence, work pressure is high and the motivating potential of jobs may suffer. In this paper we contend that the concept of “creative tension” (Womack, Jones, & Roos, 1990) taken from the lean production (LP) philosophy may provide for the LSP a way to reconcile the need for added value and the need for cost control. Lean jobs not only require workers to continuously reduce waste in the work environment, but they also bestow on them certain responsibilities to create value. Their contributions to Kaizen support a company’s lean journey. In this paper we show that lean can overcome the misfit between worker expectations and job characteristics which will enhance employees’ personal outcomes. The fit between job characteristics and workers’ expectations and preferences was investigated using Hackman & Oldham’s job characteristics model (JCM; Hackman & Oldham, 1976). A survey to measure the variables from the JCM was administered to a sample of 32 employees from a Dutch LSP. The most important result indicated that the extent to which the level of creativity desired by workers fitted the level of creativity required by their jobs was a strong predictor of psychological states (e.g. meaningfulness) and outcomes (e.g. turnover intent) Given the possibilities offered by the concept of creative tension, we argue that the lean philosophy provides the tools to promote the human side of logistics.

INTRODUCTION
Logistic service providers (LSP) generally tend to get small margins on their activities. When market conditions do not allow for an increase in revenues, a strong focus on cost reduction prevails (Johnson, et al., 1999). Since the cost of labor is the major component of logistics costs, an excessive emphasis on cost reduction induces management to see labor as a source of costs that needs to be disciplined and controlled, rather than a source of added value that needs to be fostered and promoted. As a consequence, work pressure is high and the motivating potential of jobs may suffer. Thus, we signal a managerial dilemma. In this paper we contend that the concept of “creative tension” (Womack, et al., 1990) in the lean production (LP) philosophy may provide a way to cope with this dilemma.

One of the consequences of excessive cost control may be a decrease of service level. For logistic service providers, a way to maintain or even improve their service level is to adopt an image of workers, as a source of added value, rather than of costs, a shift reminiscent of McGregors theory X, saying that the average worker has an inherent dislike of work, prefers to avoid responsibility, and needs to be directed and controlled, to theory Y saying that the ordinary worker does not inherently dislike work, will exercise self-direction and self-control, and learns to not only accept but also seek responsibility (McGregor, 1960). In LP both perspectives merge into the need for creative tension, saying that waste reduction requires strict process control that can only be accomplished through the creativity of the people involved. Although workers may fit, at least to some extent, both categories, jobs need to be designed such, that they fit both managerial and workers’ expectations about it. The fit between job characteristics and workers’ expectations and preferences was investigated using Hackman & Oldham’s job characteristics model (Hackman & Oldham, 1976).

The purpose of this paper is to show that lean can overcome the misfit between worker expectations and job characteristics which will enhance employees’ personal outcomes. The paper is organized in the following sections. First we describe logistics service providers and the position of their employees. Next we turn to lean management and the role of employees in it. We present the results of a survey among employees of a Dutch LSP on how they perceive their jobs and situation, and finally we show how lean practices can contribute to create a fit between company requirements, job characteristics, and worker demands.

LOGISTICS SERVICE PROVIDERS

LSPs can play different roles on behalf of their shippers in a supply chain. Here the emphasis will be on integrated processes, hence on 3PLs, whereas hierarchical levels, hence 4PL will be neglected, for reasons of space and scope. Next the position of employees in LSPs will be analyzed.

The role of logistics service providers

Logistics creates value by bridging gaps in time, place, and quantity by means of storing, transport and handling. Storing bridges the gap in time between production, either for seasonal or for technological reasons, and consumption, enabling availability of the product at the right time, i.e. when needed. It implies seeing that the goods are kept in a proper way both in quantity and quality. Transportation bridges the gap between the location of production and that of consumption, enabling the availability of the product at the right place, i.e. where it is needed. Finally, inbound and outbound processes bridge the gap in quantity in which the products are produced (or arrive at a warehouse) and in which they are needed by the shipper. Inbound consists of receiving, unloading, and checking goods and internal transportation to storage. Outbound processes consist of picking, packing and shipping the goods. In practice the sub processes are organized in sequence, supported by an accompanying information flow at the (random) request of the shipper (Gu et al., 2007).
LSPs perform logistics activities on behalf of shipping firms (Stefansson, 2006). The range of activities as well as the extent of clustering of activities sourced out may differ contract by contract. The activities can consist of different operational, shop floor activities, of activities of different hierarchical levels, as well as to extent of clustering, i.e. consisting of one or more orders. The simplest form of logistics service outsourcing is the operation of transporting or storing goods in one single and isolated order. Expansions hereof can follow the three criteria one-by-one or in combination. Firstly, the operational activities of one function can be clustered, clustered operational activities of different functions can be integrated, and finally, hierarchical expansion can be introduced as well: in addition to operations direct supervision can be outsourced as well and after that the tactical, policy and strategic decisions that govern the logistics activities.

The shipper buys from its suppliers and sells to its shippers and the LSP carries out some of the processes within the framework of the shippers' buyer-supplier relationships and the outsourcing contract. Consequently, LSPs may be faced with the consequences of last minute crises at the shipper and LSPs represent the shipper in their contacts with its suppliers and its shippers. Any mistake made by the LSP is a mistake made by the shipper in the eye of the buyer. Consequently, LSPs have to provide their service at a high level.

Despite the fact that logistics is a core process, shippers are able to negotiate a low price. In essence this is because LSPs are 'captive suppliers' (Bensaou, 1999) as they have to invest substantially to adapt to their customer. The shipper will and need not adapt as the choice of LSPs is abundant and logistics is perceived as just costs and hence is undervalued.
To summarize, LSPs carry out shippers' primary processes at a high service level, but at the lowest price possible. Consequently, LSPs can't make a trade off between low cost and flexible service but have to pursue both simultaneously to satisfy and retain their clients.

The emphasis on costs in decision making on outsourcing by customers as well as LSPs forces the latter to be highly cost conscious. In the cost structure labor costs are dominant. In the Netherlands hourly wages for people employed by LSPs are lower than those for comparable jobs, as table 1 shows.

Type of employee	Average hourly wage
Operator in manufacturing and process industry	21
Trucker	15
Forklift truck driver	13
Warehouse operator	11

Table 1 Hourly wages in LSPs and industry (Hagoort and Van der Linden 2007)

These differences in labor costs enable LSPs to outperform internal logistics departments even if they would be less efficient. However, low labor costs at the outsourcee cause risks for the outsourcer as Jiang et al. (2009) show. Labor problems can result in operational risks such as: poor quality, low productivity, unfulfilled orders and, high turnover. The latter is associated with organizational friction, instability of skills and damaged customer service. This risk also applies in case of LSPs. Finally, reputational risks for the shipper may occur.

The relationship between employees and logistics service providers

Autry and Daugherty (2003) mention that turn over rates in LSPs are very high not only for truckers but also for warehousers. 20% and more of new hires will leave their job within one year whereas replacing each of them costs thousands of dollars. Their literature review showed that logistics researchers only recently began to focus on employee behaviours and attitudes, with an emphasis on truckers. Most research concentrated on employee turnover and only a few addressed recruitment or incentive plans. Autry and Daugherty (2003) studied the relationship between person-organization fit, satisfaction and coping, building on only two papers on each of the latter two concepts. Employees of LSPs who have realistic expectations about their company and supervisor characteristics are more likely to be satisfied with their employment. More satisfied employees exhibit behavior that benefits themselves and or the company whereas dissatisfied employees try to leave the company or behave counterproductively. Consequently, person organization fit is positive for both the employee and the company.

Min (2007) examined sources of warehouse employee turnover, categorized in three variables: occupational (e.g. skills), organizational (e.g. size), and individual (e.g. job security). He found that job security was one of the most important factors for retaining employees, whereas monetary incentives hardly influenced turnover. However, the larger the company, the higher the turnover was because of lack of personal attention. More experienced employees were less inclined to give up their current jobs probably because of a proper fit. Ellinger et al. (2008) studied employee level and organizational performance in LSPs and discuss three options to align staff and organization: service-related training, coaching and empowerment. Empowerment does not support the organization or the employee performance; training supported employee performance but not organizational performance and finally coaching supports both types of performance. Hackman and Oldham (1976) present a general Job Characteristics Model which integrates employee demands, job characteristics (person-organization fit), psychological states and outcomes (cfr. Min) (see Figure 1). Certain options exist to align these three aspects (Ellinger et al.)

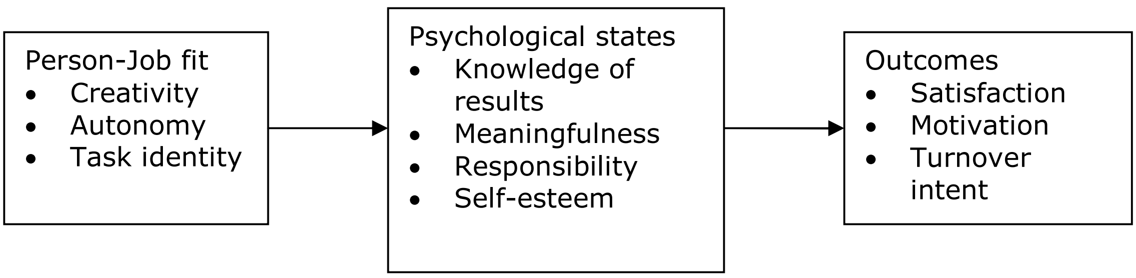

Figure 1 Research model, adapted from Hackman & Oldham (1976).

LEAN MANAGEMENT

Principles

The lean philosophy can be summarized as: produce twice as much with only half of the inputs (Womack et al., 1990). Although various lists of principles to characterize lean are found, they show quite some resemblance. In essence it is about three principles: create value, reduce waste and improve continuously.

Its starting point is to create customer value by producing only what is needed and when it is needed. This ultimately leads to uninterrupted flows of products through the various stages of production.

Such flows require 100% process control and zero waste (e.g. inventory or defects) causing perfect processes. Harrison and Van Hoek (2008) present a pyramid of key factors that underpin uninterrupted flows, without any waste whatsoever.

The final key principle is continuous improvement, as lean is 'a journey' rather than a pre-set recipe. When gaining more experience with a process, ideas for improvement will pop up, using input from those who actually work in these processes. The continuous improvement causes increased perfection in performance as reflected in a learning curve.

Practices

Over time dozens and dozens of lean tools and techniques have emerged as a result of the continuous improvement approach. Some of them are more popular than others in the literature as well as in practice. Shah and Ward (2003) clustered these tools and techniques into four bundles: Just-in-time (JIT), Human resource management (HRM), Total productive maintenance (TPM) and Total quality management (TQM). The first deals with the content of the firms' primary processes, whereas the latter three provide conditions to facilitate JIT. JIT is about the continuous, uninterrupted production flow with a constant and balanced use of the available resources. Flows are pulled by a customer order and produce the right item at the right time and in the right quantity. Preferably it is about batch size one, based on minimal set up times and proper scheduling. For employees these uninterrupted and balanced flows imply the discipline and tension of standardized operating procedures (cfr. Womack et al., 1990). However, when a product that has to be processed enters a workstation the employee will check it. If a mistake is detected either by equipment or by an employee it has to be corrected immediately. The employee can stop the production flow autonomously to do so. HRM ensaves that staff is trained properly both to produce as needed and to improve processes when needed. In the end the 100% -controlled processes facilitate meeting all performance criteria simultaneously. TPM supports the availability of the needed physical equipment and its proper functioning to facilitate the production flow. TQM enables quality throughout the system as well as process improvements to meet the ideal of zero defects. In case of structural problems, employees will form a kaizen group to analyze and solve the problem. The in-process quality checks and the participation in kaizen groups add the 'creative' to Womack et al.s' creative tension. In literature (e.g. De Treville and Antoniakis, 2006) the emphasis is on the tension aspect of lean jobs as the creative aspect is neglected.

RESULTS

Building on Hackman and Oldham's (1976) well-known job characteristics model (JCM), we hypothesized that a fit between core dimensions of an employee's growth need and the growth potential offered through the corresponding dimensions of the job would affect the worker's psychological state, which would in turn influence outcomes. As core dimensions we measured the need for vs. the potential for autonomy and creativity in the job, and task identity. As psychological states we measured meaningfulness of the work, responsibility, knowledge of the results, and organization-based self-esteem (Pierce, Gardner, Cummings, & Dunham, 1989), and the outcomes measured were job satisfaction, motivation, and turnover intent. In addition we propose that lean management can solve misfits that may be discovered.

Participants in our study were 32 employees from a Dutch LSP. All of them were men, their mean age was 30.7 years (*SD* = 12.4) and their mean tenure was 8.5 years (*SD* = 8.4). They were administered a pencil and paper survey and they were allowed to answer the questions during work time. All constructs were measured reliably, with Cronbach's alphas of .70 and up, based upon a 1-7 scale. To determine the misfit between the worker and the job, we calculated difference scores for the autonomy (DifAut), creativity (DifCrea), and task identity (DifID) desired by the worker and offered by the job. The descriptive statistics for the variables in the model are presented in Table 2:

	Variable	M	SD
Person-Job misfit	DifCrea	1.19	1.01
	DifAut	-.01	1.38
	DifID	.46	1.17
Psychological state	Knowledge of results	5.09	2.00
	Meaningfulness	5.96	1.44
	Responsibility	6.06	1.65
	Self-esteem	4.83	1.37
Outcome	Satisfaction	5.71	1.25
	Motivation	5.98	.80
	Turnover intent	2.63	1.64

Table 2 Descriptive statistics

Table 2 shows some interesting results. The creativity dimension shows the largest gap between what workers want and get from their jobs, whereas in terms of autonomy they make a good fit on average, but the standard deviation indicates relatively large individual differences. As regards the psychological states and outcomes, the results are quite encouraging for the employing organization, but the large standard deviation for knowledge of results shows that not all are aware of the fruits of their efforts.

The relationships can be summarized as follows (all correlations significant at the $p < .05$ level).

First, both age (r = -.51) and tenure (r = -.48) are significantly related to DifCrea. In other words, younger workers and those with shorter tenure perceive more difference between what they want and what they get from their job in terms of creativity. Contrary to tenure, age also predicts responsibility (r = .39) and turnover intent (r = -.33).

Second, DifID does not predict either of the psychological states and the outcomes.

Third, DifCrea predicts the psychological states self-esteem(r = -.40), meaningfulness (r = -.45) and responsibility (r = -.40) and the outcomes satisfaction (r = -.30) and turnover intent (r = .33).

Fourth, DifAut only predicts the psychological states self-esteem (r = -.42), meaningfulness (r = -.31) and knowledge of results (r = -.29), but no outcomes. It is important to note that DifAut and DifCrea constitute distinct dimensions as they are not significantly related.

Fifth, the relationship between DifCrea and turnover intent is partially mediated by self-esteem (R^2 for total model = .21).

DISCUSSION

The key argument in this paper is that, to stay competitive, LSPs are required to increase their service level while decreasing their costs. We have argued that the lean manufacturing philosophy may provide a way to simultaneously meet both requirements, and the concept of creative tension, which has been neglected in research thus far, offers a promising perspective to do so. The tension aspect relates to the fact that workers are required to apply standard operating procedures with limited takt times to ensure an uninterrupted production flow, and the creative aspect relates to the fact that basically it is the workers' insight and creativity that helps to identify sources of waste and ways to deal with it, thereby making the processes go ever smoother. We have argued that lean can be expected to affect work in general and job characteristics in particular. In prior research, de Treville and Antonakis (2006) have raised the intriguing question whether lean job design can be reconciled with motivation. We have investigated this question in the theoretical perspective of the JCM.

Our most important finding is that, depending upon age and tenure, to the extent that the creativity offered in the job meets the creativity required by the worker, positive effects in terms of high self-esteem, experienced meaningfulness and responsibility, and high satisfaction and low turnover intent may be expected, whereas, contrary to expectations, a fit in task identity does not. A misfit with respect to autonomy also affected psychological states. This adds to Autry and Daugherty's findings (2003) with respect to person-organization fit, as well to Min's (2007) findings with respect to the relationship between psychological states. Hackman and Oldham's model provides a nuanced picture of how employees react to their jobs, also in LSPs. Management of LSPs should try and balance job design with both the requirements of the primary processes as well as with the expectations of their employees. Consequently, the LSP involved in this study should improve on implementation of the 'creative' aspects of the jobs to become more attractive as an employer, in particular for younger workers. Coaching (Ellinger et al., 2008) could be directed towards more autonomous behaviour as well as to contributing to solving problems either when performing primary processes or to solve structural problems.

Although the small sample size is an important limitation of our study, the fact that nevertheless the aforementioned relationships were all significant at the $p < .05$ level is an important indication that lean jobs can be intrinsically motivating in LSPs. Lean may provide requirements concerning the worker's growth need which may satisfy important needs and produce positive outcomes. This is an important finding, worthy of future research into two directions. On the one hand this research should be replicated on a larger scale, but on the other the general direction of 'autonomy' and 'problem solving' should be specified. The latter requires LSPs to undertake the lean journey and discover what the human side of lean logistics looks like in their firm.

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USING LOGISTICS SERVICES TO ACHIEVE SATISFACTION AND TURN CORPORATE BRAND EQUITY INTO LOYALTY

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ABSTRACT
Purpose: This research applies theory and techniques from the services and marketing literature to a logistics service provider (LSP) context to determine whether corporate brand equity and the LSP's service offerings lead to customer satisfaction which in turn leads to increased customer loyalty towards the LSP.

Methodology/Design: A conceptual model was developed from the literature and includes four latent constructs of corporate brand equity, satisfaction, service and loyalty that are underpinned by nine manifest variables. A survey of over 200 Finnish industrial firms was conducted to explore these constructs.

Research Findings: Data were analysed using structural equation modelling and the relationships among the four constructs in the conceptual model were supported.

Research Limitations: Although primary empirical research was conducted the context of the research was companies in one geographical context, Finland. However, the results indicate that the theory and constructs should hold in other contexts.

Practical implications: The findings of this research should enable management of LSPs to determine those service offerings most important to their customers and develop a service package using such offerings to satisfy the customer needs and thus build corporate brand equity and loyalty.

Originality/value of the paper: This paper adds to knowledge of customer service and satisfaction in logistics, particularly LSPs, and provides an interdisciplinary approach to research in the logistics domain.

INTRODUCTION AND BACKGROUND LITERATURE
This paper reports on a research study investigating how corporate brand equity can create loyalty towards a logistics service provider (LSP) based on extant theory from the services marketing literature. An LSP is usually termed a 'third-party' as it is 'outside' the usual the buyer-seller relationship. As such, the LSP is sometimes neglected below a 'line of visibility' as shown in Figure 1 below.

A customer's *ex-ante* expectation of a manufacturer or supplier's ability to meet their needs is based on influencers such as word-of-mouth, previous experience and sales promotion. When a customer actually receives the goods they have purchased they will perform an evaluation of the entire service experience provided by the manufacturer or supplier as well as the LSP and compare this *ex-post* perception to their original expectation.

If their perception is equal to their expectation their expectation is confirmed and the customer is satisfied. Over time and repeat experiences continued satisfaction should lead to increased loyalty towards the manufacturer or supplier as well as the LSP and thus build corporate brand equity (Grant, 2004; Davis et al., 2008).

If however their perception does not equal their expectation the expectation is 'disconfirmed' and the customer is either dissatisfied if their perception is less or possibly 'delighted' if their perception is greater. This 'expectancy-disconfirmation' paradigm is commonly used in the services marketing literature for consumer services such as banks and restaurants (Grant, 2007).

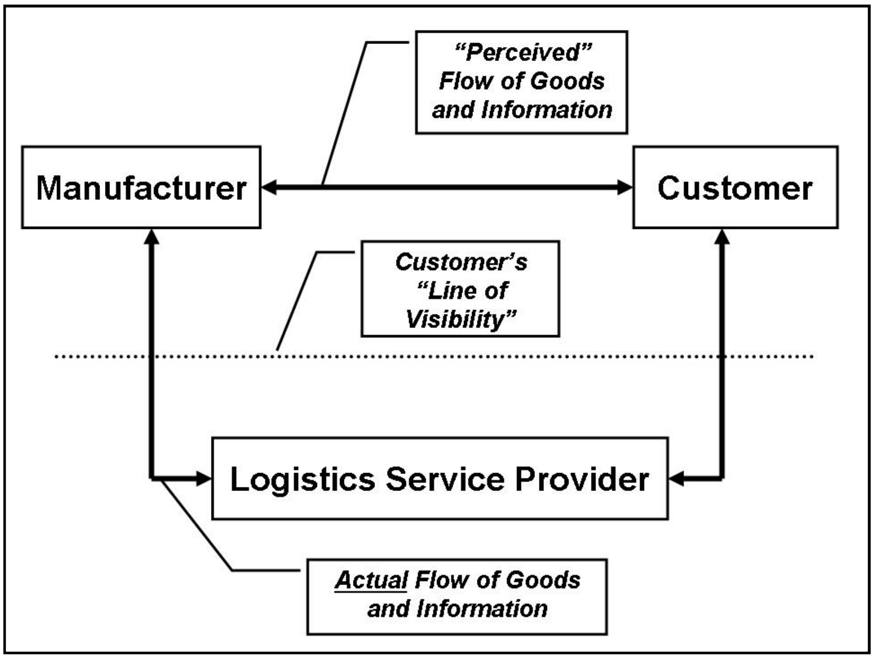

Figure 1: Customer's Perceived versus Actual Logistics Flows

LSPs may be considered services in the marketing sense as the services they provide are intangible, heterogeneous and cannot be 'inventoried' (Grant et al., 2006). As shown in Figure 1 a customer's perception of the flow of goods and information may be very different from the actual flow. Because the LSP actually provides the flow from supplier to customer their impact on the service provision process is important and thus their corporate brand equity is also important to both customers and suppliers to ensure expectations are confirmed by perceptions and generate loyalty towards the LSP.

Additionally, there seems to be a strong 'halo effect' between corporate brand equity and the service levels experienced by customers (Davis et al., 2008) that affects supplier and customer perceptions regarding the LSP.

Given these considerations, we argue that models and research techniques used in marketing and services marketing contexts are also applicable to logistics in general and LSPs in particular (Stock, 1997; Grant, 2007). We thus developed the path model (Loehlin, 1998) shown in Figure 2 from the LSP and marketing and services marketing literature (Davis et al., 2008; Grant 2004, 2005) where the dependent construct of loyalty is affected sequentially by constructs of satisfaction, service levels experienced and corporate brand equity of the LSP.

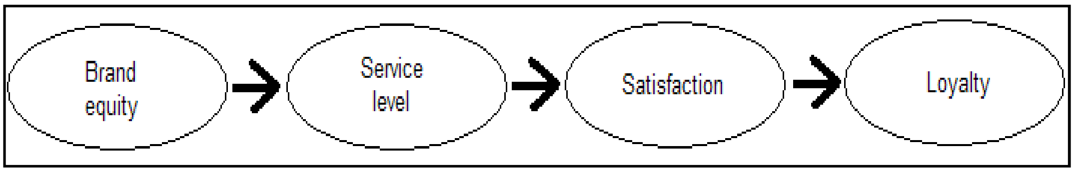

Figure 2: Proposed Path Model

The constructs in the model are considered latent constructs or factors that are not directly observable but are inferred from other manifest or measurable variables. In practice, the operational measures are usually presented in a questionnaire as attitudinal statements based on the 7-point Likert scale (strongly agree … strongly disagree). The descriptions and the operational measures of the concepts are presented in Table 1 below.

EMPIRICAL ANALYSIS

The path model was tested in a survey of 235 Finnish firms that purchase LSP services during early 2008. The survey was conducted using the Internet and the Webropol online survey software package. The questionnaire included various sections intended for mapping outsourcing-related issues for logistics in Finland as well as the research discussed in this paper. The questions in the questionnaire were based on a seven-point Likert scale as discussed above.

The first criterion for the target group was that their line of business uses a lot of logistics services (e.g. mining, manufacturing, oil- gas- and water maintenance and construction). The next criterion was that companies in the target group must have at least 50 employees. Following the previous criteria, the next step was to include only the companies with revenues over 400,000 Euros. This yielded a total target group of 1043 companies and 235 acceptable responses were received for a response rate 23%.

The respondents had filled the questionnaires fairly accurately but any missing data were completed using SPSS software's expectation maximization (EM) function. The data were analysed using structural equation modelling (Bollen and Long, 1993) and estimations were made with Lisrel software (Jöreskog et al. 2000). The estimates were calculated using the ML (maximum likelihood) method based on covariance matrix and the normality of variables was determined using Prelis 2 software (Jöreskog et al. 2000).

Construct or Latent Variable	Explanation and Operational Measure in the Questionnaire	Label
Corporate brand equity	Refers to corporate equity of the brand (Davis et al, 2007).	**BE**
	"We are willing to pay more in order to do business with this logistics service provider."	paymore
	"This company's brand is different from other logistics service providers."	difbrand
	"The name of this provider gives them an advantage over other logistics service providers."	nameadv
Service level	Refers to service levels experienced by customer (Grant, 2004).	**SERV**
	"Recent experiences in logistics service related to keeping schedules."	schedule
	"Recent experiences in logistics service related to sufficiency of capacity."	capacity
	"Recent experiences in logistics service related to service-mindedness of personnel."	service
Satisfaction	Refers to customers' overall satisfaction (Grant, 2004).	**SATIS**
	"Give an evaluation of your overall satisfaction with the operation of your main logistics service provider."	satisfi
Loyalty	Refers to the customer's loyalty towards service provider (Grant, 2004, 2005)	**LOYAL**
	"With high probability we will continue the relationship with our present logistics service providers as long as possible."	continue
	"With high probability we will change our main logistics service provider in the next few years."	change

Table 1: Constructs or Latent Variables and their Operational Measures

Using the operational measures described above, the proposed model was tested and the results are shown in Figure 3. It can be seen that brand equity has a positive relationship with service levels experienced, service levels experienced has a very strong and positive relationship with satisfaction, and satisfaction has a positive relationship with loyalty.

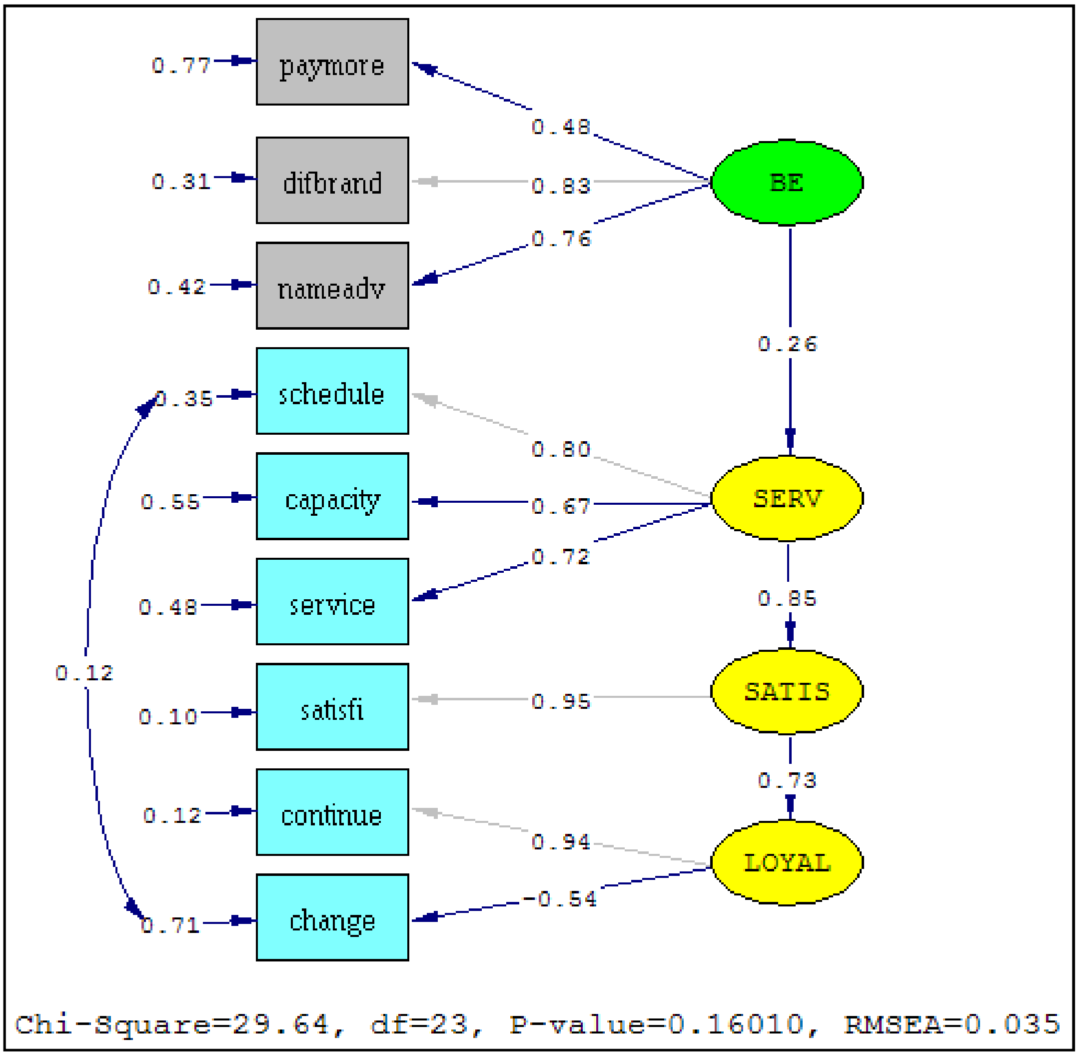

Figure 3: Final Empirical Model

The model provides a good statistical fit as shown in Table 2. All relationships in the final model are statistically significant and their directions are similar to the proposed model. Individual factor loadings are also good. Modification indexes indicated a high correlation between the error terms of the measures 'change' and 'schedule'. This is understandable as intuitively customers will begin to seek new LSPs if their current provider cannot adhere to schedules.

The Chi-square test shows an acceptable fit of the model to the data, the minimum acceptable p-value normally being 0.05. According to Browne and Cudeck (1993), an RMSEA value below 0.05 indicates a close fit of the model. Jaccard and Wan (1996) argue that the model's CFI and GFI values should be above 0.90. The value of the normed chi-square should be between 1.0 and 2.0. Thus, based on the test values, the model can be considered acceptable.

Test	Value	P-value
Chi-square (df)	29.64 (23)	0.16
RMSEA	0.04	
CFI	0.99	
GFI	0.97	
SRMR	0.05	
Normed Chi-square	1.29	

Table 2: Goodness-of-Fit Indices of Final Model

Additionally, each construct was evaluated for construct reliability (CR) as shown in Table 3. Because some factors have only one or two measures, they are unidentified without full structure and it is impossible to perform factor analyses of individual latent variables. This also weakens the usability of traditional test values like CR and average variance extracted (AVE) and, therefore, the results should be evaluated primarily on the basis of the fit indexes of the full model and theoretical background of these measures. Mainly also CR and AVE values support good statistical fit of the model, but SATIS has low AVE value. However, as there is only one measure for overall satisfaction it is not surprising that the AVE value is below 0.5.

Latent variable	CR	AVE
BE	0.74	0.60
SERV	0.78	0.62
SATIS	0.90	0.47
LOYAL	0.73	0.54

Table 3: Construct Reliabilities and Average Variance Extracted

CONCLUSIONS

The research study's findings indicate corporate brand equity has a positive effect on service levels experienced; service levels experienced have a strong positive effect on customer satisfaction; and customer satisfaction has a positive effect on loyalty towards the LSP. The strength of the corporate brand equity relationship with service levels experienced is not particularly strong, nevertheless there is an effect and the relationship is positive.

From a theoretical point-of-view this research study adds to knowledge of customer service and satisfaction in logistics, particularly LSPs, and also considers corporate brand equity as a factor (Davis et al., 2008). However, the study also answers a call (Stock, 1997; Grant, 2007) to conduct more interdisciplinary research in the logistics domain.

This study is important to managers as well as academics since there is little research simultaneously investigating service levels, customer satisfaction and loyalty, and corporate brand equity in LSP activity (Holter et al., 2008). From a managerial perspective LSPs should concentrate on the quality of their service offerings to ensure customer satisfaction and thus increase loyalty from suppliers and customers. This will add to their corporate brand equity which should also be beneficial in the long term. By doing so, LSPs will better position themselves strategically and should generate a competitive advantage relative to competitors or firms considering internalising their logistics activities (Juga et al., 2008).

Methodologically, the research study exhibits good face, construct and internal validity (Mentzer and Flint, 1997). However, the research was carried out in the discrete context of Finnish industrial companies. The results should apply to other contexts but further research should replicate this study in such contexts to determine the external validity of the findings.

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SUPPORTING THE IMPLEMENTATION OF THE INTELLIGENT CARGO CONCEPT BY DEVELOPING A MULTIMEDIA LEARNING FRAMEWORK

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ABSTRACT
Due to the implementation of new information and communication technologies, an increasing globalisation as well as the need for a reduced time to market, the competition between different supply chains and their stakeholders increases. Not only the efficiency of the implemented ICT is a key indicator for the competitiveness, also the skills and the competencies of every involved stakeholder is important, thus the need for vocational training of the stakeholders in a supply chain increase. This paper will present an approach developed within the EURIDICE integrated project on how such training could be organised and which components needed.

INTRODUCTION
Globalisation of manufacturing has caused an increase of locations with common markets and customers resulting in harder competition for each of the involved actors. Furthermore, each company has to operate in an increasingly dynamic market and sourcing situation which again lead to complex logistic networks. Some of the main problems affecting freight transportation on a global scale are logistic processes that are characterized by limited information on goods movements. Despite several attempts from large logistic operators and supply chain leaders, the largest majority of goods still moves without accompanying information in electronic form. According to a survey sponsored by Wolters Kluwer[1], 62% of the carriers are handling call-off management manually, while 90% of the communication on rush orders is handled via phone or fax. This has a negative impact both on logistic efficiency and on safety and security. This situation leads to very vulnerable supply chains, but different strategies can be implemented in order to reduce the limitation on the information flow. Furthermore, inefficient handling of the cargo and accompanying documentation hampers the take up of intermodal and combined transport, thus limiting the possibility to reduce traffic congestion and pollution. Two major key factors to deliver a partial solution to the problem mentioned above and thereby increase the logistics competitiveness is to implement advanced ICT services (Giannopoulos, 2004) allowing on-line information and communication flow (Feng and Yuan, 2006) as well as to increase the level of competencies of all involved stakeholders.

Despite the challenges the logistic sector is facing, it is expected that the employment within the logistic sector will increase with the next 5 years (BVL, 2007, CEDFOP,2008). Furthermore, there several survey examining the training needs within this sector have been carried out (compare Hausladen 2009, BVL 2008; Eckerland,Borchert 2008; Ahlene, Dobischat, 2008). All of them state that there is a large need for improving the qualification of employees working at all stages and positions within the supply chain. The need of qualified persons cannot only be fulfilled by education more logistic field experts at university level (BVL, 2007), but there is also a need for vocational training (Hausladen, 2008; Cedefop, 2008).

A newly started integrated project, EURIDICE, will contribute to the gradual direct overcoming barriers. It aims to create the necessary concepts, technological solutions and business models to establish the most advanced information services for freight

[1] "What It Costs to Manage Collaborative Logistics", Eye For Transport Research Services, November 2005.

transportation in Europe. The project is built upon the Intelligent Cargo concept in relation to the capabilities of self-awareness, context-awareness and connection through a global telecommunication network to support a wide range of information services.

PROBLEM

The EURIDICE platform will support "on the fly" combination of different categories of services to fulfill the unique needs of every specific interaction between user, context and cargo. Accordingly, the project will integrate and further develop technological components and approaches in three main areas:

- Cargo Connectivity
- Cargo Intelligence as well as
- Cargo Services Infrastructure

The basic concept of EURIDICE is to build an information services platform centered on the individual cargo item and on its interaction with the surrounding environment and the user. The platform will allow addressing simultaneously the logistics, business and public policy aspects of freight transportation, by dynamically combining services at increasing levels of extension:

- *Immediate proximity* of a cargo item, for services directly interacting with the item itself (e.g., a shipment, package or individual product)
- *Supply chain* services, for interaction with the actors responsible of shipping, carrying and handling the goods, as well as of the goods themselves (producer or consignee)
- *Freight corridor* services, managed by authority and infrastructure operators who are not directly involved in supply chain business processes, but are in charge of infrastructures efficient operation, security and safety control

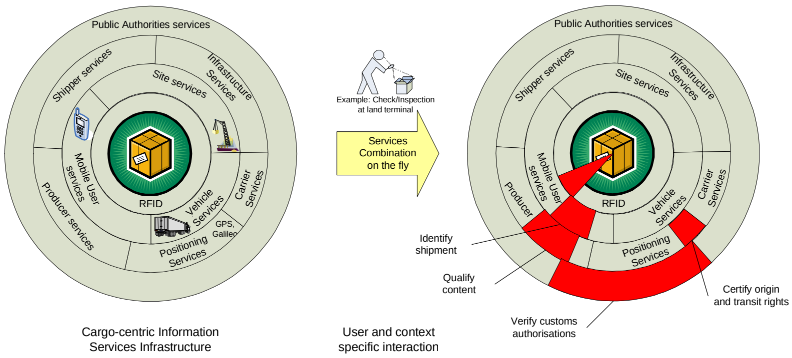

Figure 1: EURIDICE Solution (Source Euridice consortium)

A successful introduction, implementation and operation of such an advanced technical solution as that of the Intelligent Cargo is not only a matter of hardware and software, but it does also imply changes both in the organisational structure of the stakeholders' organizations as well as in the working environment of the employees.

Therefore, the EURIDICE project does not only include the development of the technical solution, but also the development of stakeholder specific training material based upon a set of user centric curricula. The main objectives is therefore to develop a learning framework including different curricula and training material exactly fitting the training needs of the involved stakeholders, so that the participation of an employee in the EURIDICE learning and training framework will improve his/her skills in applying the implemented ICT in the most efficient way as well as to increase the awareness for needed organisational changes.

OBJECTIVES

Preparing an organization for the new requirements, which are requested by dynamic networks, is to a large extent a question of preparing the employees and organizational structure. Indeed, successful co-operation does rely on a seamless information flow between all partners as well as on the ability of the participating organizations to learn and to act in a dynamical environment. A living and learning organization can be characterized by the possibility of and room for the development of creativity and individuality in and outside the organization (Fuchs-Kittowski, 1998). Important parameters involve deriving information out of the process of self-organization as well as collecting and processing information from outside the organization (Fuchs-Kittowski, 1998).

Organizational learning is interpreted from a multi-level perspective comprising the individual, group, organizational and inter-organizational aspect This point of view considers the main levels of action within an enterprise. According to this perspective, Schwesig (2005) created the following working definitions of the different learning levels. First, individual-level learning focuses on individual knowledge acquisition without further social interaction. Second, group-level learning happens if more than one individual consciously or unconsciously acquires knowledge interactively. Third, organizational-level learning occurs between groups in an organization. Last, interorganizational learning happens in two ways: either through the transfer of existing knowledge from one organization to another, or through the creation of new knowledge

Because of the inhomogeneous constellation of the potential users of the training as well the involved stakeholders in the EURIDICE project it is expected that they will have very different training needs and requirements. Furthermore also their main interests as wells level of skills and knowledge will be very inhomogeneous. This needs to be reflected in the EURIDICE Learning Framework (ELF). ELF will therefore not only offer a personalized training concept, but also support individual as well as group and organizational learning.

STAKEHOLDERS AND THEIR TRAINING NEEDS

Since there are several surveys stating the need of vocational and educational training with the field of transport and logistics, it is an overwhelming number of courses, workshops, presentation already existing in the market offered by higher education institutions, EU- and national projects, companies offering advanced ICT-solutions as well as vocational training institute across the world. The training and educational units are targeting different qualification needs as well as target groups. The offers are available both on-line as well as traditional mediating forms like short and long term courses and on-site workshops, but most of the existing material is only available for participants. There is no added- value for the EURIDICE stakeholders to develop already existing training material unless the IPR do call for this, so from September 2008 to December 2008, we analysed the content and the structure of more than 300 courses, both at university level as well as offered by vocational training institutes. It can clearly be stated that four main topics are mostly addressed:

- Logistics (example, inventory and warehousing control, outsourcing, purchasing, PPC, transport and distribution management, etc.)
- Supply chain management skills(change, risk and innovation management, Human resources, organizational analysis etc
- Tools and Technologies (ICT, RFID, SC simulations, Project planning, management and control tools, interfaces, SCM tools etc.)
- Business context (customs and legal aspects, financing and accounting management, business and strategic marketing strategy, supply chain design etc.)

The level as well as the depth of the offered courses within these topics depends on the competency level of the participants as well on course length, but all from basic courses to highly specialized once are offered. The identified topics seems to correlate to the results of a survey on qualification need carried out by Hausladen et al. 2008). However, we are not aiming at developing generic training materials, but a generic learning framework on intelligent cargo, so in order to understand the stakeholders' training needs, we analyzed each of the nine pilot cases, looking at any involved stakeholder, the characterization of his job and expected qualification as well as organizational aspects then combining this with which elements of the EURIDICE technical solution all together lying the basis of the EURIDICE learning framework (ELF) and later on the EURIDICE training program. The preliminary outcome of the analysis did however to a large extent correspond to the results of similar analysis and survey, thus the EURIDICE learning framework on intelligent cargo will comprise courses on:

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

LEARNING FRAMEWORK

The EURIDICE solution comprises all elements in the supply chain and will therefore involve several different user groups with different competencies and therefore different training needs. However, it is important to have one generic framework including different training modules and a generic game frame, so that theses can be customized according to users' needs. The EURIDICE learning framework aims at providing a framework to be applied and implemented for all training activities in the EURIDICE project. These activities need to take the different needs and requirements of different stakeholders into account. These stakeholders can be either individual persons or institutions/organizations.

The first analysis of the nine pilots showed that even though it was possible to define groups of stakeholders (i.e employees doing the same task), the stakeholders did have a very inhomogeneous competency and experience level, thus it became obvious that the learning framework needed to take this into account and therefore to offer a framework ensuring a customization of training material at an individual level.

The base model is therefore the Personalized Knowledge Transfer (PKT) model, which have been used for training in several other projects (ECOLEAD, Tool-East, E4) aiming at training people in distributed environments. Up to know we, have had good experience with the model and it supports the newest didactical approaches on individual learning goals and processes. This model defines the methodology and technique for knowledge transfer (training) personalization. The innovations in this model are:

- The users' needs and preferences assessment from user log files using advanced data mining techniques,
- Knowledge base structure that uses a semantic network as a basic principle in which every atom of knowledge can have several instantiations,
- The matching principle.

The model takes under consideration the user needs and preferences that encompass learning characteristics (preferred learning style, motivational elements, general psychological profile), communication characteristics and a background knowledge. The model is described in more detail in Jermol 1998 and in ECOLEAD Virtual Learning Community based on Personalized Knowledge Transfer Model document.

The goal of managing knowledge transfer (KT) is to enable efficient knowledge transfer from source to the user. When the transfer is finished the knowledge (explicit and tacit) about the specific domain needs to the same on the side of the sender and the recipient. The process can be divided in several processes that are dependent of the personalization characteristics, actual ontology sharing and knowledge construction at the recipient side. The quality of knowledge transfer therefore very much depends on

subjects' preferences, learning profile, subjects' background knowledge, subjects' cultural background as well as the type of knowledge being transferred, media and the learning time.
In proposed PKT model the KT (Jermol 1998) is described by 6 major basic groups of attributes:

- Content and context
- Methods and tools
- Monitoring
- Guiding
- Motivating and
- Setting the goal

Mediating skills to employees puts different requirements on the learning environment than to students as an employee usually cannot leave his job for longer period. Looking at the stakeholders' working environment as well as the spatial distance among the EURIDICE partners, it was necessary to choose training concepts supporting distance learning to a high degree. On the other hand, the potential user groups do have very inhomogeneous training needs as well as different ways of acquiring knowledge: In order to learn about a specific technology it might be enough to read about it, but in order to be able to understand the impact the application of this technology has on the supply chain and on the own working environment, it might be necessary to apply and experience the technology. This can be done both in virtual setting as well as in workshop setting, depending on what is most suitable. The pedagogical approaches behind acquiring knowledge through reading and through experiencing are different. Both will be used in EURIDICE.

Traditional approaches of education mainly apply to teacher centred training, tutored workshops or similar teaching methods that are based on a materialistic view. Such behaviouristic and cognitivistic teaching approaches can be used to mediate specific knowledge of action patterns or procedures and methodologies as well as their correct selection and application to solve a well defined problem.

E-learning is a suitable method for vocational training. It provides many of the benefits of classroom training from nearly anywhere and at any time. It is flexible, virtual learning that reduces the cost and time efforts, and it demands active participation. Additionally, the employee can monitor the progress as well as test himself.

E-Learning approaches mostly focus on the use of ICT in the learning/training set-up, but do not focus on using adapted pedagogical models. Therefore, e-Learning approaches still work like traditional approaches, but with innovative ICT support. Most E-learning concepts are based upon the theoretical learning theories of behaviourism and cognitivism. In order to achieve the best learning results it is important that the learning courses are supplemented with tutorials. E-learning is a very useful way of mediating skills and knowledge in distributed environment, but it require a good time- and self-management. Since e-learning classes are mainly without a lecturer, it is also important to develop curricula, syllabus and training materials to fit the different need of each participant.

In the virtual training environment, we will also offer training courses based upon the active participation of the participant. These will mainly be computer based games, which will allow the user to actively apply the knowledge he/she has gather in the more theoretical training courses.
The model behind educational gaming is in most cases constructivism. As constructivism sees learning as learning by experience, the learner is an active agent, not a passive processing unit, and she or he feels knowledge as personal and subjective construction. Knowledge is constructed by performing actions and experiencing the results. The more the virtual world allows comparison with the real, the better the constructed knowledge

can be transferred to real situations. The advantage is that the user can experience in a failure tolerant environment.

In EURIDICE, there is a training need also on using specific tools. Developing electronically training units in which the user can apply and use the right tools, will be too costly, so that we here will offer on-site workshops. For those not being able to attend such on-site workshops, videos will be made available. This will of course then have the disadvantage, that the user cannot actively apply it, but it will support the learning process more than if he does only have access to the theoretical training curses with tutorials.

EURIDICE TRAINING PORTAL

A key element for the EURIDICE learning and training framework is the training portal. It is based upon the LMS Docebo and offers every user to set up his own training program. In order to describe each training course in such a way that it will be exportable to other projects or to LMS systems kept at the pilots and offering searching functionalities, we have chosen to use a standardized interface for content authoring and content exchange. SCORM (Sharable Content Object Reference Model) is a standardized data model for learning content. It is a container format that allows the structuring of learning content. The main benefit of this is that it is possible to transfer SCORM content from one LMS to another. This makes it easy to reuse specific contents in later projects. SCORM does not define a format for content; it defines a structure for learning contents. Thus, it is possible to use almost any data format to present the content.

For the purpose of the training content interconnection with the similar activities and to support the personalised knowledge transfer model, we have defined a metadata and meta-model. Based on the adapted Dublin Core meta-model (http://dublincore.org/documents/dces/), analysis of the personalization results and some users' comments, we needed to adapt the initial meta-model to the new one (table 1)

Attribute	Description
DC.Title	Course title
DC.Subject	Keywords used to describe the topics of the course
DC.Description	Short course description – abstract
DC.Type	Collection, Text, Image, Sound, MovingImage, Software, InteractiveResource, Dataset
DC.Source	Reference to the source (Deliverable), URL, etc
DC.Creator	List of authors
DC.Publisher	EURIDICE
DC.Contributor	List of contributing individuals/organizations
DC.Rights	Distributable, Not editable, Copyrights
DC.Date	Date of preparation
DC.Format	MIME media type i.e. pdf, msword
DC.Audience	researchers, business decision makers, engineers, students, etc.
DC.RightsHolder	EURIDICE
DC.InstructionalMethod	Explaining, teaching, assessment, exploring, case study
Date.Valid	Date of validation
Category	Basic, Supplement, Specific
Background knowledge	Describe needed background knowledge
Learning style	Conceptual, Linear, Structural
User	Scientific, Technical, Operational, Informative
UserLevel	Secondary school, Student, Postgraduate, Adult

Table 1: extended meta-model to describe content objects used in ELP

During the next two months 10 different training courses will be developed and available on the training Portal. In the first step basic courses on the principle of logistics, management of logistic networks (customes regulations, unit documentation, network management), Euridice Key Perormance indicators; fundamentals and applications of RFID in logistic networks as well as an introductory course to the intelligent cargo concept will be available. As soon as the all curricula have been completed more advanced courses will be developed. These will be based on the specific training requirement of the pilots' stakeholders. For the training offered via the portal we will ask all participants to complete a questionnaire, in which we will use a combination of open and closed questions. Based upon completed questionnaire, it is possible to collect the subjective quality in use of each user. Additionally, for most of the training courses we will collect quantitative indicators like numbers of wrong and correct answers as well as the number of completed answers/time. This will give a more objective assessment of the training courses.

CONCLUSION AND FURTHER WORK

The main objective of this article was to describe a training framework supporting the implementation of advanced information and communication technology reducing existing barriers. It presents a learning framework on the intelligent cargo concept not only supporting distance training but also allowing customised training materials at an individual level. This is especially important because the inhomogeneous group of stakeholders with diverging training needs. The presented framework is the first step in the development of a complete set of training material and curricula needed for a successful implementation of the intelligent cargo concept. Curricula and training material will be developed during the next year.

ACKNOWLEDGEMENTS

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WASTEPAPER MINING: A SUSTAINABLE GOLDMINE

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ABSTRACT

In this research paper we want to explore a new way to handle recovered paper. The purpose of this paper is to understand the situation with China. Since years, this country is the most important market for recovered wastepaper collected in western countries from households. The efforts to get it there, necessitate an enormous number of transport movements, both within Europe and outwards to China and this number is growing exponentially. This paper is the result of a research of an alternative collecting and processing (The WastePaper Mining) concept, which will make a substantial contribution to reducing the number of transport movements and alleviating the pressure on infrastructure capacity. It will have potentially great implications for the collection and movement of recovered paper. On balance that makes it possible to come a big step nearer to achieving sustainable logistics in the recovered paper sector.

INTRODUCTION

Our project is part of the "European Networks" project. This project aims to improve our knowledge – both theoretically ànd in business practise – about the question how to best build up a European Network. Creating sustainability in building up these networks, is included in our objectives. That is the reason why our project is supported by Transumo: TRansition SUstainable MObility. The Dutch government has created this organization in 2004, in order to bring about a major shift in the development of sustainable mobility, and to develop knowledge about this in, among others, the goods transportation sector. In our project European Networks we combine the improvement of theory ànd business practise, by researching the application of models, as well as setting up three example projects. WastePaper Mining is one of the latter. Big River cooperates in this project with Buck Consultants International and HAN University. A number of research projects have already taken place, in support of this initiative. One of these dealt with the location alternatives, another with the present collection method structures in several countries, including the logistic and transportation components of this, and a third research project focused on the recovered paper trade with China. This paper will mainly focus on these last two projects.

RATIONALE

The purpose of this paper is to make a recommendation about the conditions under which it is viable - from the point of view of the Transumo philosophy - to upgrade paper from recovered mixed household collection. We will give an outline of the market for recovered paper and of the logistic concept that is used in the traditional recovery process. After this, we will describe the alternative method proposed. In order to be able to judge accurately whether there is enough recovered paper material available, we have investigated three regions in Western Europe with large population centres: Ile de France, the Rhine-Ruhr area and Greater London. The underlying assumption is that if there is not enough recovered paper material available in these centres, then there is a very small chance of finding other places offering favourable conditions for successful studies. In this paper we sometimes use the term "wastepaper." In the paper sector, it is usually referred to as "recovered paper" which has a more neutral meaning. In fact, a new term for such a valuable resource as wastepaper or recovered paper seems to be justified.

THE RECOVERED PAPER MARKET

Once in their lives, many people have taken old newspapers or other used paper into the local school or sports club. In the Netherlands clubs and schools take an active part in the collection of

recovered paper for many years. This way, they can earn extra money and local authorities don't have to collect and dispose of the same amount of rubbish for incineration.
Recovered paper is an important resource in making new paper. And with the increasing resistance to cutting down trees for the case of producing paper, the recycling of recovered paper is becoming ever more important. The greater the homogeneity of a load of recovered paper, the more valuable it is for the paper-making industry. There are of course, many types of paper qualities. The maximum quality possible of a particular batch of recovered paper, is determined by the part of the batch with the lowest quality. For example, if a load contains cardboard, it is not possible to produce a better half product out of this complete load than for cardboard: you can't make standard or glossy paper out of this load of recovered paper.

Loads that consist entirely of one type of recovered paper – for instance, newspapers, flyers, magazines, cardboard, books, etcetera – are more attractive for reusing, than mixed loads are. In the market for recovered paper, a ton of used copying paper for example, will yield much more than an unsorted load. By sorting recovered paper into homogenous quality loads, its attractiveness increases and with it, the price that one can get. On the side, the united European paper producing industry has set itself the ambitious target, to recover 66% of all the cellulose it needs out of recycled paper, by 2010 (CEPI 2007).

On a global scale, about 150 million tons of recovered paper are recycled each year and used for the production of new paper, together with an almost equal quantity of other fibre materials from other sources, mainly trees. Because of the efficient methods of collection in Western countries (EU, USA, and Japan) and the limitations on the use of "mixed" material, one third of this total amount is responsible for creating large export flows: these recovered paper export flows accounted for 41 million tons in 2005.

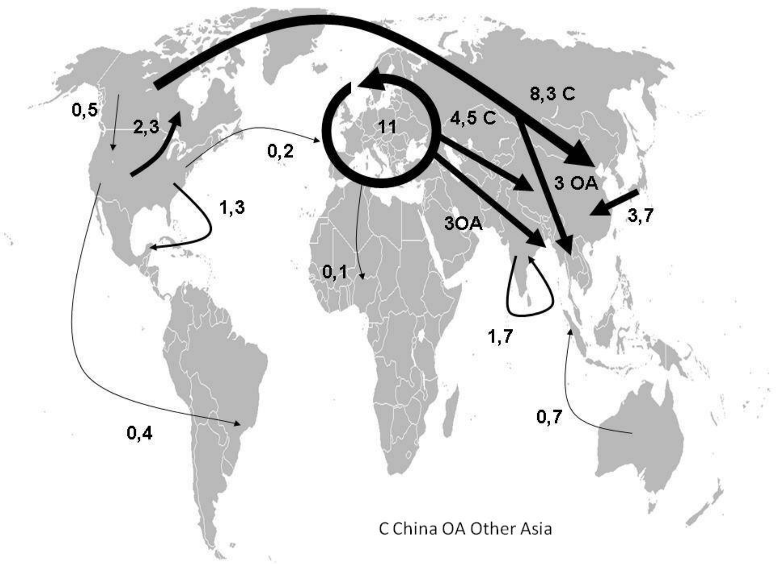
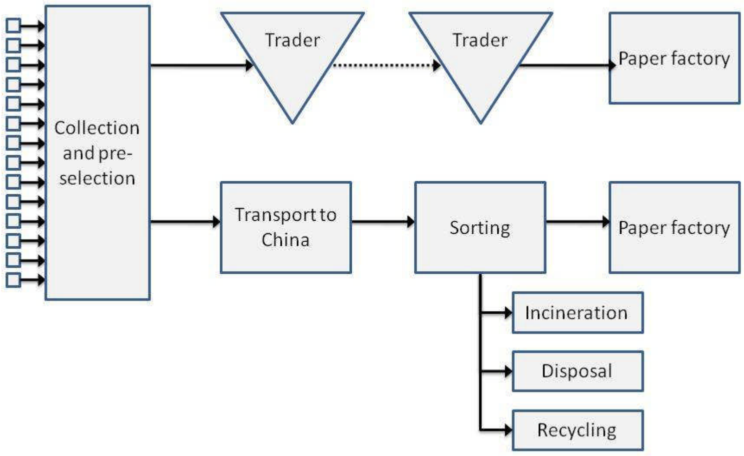


Figure 1 Overview of the global export flows for recovered paper in millions of tons – 2005 (PÖYRY 2006)

In figure 1 you can see the most important export flows for recovered paper for the year 2005. The largest flow is among the EU countries themselves (11 million tons). Taking one country as a destination, the flows to China are by far the largest: 8.3 million tons from the USA, 4.5 million tons from the EU and 3.7 million tons from Japan. The EU also sends 3 million tons to other destinations in Asia and the USA sends another 2.3 million tons to Canada. The other flows are relatively small.

THE PRESENT SITUATION
Businesses and organizations collect recovered paper in two different ways: recovered paper only, and recovered paper mixed with other (dry) packaging materials: plastic bottles, tins etcetera. This last type of material is called co-mingled. This material has limitations due to hygiene considerations, and is not used for producing new paper. Recovered paper can be sorted manually, but this is



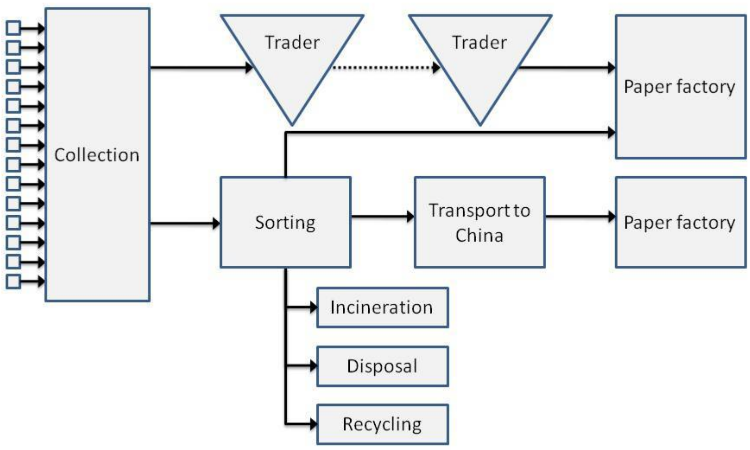
a relatively labour intensive process, and therefore less interesting from an economic point of view. In China labour is cheaper and the growing economy is clamouring for raw materials, among others for making paper and packaging cardboard. This is the reason that recovered paper that cannot be economically processed in Europe, is sent to China.

Figure 2 Present logistic structure for recovered paper flows

An added advantage is that container transports onto China are cheaper than out of China, because there are many more full containers taking goods onto Europe than vice versa. However, the way this material is processed in China and the environmental effects of it, are unknown. Environmental issues are beginning to appear on the agenda in China too, and it is expected that higher standards will be set for the supply of raw materials. At the same time, labour costs in China are already on the increase. Altogether this means that these developments may affect the willingness of China to accept unsorted material. A new aspect which has appeared is the recent economic crisis. This has caused the Chinese export to fall and as a result the Chinese demand for raw material has fallen as well. This puts the price for recovered paper under pressure.

THE WASTEPAPER MINING CONCEPT

The present way of dealing with recovered paper and its enormous transport flows to China and among Western European countries, can be changed by basing it on other principles. We are currently working this out in the WPM project.



By sorting recovered paper, compacting and removing unusable components into homogenous loads, we are convinced that we can create added value. The principle is the same as the one involved in delving and refining ores and other natural resources. Big River has developed a method by which recovered paper can be sorted and cleaned by the use of machines; we call it the WastePaper Mining project, as running within the European Network project.

Figure 3 Logistic structure for recovered paper following the WPM concept

In this way, recovered paper can be made more compact and in part reused locally/regionally within Europe. It will mean less bulk to be shipped, and less mileage for transport. Using the new method, the basic material is in principle collected in the same way as it is at present. After this, it is taken to centrally located WPM sites. There the pure recovered paper is converted into loads consisting of 100% of one type of paper. In this way there is a greater probability of it being re-used for higher quality products at local markets.

After sorting, part of the material consisting of 100% of one type will be converted into pulp, and undergo cleaning up to fibre level. No more mixed material will be transported, but instead it will be further processed with the help of new technologies. The resulting products can be offered for sale to the paper factories in the region using existing sales channels. They can also be sent elsewhere in Europe or to China. The separated unusable waste can then be incinerated, disposed of, or recycled in other ways. So high grade recovered paper and pulp, consisting for 100% of one type of raw material, can be supplied to the factories, direct from WPM as a neutral party, which exactly matches the needs of the paper factories (mills). These mills are often not capable of performing such a WPM-process themselves due to the lack of economies of scale.

The WPM-formula leads to a approximately 30-40% reduction of waste flows. That is significantly. Moreover, thanks to the pulpprocessing, its volume is also greatly reduced. Additionally, by means of improved possibilities for local re-use, less transport will be needed, and fewer trees will have to be cut down. In the case that material is exported, there will be a large reduction in volume in excess of 20%, which will lead to less transport and its associated costs.

Despite previous predictions from the 1980's on, paper use is on the increase in the digital age. This also applies to China. Its paperconsumption rose from 28 kg per head of population in 2000 to 42 kg per head of the population in 2004 (ERNST AND YOUNG). In 2006 it was predicted that China would use 76 million tons of paper and cardboard in 2010, and more than 100 million tons in 2020. At that time the USA, EU and China would each account for about one quarter of the world consumption of paper and cardboard (IITO 2006).

COLLECTION

In order to get an idea of the possibilities for the WPM-concept to make use of existing collection method structures, research has been done in several regions on the question how recovered paper is collected. Our attention was focused on three regions with large population centres. The underlying assumption was that if the WPM concept was going to be successful, it was important to know whether there were enough large recovered paper flows available. To this end, an investigation was carried out in Paris-, the Ruhr- and London-areas into the question how the collection of recovered paper is organized at the present time.

Ile de France

With more than 11 million inhabitants, Ile de France is the most important region of France. The area comprises ten prefectures, including the city of Paris. There is, however, no common way of collecting and processing waste and paper flows. In principle, each of the 1281 municipalities in the region can organize its own waste collection and processing. Most of these have formed cooperatives which are organized at prefecture level. In 2005 a total of 358,400 tons of paper and cardboard were collected using this selective collection method. 75% of it has been recycled, 25.25% incinerated or disposed of.

Rhine-Ruhr

With more than 11.3 million inhabitants and cities such as Essen, Duisburg, Düsseldorf, Bonn and Köln, the Rhine-Ruhr-region is the largest urban area of Germany. Here, waste collection is a city municipality responsibility. Each city has its own rules and collection methods. Large numbers of collection containers for recyclable material can be found at locations with a high concentration of people. Residents therefore do not have to travel far with waste or recovered paper. Increasingly, local councils are providing residents with different coloured containers to stimulate them to sort their rubbish at home. A blue container is used for recovered paper in many cases. Yellow is used for other packaging materials like milk cartons and tins, and grey is used for household rubbish. The emptying of these containers is done differently in each city. Grey containers usually still contain a lot of recovered paper. As recovered paper is sorted at its source, it is generally of a good quality. In 2006, 75% of the paper used was collected. “

Greater London

Greater London is smaller than the other two regions, although the way waste collection is organized is similar. Each borough, or local council, assigns responsibility to different partners, very often private companies. This cooperation is based on long-term contracts, even up to 25 years. Recycling is often not the main concern of these councils. Incineration and disposal are the commonly applied methods. The Greater London Authority (GLA), the umbrella organization for the London area as a whole, wants to change this policy. It aims to ensure that 33% of household waste will be recycled in 2015, and it intends to levy a tax on disposal, in order to make this option less attractive. Londoners at present do not sort much of their waste. There are almost no paper containers at public places. Once or twice a week, people can put certain types of rubbish out on the street, to have it collected. 90% Of the households has acted in this way in 2006, and 56% of all recycled materials originates from this source. The waste is partly separated; the mixed part we call 'co-mingled'. In case of separation, the collector uses separate compartments for different sorts of waste. This requires extra organization, of course. That is the reason that local authorities and waste collectors prefer the unsorted collecting of (dry) household waste. In 2006, 62.6% of all paper and cardboard in the UK was recycled.

	Ile de France	Greater London	Rhine-Ruhr
Population	11 million	7.8 million	11.3 million
Estimate of recovered paper in 2006	358,000 tons	685,000 tons	750,000 tons
Original estimate for 2006	800,000 tons	840,000 tons	1,000,000 tons
Sorting at source	Common, but differs per local authority/ region	Seldom, but increases, due to environmental awareness	General
How is paper collected?	Per household Public containers	Per household Recycling centres Local authorities	Per household Private containers Recycling centres

Table 1 Overview of Waste Paper Collection methods, by region

Especially the situation in Ile de France shows large room for improvement; perhaps applying the WPM formula could help to increase the amount of recoverable paper. In addition, the application of WPM can lead to a reduction in transport movements from and to the collection points and the processing plants. So in the end, less paper will find its way to the tip or the incinerator. In all cases these areas are promising for large scale WPM plants.

In short, in all the regions under discussion, there is a clear trend towards greater recyclability of household waste. The methods are, however, different. In Germany, the emphasis is put on sorting at the source, in London on sorting after collection, and in Paris it is somewhere in between. The quantity of recovered paper is considerable in all three regions.

RECOVERED PAPER AND CHINA

Trade between Holland and China has been growing steadily, but mainly one-sided. In 2004, a freight flow of about 500,000 TEU came from China to Rotterdam by container. These containers themselves have to be returned, and in practise that often means without any cargo. In 2005, almost 120,000 TEU went back to China empty (VOLLAARD, 7 July 2007). China has little interest in (Western) European end products, but is interested in its raw materials. Recyclable material, such as recovered paper, scrap metals and plastics are much in demand. In the Rotterdam Harbour Authority's annual report, these materials are described in the category "Other Bulk Goods for shipment to China". This category continues to grow each year. Recovered paper forms a major part of this trade. In 2000 Holland exported 100,000 tons of recovered paper to China. In 2007 this export had grown to twenty times that amount. According to the Central Statistics Office, half of it came from other countries than Holland. Measured in transport units, this amounts to

approximately 155,000 TEU. As a result, about one third of all containers returning to China are filled with recovered paper, and per volume, this constitutes Holland's largest export flow (ROTTERDAM HARBOUR AUTHORITY, 2008).
As said, at present about one third of all containers returns empty to China. This puts a limitation on the remaining available transport capacity for recovered paper to China. If the demand for this transport capacity continues to grow, the transport costs will increase proportionately. This will affect the attractiveness of trade using this route. However, if recovered paper with a higher value were to be shipped, these transports could still remain attractive. For shipping companies, the prices they can ask for transport from China to Rotterdam are higher than from Rotterdam to China. In case they are afraid of losing cargo to Rotterdam due to a container shortage in China, then they will not wait in Rotterdam for a return cargo, but will sail back empty instead.

CONCLUSIONS, RECOMMENDATIONS AND IMPLEMENTATION

The large conurbations in Western Europe all produce large amounts of wastepaper. Collecting recovered paper appears to be organized differently in the three studied regions. So, the creation of a consortium building on the WPM formula, will have to take place each in a different way in each region. However, there is clearly enough potential. When sorting paper of course, there has to be a certain amount of suitable raw material available in order to make an investment in WPM worthwhile. This is especially true for sorting at source. It would seem a good idea to conduct a break even analysis to see where the break even point lies.

China at least will continue to need raw materials, including recovered paper. At the moment, the profit margin on a ton of recovered paper is relatively low, and paper mills are vulnerable to price increases and decreases. A method to increase the added value of the product and thus lower the cost price of transport per unit of usable recovered paper can provide a positive stimulus to this trade. Another advantage is related to the fact that at present, two thirds of all containers leaving Rotterdam for China are fully loaded, 50% of which now contain recovered paper. There is therefore little room for increased capacity, especially if shipping companies prefer to let a container return empty to China, than to lose a return cargo to Rotterdam with the associated loss of income. However, if the load has been sorted at the collection point beforehand, fewer containers are needed for the same amount of half products, meaning less mass of transport to China. Additionally, fewer lorries will be required to bring the loads to and from the harbours in Holland and in China. In this way, more usable recovered paper can be taken from a load than previously. It is not known how the sorting process takes place in China (if done at all), but in this way too we might prevent people there being exposed to dangerous methods and other risks.

Moreover, by separating mixed material, its re-use in Europe becomes more attractive, again leading to less transport within Europe, and possibly also to China. Both markets have potential and in both cases WPM will reduce transport movements, and waste will be processed more efficiently. In short, WPM can lead to a shift in the chain in favour of environmentally friendly solutions: processing at the source, more effective transport to China etcetera. It is important not to lose any time and to demonstrate that the concept is viable by means of example projects so that it can be set up and anchored as a hub in the paper industry network. Effort should also be made to change the patterns and structures within the chain. For this reason cooperation within Transumo between the private sector and other organizations in an open framework will be encouraged.

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SUSTAINABILITY IN LOGISTICS PRACTICE

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ABSTRACT

This conceptual paper wants to emphasis the use of the concept of sustainability within logistics and especially transportation. While working on a new tool to help companies develop sustainable European networks, we discovered that we wanted to use a specific concept of sustainability: People, planet and profit. This paper will first discuss the main concepts of sustainability and show a tool which could aid decision makers in the choice between networks in Europe. We will show that making the results of network possibilities visible will aid these decision makers and show the implications on sustainability.

INTRODUCTION

Effectiveness and cost reduction have always formed the main focus within logistics, and perhaps always will be. But next to these well known focus points, society demands more from all branches of industry. Aspects like sustainability have become en vogue especially since Al Gore's *An Inconvenient truth* (GORE 2006) reached a universal audience. Whatever our personal views on these aspects, sustainability will be one of the aspects on which the performance of an industry will be judged. Logistics has become aware that it should cope with demands on sustainability as well. Was earlier sustainability something done by individual companies, now measures to make logistics more sustainable have emerged with an emphasis on transportation.

To understand what logistics should do in order to become more sustainable, a clear cut idea what it implies is needed. But the concept of sustainability has many connotations. Some authors have recognized over fifty different definitions (PEZZEY 1997). Too much for intellectual comfort and a clear sign that a worldwide general recognized definition is still lacking. Still All definitions pay homage to one of the best known definition as given by the Brundtland Commission (WORLD COMMISSION 1987) which states that:

"Sustainable development meets the need of the present without compromising the ability of future generations to meet their own needs"

This definition however does not give any clue how to achieve and measure sustainability. For transportation this lack does not help to monitor her contribution towards a cleaner environment. This could cause trouble as links have been laid between the emission of gases and global warming. United Nations Conferences like Kyoto in 1997 tried to get countries to restrict these emissions. Under the Kyoto Protocol the European Union (the EU-15) committed to reduce greenhouse gas emissions by 8% by 2012 compared to 1990. More recently the European Heads of State and Government (EU-27) decided to reduce greenhouse gases by up to 30% by 2020. They also established targets of 20% renewable energy and 20% energy efficiency to be achieved by the same date.

TRANSPORTATION MADE GREENER

With all government attention focused on these gasses, it should not come as a surprise that also logistics concentrates on reducing truck exhaust. This includes emission reductions of Carbon Dioxide (CO2), Nitrogen Oxides (NOx) and particulate matter (PM), which pose the most serious health problems. In December 2007, the European Commission proposed to reduce emissions from heavy-duty trucks and buses by 80% for NOx and 66% for PM compared to the current standard caps on pollutant emissions. The Euro standards are part of a broader EU strategy on clean air, which aims to reduce illness and related health costs, like premature deaths related to pollutant emissions. From 1 Jan. 2014: the regulation emission limits will apply to new heavy goods vehicles. The registration, sale and entry into service of vehicles that do not comply with the standards will be prohibited (EU 2008).

In some countries restrictions have been set to prevent polluting cars to use certain areas. As for instance in Germany where whole regions as e.g. the Ruhr Area, Cologne and Berlin have been turned into so called Umweltzonen or “Environmental Areas”. In these areas all cars are obliged to carry a label which indicates how far a car may penetrate an area. Local councils may refuse entry of certain labels within their own jurisdiction. At present, all trucks which want to deliver goods in these areas still are excluded from this restriction, but after September 2009 all exceptions require a special permit. Failing to meet these regulations will be penalized with a fine of €40 euro and one point in the Flensburg register. All German traffic violations are with certain points and when the total amount reaches 18 points, the driver licence will be revoked.

With governments, local, national and European, concentrating on the reduction of emission, it should not come as a surprise to find that most Logistic Service Providers (LSP) have opted for solutions in this field. These options can be split into four categories:

1. Cleaner cars
   - Modern trucks have become much cleaner as engines are designed to produce less exhaust. For instance Scania P-, R-, and T-series have a 12-litre Euro 4 engine that features emission reductions of NOx by 30 percent and by 80 percent of particulates compared with Euro 3.
   - Soot filters can help to reduce the emission of soot and particle dust. DAF trucks for instance promises that her trucks can get 50% fewer particulates by equipping the Euro 5 engines with a passive soot filter, particulate emissions can be further reduced by up to 50% to a value of around 0,015 gram/kWu.
2. Fuel
   - Truck engines are designed to be fuel efficient thanks to improved aerodynamics, smarter control of engine auxiliaries as well as lighter trucks
   - Biofuel like rapeseed derived biodiesel (RME) generates less emission as compared to petroleum diesel. Policymakers would like to see more biodiesel being used. The EU wants to increase the use of biodiesel from 2 percent now to 5.75% of all transport fuels by 2010. The goal is to increase this to a 10% share in 2010.
3. Mileages reduction
   - This can be achieved by:
     - full truck loads, less empty vans will be using the roads;
     - placing shipments to the same destination in one truck. This implies coordination between partners and even between potential LSP competitors;
     - getting cargo for the return trip;
     - getting bigger trucks like the LZV. In 2004 the Langere en Zwaardere Vrachtautocombinatie (Longer and heavier freight combination) or LZV has been introduced in the Netherlands. The LZV can be compared with the Road Train from Australia. An LZV or Ecocombi has a maximum length of 25,25 meter and weights 60 ton. A normal truck has a maximum length of 18,75 meter and the maximum weight for the Netherlands is 50 ton. As the volume increases but the fuel use remains almost the same, the fuel use can be 4 till 30% lower

		compared to a conventional truck The Dutch government wants to gain more insight into the pro's and con's of using an LZV and is expected to make a final decision in 2012.
4. Alternative modes	•	Trucks are flexible but not the only way of getting something shipped. More modes are available. Transportation by water could be good alternative for road transport. Planes have the advantages of speed, but fail in emission.

It is not easy to compare all these aspects with each other as some have hidden costs. For instance comparing biodiesel with petroleum diesel should also include the emission generated during production of the fuel. Petroleum diesel emits 85% of its greenhouse gases at the final stage, when burnt in the engine. By contrast, two-thirds of the emissions produced by biodiesel occur during farming of the crop, when cropland emits nitrous oxide (N_2O), that is 200-300x as potent a greenhouse gas as CO_2. Another example: during the last decade new truck engines have been developed which have made them cleaner compared to rail and water.

OTHER WAYS TO LOOK AT SUSTAINABILITY

Just looking at the effects during transportation is evidently not enough. Measuring the carbon footprint could be of help here. The carbon footprint is a measurement of all greenhouse gases we individually produce and has units of tons (or kg) of carbon dioxide equivalent. This includes the primary footprint from direct emissions of CO_2 from the burning of fossil fuels and the secondary footprint or the indirect CO_2 emissions. These are connected with their manufacture and eventual breakdown like for instance the recycling of trucks. Some companies have tried to make this carbon footprint visible to its partners. Mars Food BV for instance will put the CO_2 emissions generated by a delivery on the shipment papers (JORRITSMA 2009). They hope it will have an impact on customer order behavior.

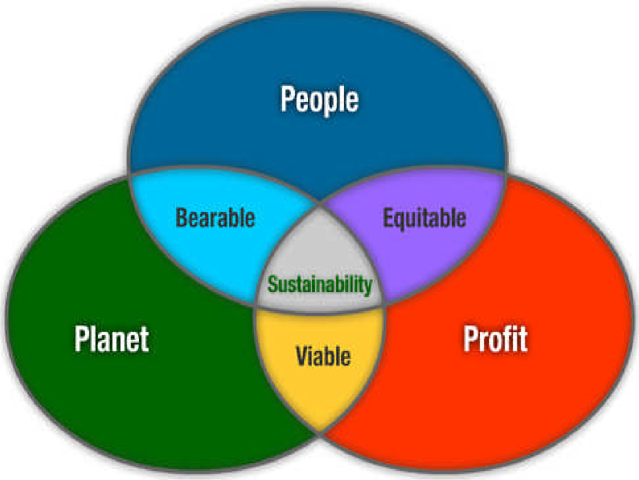
An interesting concept is Cradle-to-Cradle (C2C). C2C places sustainability in a very different setting. According to C2C (MCDONOUGH AND BRAUNGART 2002) the old idea of sustainability as explained above is wrong. It simply implies that you want to limit the negative aspects but not consider whether it all could be avoided. According to C2C it should be a circle. Whatever you put into a process should once been used, be used again and again. The old fashion way of recycling by turning waste in lower grade material should be changed into higher grade material.

For transportation, requiring to overcome friction and using (fossil) fuel, this aspect alone will be reason enough to have sincere doubts whether it will achieve this goal. For concepts like transportation may even seem more far fetched or perhaps unattainable. An additional problem is that it implies that all links in the chain will have to work together to ensure that all waste generated in this chain is upgraded when recycled. Funny enough McDonough and Braungart even use transportation as an example where once C2C almost was achieved. They state that in the time of tall ships wind provided the energy and trees the material for building the ship. The wood would disintegrate and the circle would be made complete. They apparently have not considered the effect of ship building on the environment at that time. The construction of the Great Armada in 1588 required huge quantity of prime timber. For this whole areas of Spain were deforested and still show the scars today.

When all partners: logistic service providers, shippers, governments and other stakeholders all seem to hold different ideas about what sustainability means and how it can be achieved. How can we ever achieve an agreement on this issue? For this we would like to use the approach as given by the concept of People, Planet and Profit (PPP). PPP wants to consider all aspects which could influence a decision on sustainability. Innovators and initiators are often people that develop business plans based on a vision and concept. In order to develop the provisioned new supply chain, it is necessary getting the board and / or external investors prepared to make, sometimes very large, investments. That requires an acceptable Return on investment (ROI), both on an economical and strategic level. That in many cases asks for pre-cost calculations.

Funds from authorities may help to overcome start-up costs, but also these funds always ask for quantitative underpinnings of the plans, and quantitative insight in the predicted benefits of the new supply chain (external costs, regional development etcetera). So, pre-calculations of both market costs and external costs (people, profit, and planet) in many cases are necessary as a support to new sustainable supply chains and networks that are started up by companies.

Figure 4 The three P's: circles of influence



It is this aspect that the Transumo wants to promote. Transumo (TRANsition SUstainable MObility) is a foundation founded in 2004 by the Dutch Government to find new ways of making the Dutch transportation sector more sustainable. They want to help companies build up their European Networks, by offering a set of tools that not only focus on gaining efficiencies and effectivities, but also help them to find radical new solutions, also in terms of sustainability. The goal should be to improve competitiveness within Europe and the world of the Dutch transport sector ('Profit') and to preserve and improve spatial and ecological ('Planet') aspects of mobility, while at the same time improving the social working conditions ('People').

EUROPEAN NETWORKS MODEL

One of the themes within Transumo is to develop a tool to aid medium sized companies (SME) when building up their Supply Chain Networks. These tools should look at new approaches to use networks differently, looking for alternative forms of modal transportation and allow a glance in the situation in the (near) future by setting up new European networks.

The results of European Networks model should be to help companies build up their
European Networks, by offering a set of tools that not only focus on gaining efficiencies and effectivities, but also help them to find radical new solutions, also in terms of sustainability. The European Networks model should fit in with Transumo's mission to accelerate and/or encourage this necessary transition into a renewed mobility phase. This transition should lead to improvements that will strengthen the economy. This model should become operational at the end of 2009.

The general assumption in model building is that the end-users – say in our case logistics managers – will be convinced by quantitative arguments. Knowing that a given alternative solution will raise efficiencies substantially, would be enough argument to convince logistics managers and their board, is the general feeling. In business practice this does not always appear to be the case. Although we are convinced that modeling can be a helpful argument, we set ourselves the question whether any other tools might be of help as well for companies in order to get a breakthrough in building up a European Network... In certain circumstances for example tools that help companies in guiding cooperation better, might be more fruitful than any other tool. Because, failures in inter-firm cooperation processes range between 60-80 percent of all cooperation project. That is a lot. And then, cooperation supporting tools might be very effective. In other cases companies may be better off by making scenario studies; in general transport companies are not used making scenario studies. In fact that is strange because most transport companies are extremely dependant on their environment, and in such cases scenario tools are the best tools, we believe. Can we help them with a dedicated scenario-tool, was the question we posed ourselves.

Most Anglo-Saxon models assume that relations in principle are linear, and boil down to costs. At the same time intermodal opportunities do not have a high priority in traditional modelling, nor do PPP-objectives. So we decided to build a model – or at least a set of tools, that is different in these aspects. That means, a model that is able to deal with irregularities – suppose, for example, that a planned transport flow has to pass another terminal that expected within the corridor Rotterdam - Ruhr – Russia. We opt as well for a multi-layering model, on the one hand operating on an international scale, and on the other side offering 'simple' lane-calculations.

The goal of the model is to be a really helpful tool for companies, that offers them insights in the opportunities of different modalities, keeping sustainability in mind. The model should help policy makers as well in judging companies in terms of sustainability, position within international Supply Chains, corridors, and opportunities for intermodal and energy friendly transport. The goal of the model is to be a really helpful tool for companies, that offers them insights in the opportunities of different modalities, keeping sustainability in mind. The model should help policy makers as well in judging companies in terms of sustainability, position within international Supply Chains, corridors, and opportunities for intermodal and energy friendly transport.

THE STRUCTURE OF THE EUROPEAN NETWORKS MODEL

The European network Model has a simple frame. It consists of three independent tools which can be used to support each other (WEIJERS 2009). These tools were:

1. A calculation tool for distances and possible alternative modes. The user can give his starting point and the location of his clients. The tool will generate a visual overview of the route by the chosen mode and also make visual the various alternative using modal shift and alternative modes like river barge, short sea or train. If the user has given his financial data, he can see not only the effects on the environment and lead time, but also the costs.
2. The scenario tool (SCHWARTZ 1991) is for allowing the user to simulate possible situations for himself, the customer, partners and/or other departments. Using a step by step method the user will be guided to make a scenario, determining for himself the key drivers and learn to use his imagination. This could be a great tool to help logisticians to think "out of the box".
3. And finally the cooperation tool. Supply chains are made and broken by the quality of the partners in this chain. Mismatches between links in the chain could hinder the effectiveness and efficiency of the whole operation. With this tool the user can fill in a questionnaire and determine whether a mismatch might exist and suggestions are generated for improvement.

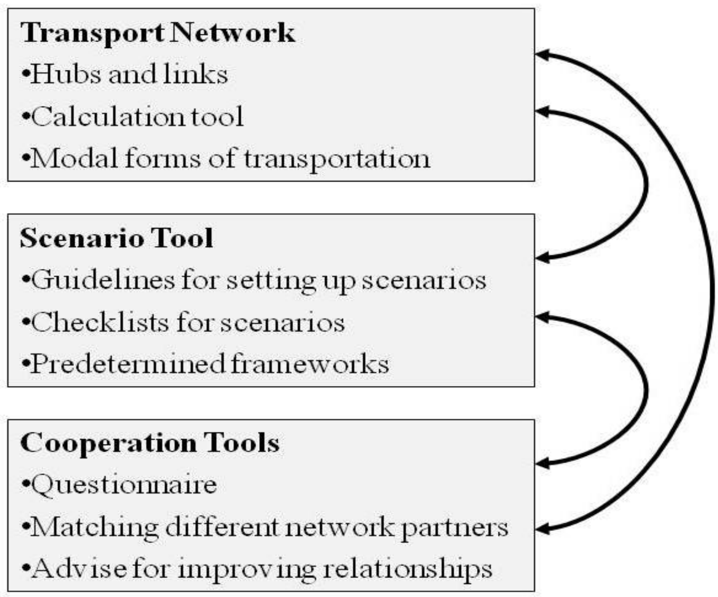


Figure 5 the layout of the European Networks model

The result of the model is to get an overview of what consequences a scenario would have on aspects like speed, costs and emission as is shown in the two figures below:

Figure 6 result scenario minimal distance

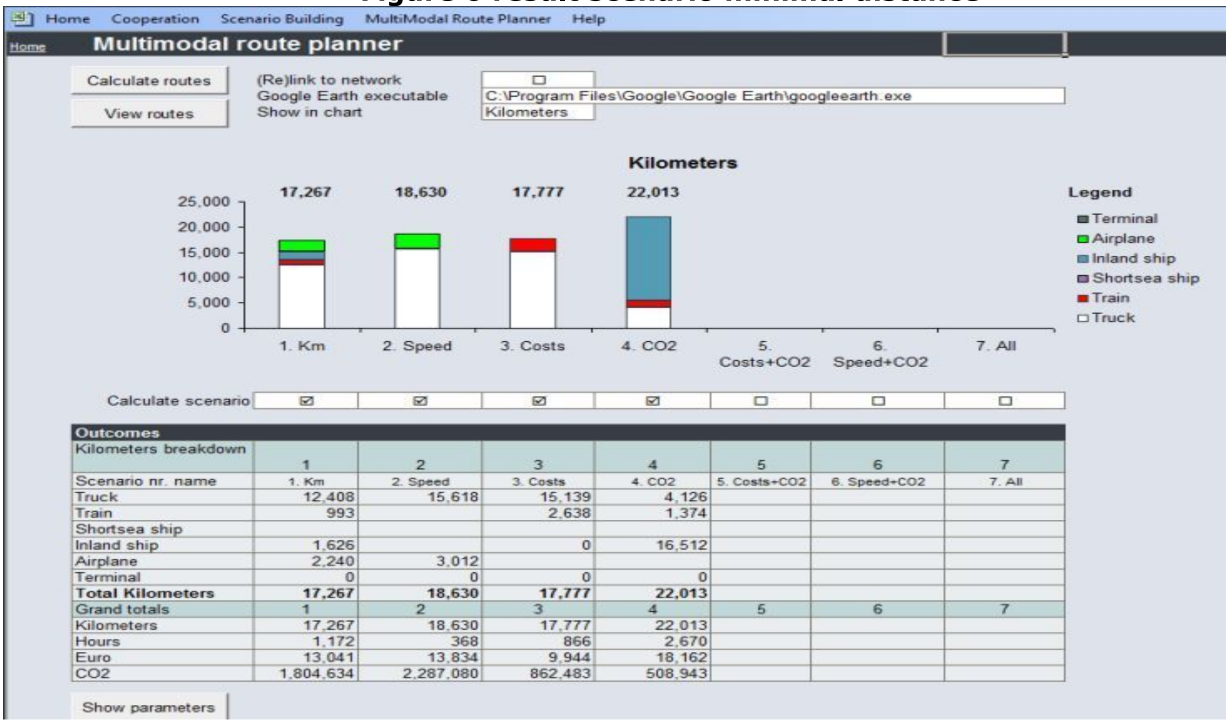
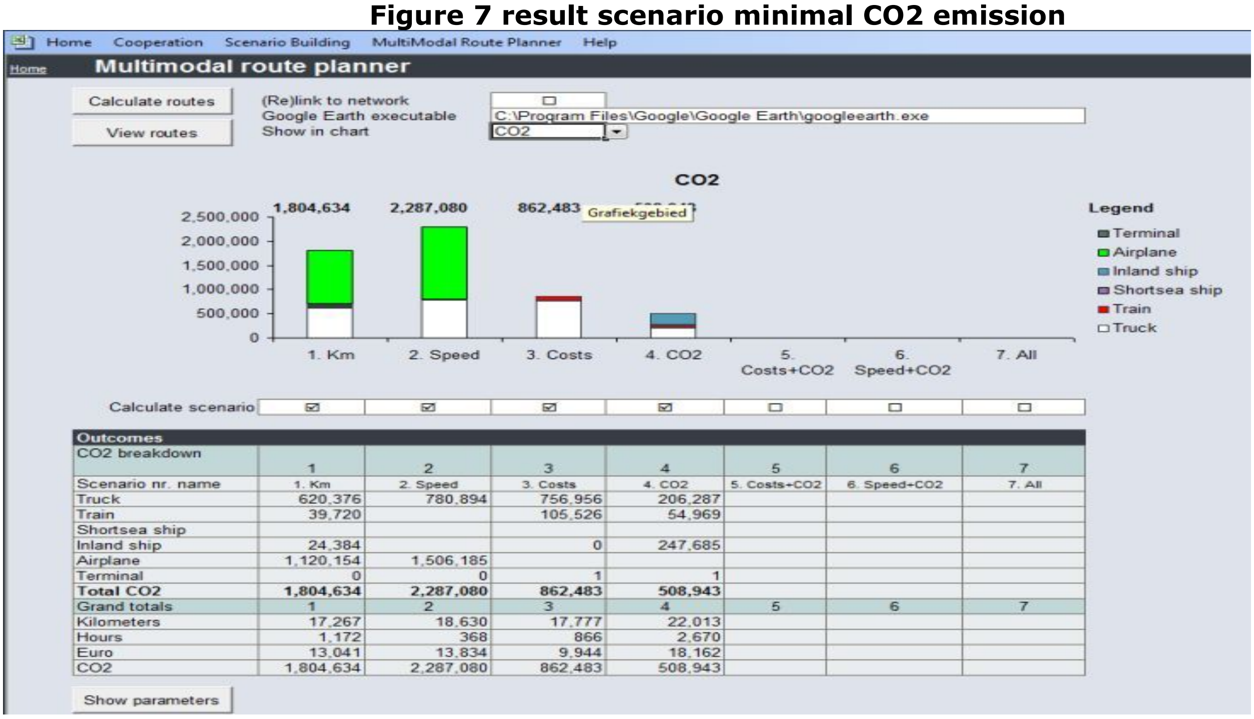
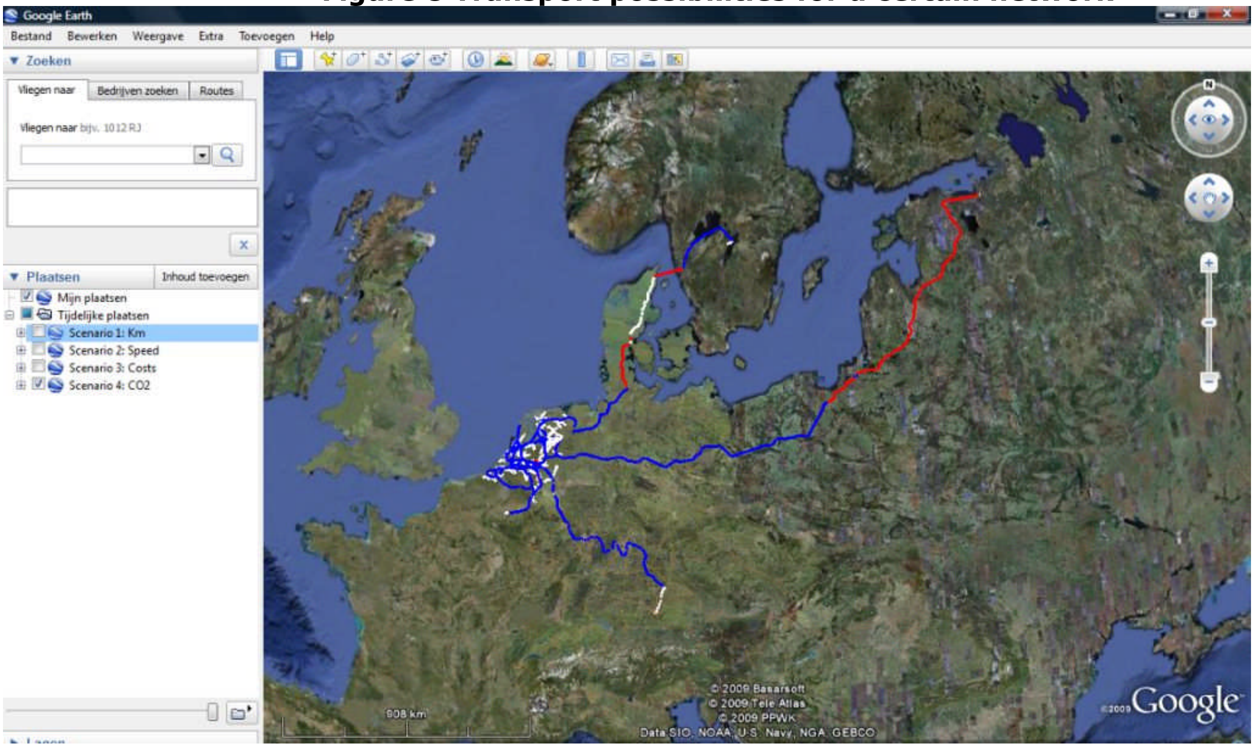


Figure 7 result scenario minimal CO2 emission



By defining different scenarios and applying correct data an idea of what could be done and which consequences it would have are made visible. All possible road, water, rail and some air links form the basis to calculate the various networks. As a result the various possible modes of transportation can be made visible in Google Earth:

Figure 8 Transport possibilities for a certain network



CONCLUSIONS AND RECOMMANDATIONS

Transportation will have to put sustainability high on its agenda without forgetting what its main tasks are: being efficient and generating profit. Looking at aspects like fuel use or emissions alone will not be sufficient. A decision on sustainability (Planet) should also be financially sound (Profit) as well as being supported by the stakeholders (People).

The European Network tool makes implications of choices visible and should help decision makers to decide how to setup a European Network. Not just on aspects like costs but also on aspects like sustainability with a well balanced chain to support it. Understanding the impact of sustainability on such a situation should helps decision makers to make the right choice. With this model LSP can understand better how he will be able to serve social aspects like sustainability without losing touch with the (financial) reality. The scenario tool in the model allows the user to image possible futures and consider possible actions.

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SELECTION OF SUITABLE METHOD AND LOCATION FOR MUNICIPAL WASTE DISPOSAL IN CHIANG MAI AND LAMPHUN PROVINCES

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ABSTRACT
The aim of this study is the selection of the suitable method and site for municipal waste disposal in southern Chiang Mai province and some parts of Lamphun province by screening subjects using the Analytical Hierarchy Process (AHP) and the Geographic Information System (GIS).

From this study, the sanitary landfill method was the best solution with the highest overall evaluation score of 0.604. The result indicated that the ranking important of primary criteria were the economic and social, environmental and technical aspects, respectively. The result by initial screening and prioritization on sanitary landfill site selection found that, for Chiang Mai, province the sanitary landfill site of Ban Tan sub-district, Hot district was the best option with the highest overall evaluation score of 0.220 and, for Lamphun province, the site of Sri Bua Ban sub-district, Muang Lamphun was the best alternative with the overall evaluation score of 0.156. In the selection step, the result indicated that the most important primary criterion was public acceptance aspect. The other significant criteria were economic, physical, and functional impact aspects, respectively. AHP and GIS which are the systematic applications for the decision making process are found suitable for this study. This evaluation alternative provided convenience, accuracy and reliability because it considered the consistency ratio of evaluation criteria and geometric mean of expert group.

Keywords Municipal Waste, Location Selection, Analytical Hierarchy Process (AHP), Geographic Information System (GIS)

INTRODUCTION
Solid Waste Problem is the main problem occurs everywhere in the world. All activities are done by human cause solid waste generation and have an effect on environment. In general, the development of a country and the waste problem are always converse. The total size of Chiang Mai and Lamphun province is 24,613 square kilometers approximately. In the last two decades, this site was extended and had many changes such as population, education, society, business, and industry. Each activity can cause the large amount of waste problem in cities if the solid waste management is inefficient. With reference to the report of Regional Environment Office 1 (Chiang Mai): The State of Environmental Quality in Chiang Mai Upper Watershed, 2006, found that nowadays the amount of municipal waste production rate is 0.7- 1.2 kilograms per person and per day. The amount of solid waste is 552.4 tons per day but the reused rate is only 18.5 percents. The main logistics problems are the problem of locations for municipal waste disposal need to carry a large number of solid wastes, problem of lacking of another suitable, and problem of providing suitable loading size of trucks to give a thorough service of waste collection. Furthermore, the inadequate number of trucks, the improper size among truck size, the width of road and distance service cause the problem of solid waste collection and transportation.

Therefore, the objective of this research is to select the method and location for municipal waste disposal in a case study site by applying the technique of the Geographic Information System (GIS) and using the Analytical Hierarchy Process (AHP) to make a decision.

THEORIES AND RELATED RESEARCH

In this research, there are two related theories. Those are solid waste management by using varieties criteria of decision making process and Geographic Information System for location selection.

The first theory, in a part of solid waste management found that solid waste problem is a serious environmental pollution problem which is more harder. The principle problems are inefficient solid waste management system, technical problem, lacking of equipment for solid waste collecting, lacking of waste disposal site, and limited budget. (S. Karnchanawong et al., 1990). Chiang Mai Municipality is confronting with the problem of uncertain waste disposal location and increasing number of wastes which is the responsibility of Chiang Mai Municipality and also the expense of waste disposal for different kinds of waste (S. Karnchanawong et al., 1990). There are three types for waste disposal system. Those are sanitary landfill, composting, and incineration. (Janya Jaiyen, 1997)

The second theory is the selection of proper location by applying the Analytical Hierarchy Process (AHP), which is the common used process, to solve the problem and making decision. For example, this process is used for analysis a factor of location, then evaluating the alternative of emplacement and finally indicating the selection of location as a way for organization to improve the proper emplacement to suit to any changing condition and situation (Yang and Lee, 1997). Moreover, Analytical Hierarchy Process (AHP) was used for such as a selecting the location of industrial estates for the Tak (province) economic border area (Apichat S. et al., 2006). Many researchers used the GIS to analyze different kinds of problem, such as providing the appropriate site for the sanitary landfill of Sanitation District 7 in Mae Sai, Mae Jan and Chiang Saen District, Chiang Rai Province, based on location selection criteria of both domestic and international institutes (Boonlue, 1998). The GIS was a primary tool for selecting the sanitary landfill location in Chachengsao Province considering from physical factors by giving score. The score is set from the entire score. The site which has the highest overall evaluation score is the maximum potential site. (Boonruang, 2001)

Moreover, there was another research which applies the GIS with solution and ambiguous decision to find the appropriate location for a city sanitary landfill in Texas, the United States. The process of GIS was run by sorting undesirable sites out of the land first. There were some ambiguous criteria, so, it needed to convert the ambiguity to be numeric value by using the method of Triangular Fuzzy Number, and then it would be calculated. Finally, the appropriate site was discovered (Chang and others, 2008).

RESEARCH PROCEDURE

The research aims to select the location for municipal waste disposal. The sanitary landfill is the most appropriate way (N. Boonpermpoon, 2008). There are two main procedures in the research as shown in figure 1.

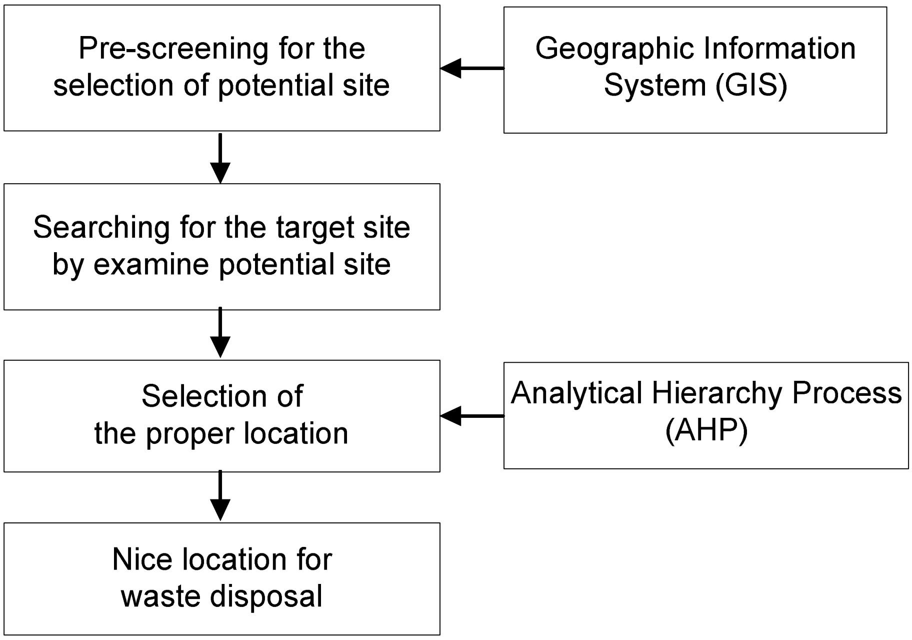


Figure 1: Research Procedure

Pre-screening for the selection of potential site and target location
It was found that to do the site pre-screening by using the GIS to analyze, must have basic information for analysis in the form of Layer and prepare the basic physical information such as topographic map, surface water resource, ground water resource, geology, soil units, forest, land use, watershed class, community, conservation areas. Then, the selection of the proper size of waste disposal site must accord with the increasing number of population and wastes in the future. However, it depends on the selection of the suitable location for waste disposal in the first step.

Research and observe a potential site to collect information and check over the screening information whether it is true. Then, define it to be a target site.

The selection of the suitable location from the target site
To study the way and to analyze the criteria of location selection, the target site will be ranked the importance by AHP again in order to find a suitable site. The influential criteria of the location section are the suitability of physical condition of engineering, economy, society and environmental impacts. There is a survey and interview the experts and related people who involve in municipal waste management. To calculate the weight score of site selection criteria is similar to the calculation of the weight score of waste disposal selection criteria in the first step.

THE RESULT
The results of study can be divided into two steps. Those are the result of site pre-screening by using the GIS and the result of the selection of waste disposal site. As below:

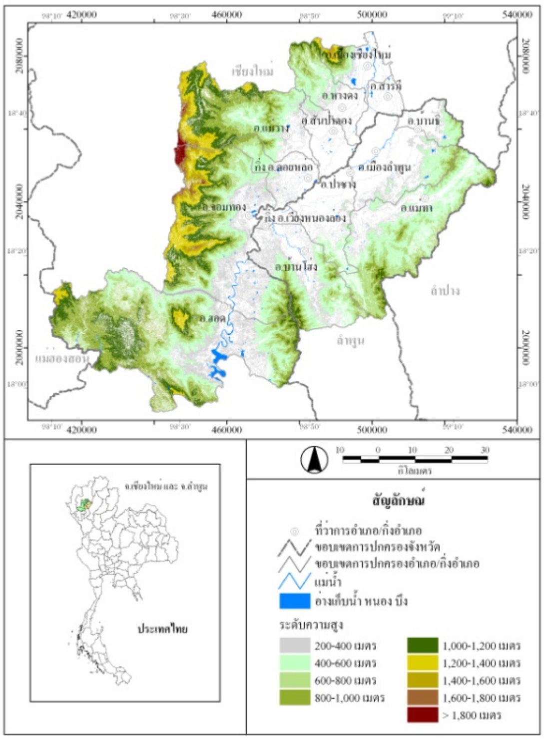
The result of the selection method of waste disposal site
From the selection method of proper waste disposal in the studied sites; criteria structure and the weight score were defined by related branch experts (see table 1). The sanitary landfill is the most appropriate way which the overall highest score is 0.604. The major criteria for determination are economy and society. The secondary criteria are environment and technical term respectively.

Table 1: The weights of criteria for the AHP methods

Main Criteria	Sub Criteria	Weight
Technical Factor (F1)	Physical condition of the area (f11)	0.022
	Geology (f12)	0.035
	Water Level (f13) –Meter	0.041
	Distance between community (f14)-Km.	0.083
Economic and Social Factor (F2)	Transportation (f21)	0.061
	Public Utility (f22)	0.097
Environmental Factor (F3)	Land price (f31)- Baht/wah^2	0.025
	Carriage (f32)- Baht/Ton	0.093
	Construction cost (f33)	0.078
	Community attitude (f41)	0.401
	Official attitude (f42)	0.064

The result of pre-screening by the GIS

According to the basic physical propriety in selecting the potential site for sanitary landfill, it is possible to use the layer for spatial analysis by GIS. There are 7 layers. Those are forest, watershed class, land use, surface water resource, artesian well, and conservation areas. In Chiang Mai and Lamphun the sites which passed screening process are 5 places and 7 places respectively (see figures 2 and 3).



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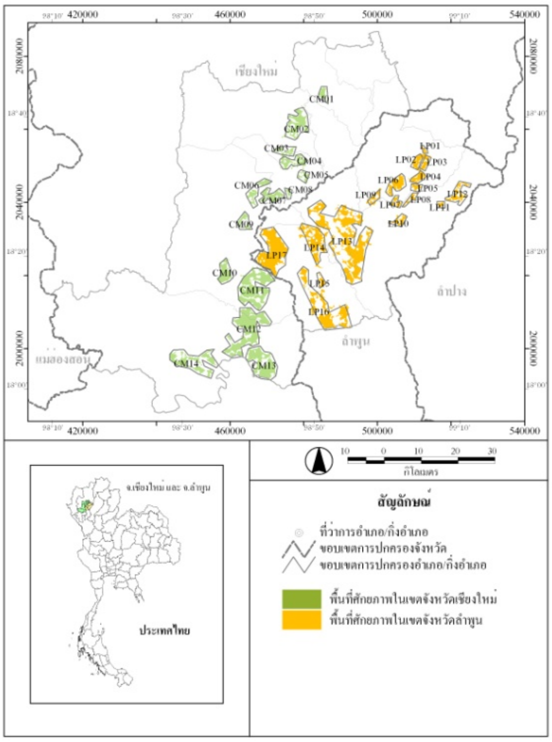

Figure The

research area Figure 3: The site for selection

The result of appropriate site selection of waste disposal

The AHP approach is applied to the appropriate site selection by comparing alternative space in pairs individually. Then, examine the index of consistency of analysis and find out the appropriate score of each alternative as the following process.

- o Examine the decision making matrix in individual criteria and do normalization in each matrix column.

- Calculate the preference score of each alternative by the average of the score in each row. And present the preference score of each alternative in individual criteria.
- Calculate the suitable score for all alternatives of each criterion by comparing the suitable score with the importance of each factor. The result from calculation the preference score of the alternative and select the alternative that has the most score

The result of determination of the relative important of particular criteria and the result appropriate site selection are considered from four main criteria and eleven sub-criteria of the appropriate site screening for Chiang Mai (see and example in table 2).

Table 2: The result of synthesis in the form of number after the evaluation target site in Chiang Mai under variety of criteria

Criteria	Weight	Selection of Location for Municipal Waste Disposal in Chiang Mai									
		CM02		CM05		CM10		CM12		CM13	
		Rating scale	Score	Rating scale	Score	Rating scale	Score	Rating scale	Score	Rating scale	Score
F11	0.022	L	0.3	L	0.3	M	0.5	M	0.5	M	0.5
F12	0.035	L	0.3	L	0.3	M	0.3	Low	0.3	L	0.3
F13	0.041	5		10		15		11		12	
F14	0.083	2		1.5		1.5		2		2	
F21	0.061	M	0.5	VH	0.9	M	0.5	H	0.7	M	0.5
F22	0.097	M	0.5	H	0.7	M	0.5	M	0.5	L	0.3
F31	0.025	1250		625		500		500		500	
F32	0.093	54.98		61.22		128.29		140.78		164.18	
F33	0.078	E	1	E	1	E	1	E	1	E	1
F41	0.401	L	0.3	L	0.3	L	0.3	M	0.5	M	0.5
F42	0.064	L	0.5	M	0.5	L	0.3	M	0.3	L	0.3

Remark: L=Low, E=Equal, M=Medium, H=High, VH=Very High

The site of Ban-Tan sub-district, Hod district was the best option with highest overall evaluation score of 0.220 and Lamphun province the site of Sri Bua Ban sub-district, Muang Lamphun was the best alternative with the overall evaluation score of 0.156 as shown in table 3 and 4.

Table 3: The result of evaluation of target sites in Chiang Mai under variety of criteria

Criteria	Weight	CM01	CM05	CM10	CM12	CM13
Physical condition of the area (f11)	0.022	0.006	0.006	0.003	0.003	0.003
Geology (f12)	0.035	0.007	0.007	0.007	0.007	0.007
Water level (f13)	0.041	0.004	0.008	0.012	0.008	0.009
Distance between community (f14)	0.083	0.018	0.014	0.014	0.018	0.018
Transportation (f21)	0.061	0.010	0.017	0.010	0.014	0.010
Public Utility (f22)	0.097	0.019	0.027	0.019	0.019	0.012
Land price (f31)	0.025	0.002	0.005	0.006	0.006	0.006
Carriage (f32)	0.093	0.031	0.027	0.013	0.012	0.010
Construction cost (f33)	0.078	0.016	0.016	0.016	0.016	0.016
Community attitude (f41)	0.401	0.063	0.063	0.063	0.105	0.105
Official attitude (f42)	0.064	0.017	0.017	0.010	0.010	0.010
Total	**1.000**	**0.193**	**0.207**	**0.173**	**0.220**	**0.207**
Raking		**4**	**2**	**5**	**1**	**2**

Table 4: The result of evaluation of target sites in Lumphun under variety of criteria

Criteria	Weight	LP02	LP03	LP04	LP06	LP07	LP15	LP17
Physical condition of the area (f11)	0.022	0.007	0.003	0.002	0.001	0.007	0.001	0.002
Geology (f12)	0.035	0.001	0.003	0.006	0.008	0.003	0.008	0.006
Water level (f13)	0.041	0.004	0.005	0.005	0.004	0.005	0.009	0.008
Distance between community (f14)	0.083	0.012	0.008	0.008	0.012	0.012	0.012	0.017
Transportation (f21)	0.061	0.006	0.009	0.009	0.006	0.011	0.009	0.009
Public Utility (f22)	0.097	0.004	0.018	0.025	0.011	0.025	0.004	0.011
Land price (f31)	0.025	0.003	0.003	0.003	0.003	0.003	0.005	0.006
Carriage (f32)	0.093	0.022	0.017	0.019	0.017	0.009	0.005	0.006
Construction cost (f33)	0.078	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Community attitude (f41)	0.401	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Official attitude (f42)	0.064	0.011	0.011	0.011	0.011	0.007	0.007	0.007
Total	**1.000**	**0.140**	**0.145**	**0.156**	**0.141**	**0.152**	**0.128**	**0.138**
Raking		**5**	**3**	**1**	**4**	**2**	**7**	**6**

CONCLUSION AND SUGGESTION

The result of this study consists of pre-screening by using the Geographic Information System (GIS) and selection of appropriate location for waste disposal by applying the Analytical Hierarchy Process (AHP) as a tool in making decision.

The outcomes were screened by the GIS in order to find the site by analyzing the data of forest, watershed class, land use, surface water resource, artesian well, and conservation areas. The reason was to exclude the inappropriate and undesirable sites. Moreover, some sites had to be excluded because the problems of area access, area condition, and land use caused the inconvenient construction in the future. This made the limited numbers of appropriate sites in Chiang Mai to be only five and in Lamphun to be only seven.

In screening the appropriate site is considered from the criteria of public acceptance aspect, the highest overall evaluation score was 46.5%. The secondary criteria were economy, physical term, and facilities, the scores were 19.7%, 18.1%, and 15.7% respectively. The result by prioritization on sanitary landfill site selection found that Chiang Mai province the sanitary landfill site of Ban Tan sub-district, Hod district was the best option with the highest overall evaluation score of 0.220 and Lamphun province the site of Sri Bua Ban sub- district, Muang Lamphun was the best alternative with the overall evaluation score of 0.156.

In selection of location for municipal waste disposal, the folks' perspective is very important and easily offended. It is the key factor to make government policy successful or failed. Even though having the appropriate site and location is an excellent outcome, the process will be not successful if it is out of people acceptance. According to the limitation of working time in collecting public poll, the best thing that the research can do is to investigate the community chiefs' opinion in the local areas and the opinion was represented as the complete data of community. If there was any profound study about folks' perspective to make a public hearing, it would make a large numbers of sample group, then, the data and the result of research would be reliable. This research will be advantage for both government sector and people in society because it involves to the quality of life. The result of research will accompany with government work henceforth.

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RO-RO SERVICE AS A CONTRIBUTION TO GREEN LOGISTICS

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ABSTRACT
This paper presents the findings from an analysis of the Sea-Road project. The project details were scrutinized, the promoters were interviewed in order to collect qualitative information and understand the reasons behind the failure of an apparently viable project which used a greener approach to transportation issues.
The findings show that, although the market analysis strongly indicated there was a real demand, external factors contributed to a surprisingly utter failure of said project. Timing, global economic conditions, such as fuel shortage for instance, the sector's capital-intensive characteristic, poor awareness of the potential added value of SSS service, the structure of the first edition of the Marco Polo Programme in itself, among others proved to be key in the process that led to the project termination.
This paper tries to highlight the reasons for the project failures and, based on the current state of affairs, hopes to contribute to a better understanding of the issues raised by alternative transport modes, namely Ro-Ro Transport Solutions as a contribution to a greener logistic.

Keywords: Ro_Ro solutions; Green Logistics; Inter-modality.

1. INTRODUCTION

This paper presents the Sea-Road project which focused on a multimodal Ro_Ro (roll-on, roll-off) solution, integrating DTD transportation service combining sea and road, based on trailers travelling weekly on regular sea freight between the ports of Leixões (PT), and Liverpool (UK). The road routes from which freight was shifted, by the offer of a port-to-port sea transport service from Portugal to the UK and back, avoiding the in-transit crossing of lorries, were in Spain and France. The Sea-Road integrated service promised to more competitive and greener than the existing road transport solution.

Sadly the project failed, but the findings can be used in future as a contribution to a greener logistics. The rest of the paper is organized into five sections: Section 2 introduces green logistics concept; Section 3 presents EU transports policies and a brief description of intermodal transports and their importance to EU environmental and transport policies; Section 4 presents the Sea-Road case. The conclusion presents the findings of the Sea-Road case and our contribution to green logistic.

2. GREEN LOGISTICS

There has been much debate about green logistics over the past decade. The term emerged with the suggestion that logistics can be environmentally friendly (Rodrigue et al.,2001). Contemporary technical developments have improved cost, efficiency and reliability of freight and passenger transport systems. With the growth of trade volume, the environmental impact of transportation gained wide recognition and is at the core of sustainability issues.

The purpose of logistics is to reduce transportation costs and improve service reliability by reducing the threat of breakage or damage, inventories, and increasing flexibility and efficiency by reducing time flows. This is achieved by using the most polluting and least energy efficient transportation modes. The increase of road and air modes, translated into tons per km (tKm), is partially due to time constraints, increased flexibility of the manufacturing and retailing sector, and the globalization of trade flows. Door-to-door (DTD) services coupled with just-in-time (JIT) strategies,

vertical manufacturing disintegration and the use of technologies (ICT) in business activities such as e-commerce has changed the logistics paradigm, which is less than environmental-friendly.
Governments recognized this and several actions; political, regulations, funds, environmental responsiveness and education have been promoted in the past years. In addition, several logistics players and manufacturers with green awareness recognized that this can be used as added-value to the business and as competitive edge. Despite that, there are still some asymmetries northern and southern EU members in what concerns environmental issues.

Despite Portugal's privileged geographical situation, with a sea coast near a 1000 km long, and several ports, most of our imports/exports to EU countries is still done by road, across Spain, Pyrenees and Alps corridors, France, etc. The intermodal transport compared with road is more efficient (Ex. Short-sea-shipping (SSS) 85,2g of Co2/tonne/km against truck 104,5g of CO2/tonne/Km, (ADANE, 2009)). Although, huge investments have been made to develop intermodal platforms in recent years, they only represent circa 10% of the transported tons.

3.EU TRANSPORT POLICIES

Globalization and the EU enlargement to the eastern European countries have created new challenges for European transport. The freight transport competitiveness grew, as well as its negative impact on the environment.

According to KPMG International (2008), the transport sector is relatively less prepared for climate changes, despite of the perceived level of risk that it is exposed to, namely, the regulatory risk.

According to Eric Heymann, a transport analyst at Deutsche Bank Research, the transport sector is responsible for an average of 13% (IPCC) of global greenhouse-gas emissions, although different modes of transport contribute with different amounts. Air and road services are responsible for the highest emission of greenhouse-gas per kilometre. Other sectors, heavily dependent on transport, are in risk too. Highly aware of this, governments are increasing the cost of transport by taxing emissions.

This is much more relevant when the estimate is that the global logistics industry represents approximately EUR 5.4 trillion, i.e. 13,8% of the global GDP (EU – Freight transport logistics in Europe), and on average, logistics costs account for 10-15% of the final cost of the finished product.

The EU has shown concern about the greenhouse effect and gas emissions by producing regulations and legislation to put Europe firmly on the road towards becoming a low-carbon economy. If nothing is done, total road freight transport in Europe is forecasted to grow by about 60% by 2013. This will result in an additional 20.5 billion tKm per year across the EU 27 Members, which in terms of external costs, according to EU, would represent and additional EUR 1 billion per year. (EU commission 2004). This is an unacceptable scenario to the EU, and pro-active policies to promote inter-modality and transport by sea, as well motorways of the sea were put in to practice, but the results are far from the expected.

Inter-modality and Motorways of the Sea

EU Commission defined inter-modality as "a characteristic of a transport system whereby, at least two different modes are used in an integrated manner in order to complete door-to-door (DTD) transport sequence". With only one B/L, national and international transport using different kinds of transportation in sequence is made easier. Inter-modality combines different technologies into a unified transport process where transhipment time and cost are substantially reduced through an extensive standardization (Roson and Sorini, 2000).

According to the EU, the "motorways of the sea" are a sustainable and competitive alternative to land transport; they introduce new more commercially efficient intermodal maritime-based logistics chains in Europe. In 2003, four corridors were proposed by the EU: 1. Motorway of the Baltic Sea; 2. Motorway of the Sea of Western Europe; 3. Motorway of the Sea of south-east Europe; 4.

Motorway of the Sea of south-west Europe. The EU target is to have a complete Network of Sea Motorways spread all over Europe by 2010.

The EU first set up the Marco Polo Programme to financially support Intermodal business initiatives. For the set-up period (1 January 2003 to 31 December 2006), 75 million Euro were available to support commercially oriented and sustainable services that clearly shift international freight transport from road to SSS, rail and inland waterway. The second Marco Polo Programme, although having the same objective, provides for a wider geographical coverage and the budget is much higher: 400 million Euro for the period 2007 to 2013. This funding stresses how aware of the financial risks of setting up a new non-road freight transport service is the EU is. As mentioned by kapoor (2002) […] regular maritime, rail and inland waterway services need a load factor of about 70 to 90% to stay viable."

Baird (2005) pointed out a couple of service attributes that shippers would consider before transferring trailer traffic from road to sea (Gothenburg-Zeebrugge, Plymouth-Bilbao, Genoa-Barcelona): a) Price – The rate charged for the sea crossing and the cost of road at the beginning and end of the journey needs to be competitive. Shippers will only use a SSS solution as long as they see no increase on the total freight cost. b) Departure/arrival schedule - Shippers require a daily departure in each direction. The ship should sail at the same time each day and arrive at the time scheduled. c) Reliability – Consistent schedule of ships arrival and departure time is absolutely necessary. d) Transit Time – Competitive transit times are required. e) Efficiency in port – Speed of loading/unloading, cargo security, absence of bureaucracy, low charges, 24-hour working and fast access to the road network, were all seen as further essential service attributes; f) On-board facilities – Drivers accompanying trailers require facilities such as restaurants, showers and cabins.

Bergantio and Bolis (2003-2004) conducted a study regarding the preferences when redirecting current on-land transport services to hypothetical maritime Ro-Ro service alternative. The conclusion was that freight rates are not the only criterion for modal choice; reliability and frequency of the service seem to be the key factors in the choice of a transport service alternative.

4 SEA-ROAD CASE

Sea-Road – Serviços e Transporte Combinado, S.A. , a Ro-Ro service, founded in 2004 by five Freight Forwarders, one Port Operator, one Haulier and one ship agent, Sea-Road invited, in 2005, two private equity fund companies to join as shareholders, bringing the total capital to EUR 2,9 Million.

Market analysis strongly indicated there was a real demand to make this project a viable one. On one hand, the EU growing environmental restrictions on road circulation, restrictive labour policies, and on trade flows, and on the other, the interviews conducted with a significant part of forwarding agencies (main potential clients) in Northern Portugal, concluded there to be a real demand for this kind of service. As it was very competitive, the concept was very well accepted by the market; however due to several constraints the project was short lived, ending 6 months after its launch.

Sea-Road, ideally consisted of a weekly regular sea freight Ro-Ro service between the ports of Leixões (PT) and Liverpool (UK). Initially an additional port call, Zeebrugge, was considered in the project, covering the Benelux market too. The rotation (in the picture): PT – UK – BENELUX, guaranteed the best use of the place available in both legs as north bound (PT-UK) is a mainly export and south bound (Benelux-PT), mainly import leg. The following statistics (table 1), considered in the project, reinforce it.

Table1: Portuguese exports and imports

Million Euro

	EXP	%UE	%T		IMP	%UE	%T
Spain	6.684	30%	24%	Spain	12.496	39%	30%
Germany	4.152	19%	15%	Germany	6.088	19%	15%
France	3.703	17%	13%	France	4.094	13%	10%
UK	2.888	13%	10%	Italy	2.676	8%	6%
Italy	1.334	6%	5%	UK	2.041	6%	5%
Belgium	1.244	6%	4%	Netherlands	1.957	6%	5%
Netherlands	1.057	5%	4%	Belgium	1.211	4%	3%
Luxemburg	25	0%	0%	Luxemburg	116	0%	0%
Others	1.207	5%	4%	Others	1.705	5%	4%
Total UE	**22.294**	**100%**	**79%**	**Total UE**	**32.383**	**100%**	**78%**
Others non UE	5.794		21%	Others non UE	9.323		22%
Total	28.089			Total	41.706		100%

Souce: INE, 2003

Changes in the market, especially the dramatic cost increase in fuel and charter contracts, forced the project promoters to eliminate the Zeebrugge call. The service timetable was set-up after several interviews with forwarders which determined that more than 80% of Portuguese cargoes leave Portugal having loaded on Friday night. The Sea-Road service departed at midday, on Saturday, arriving overnight in UK (Liverpool) on Monday/Tuesday. This allowed Sea-Road to deliver up to destination in UK 36 hours ahead of an overland vehicle.

Sea-Road offered an integrated service that was even faster and more competitive that the existing road transport solution for those markets respectively. These markets had been estimated to require an annual movement of more than 28,000 trailers, and the focus was on a specific segment of the market controlled by freight forwarders, estimated to be 12,500 trailers annually. These account for 45% of the total cargoes moved between those 2 countries by road alone and included promoters of Sea-Road with a joint capacity to transfer 60 trailers a week, which translates into 64,5% of the total expected.

Qualitative Environmental & social benefits:
The project promoters estimated that with a weekly Ro-Ro service, in 2007 5,250 trailers would be removed from the roadways, and another 7,000 in 2008, would have to cross the heavy traffic borders of Irun and Vilar Formoso and go through sensitive and heavily populated areas with the added hazards of pollution, noise, accidents and congestion in transit countries.

The old route (by road), in green, consisted of trailer traffic originating from/to northern Portugal and delivering and collecting from the following points in UK: Glasgow, Newcastle, Manchester, Leeds, Northampton, Birmingham & Cardiff. These, were the major destinations and origins of export in UK, with distribution warehouses located around the Birmingham and Northampton areas. In average, the old route represented a distance of 2486 km. On the other hand, the new route (by sea), in blue, represented a distance of 1550 km.
Recognizing environmental benefits, needs identifying external costs of the old route and the "modality shifted route", or the new route.
External costs are calculated based on the total tkm/ volume of both routes. According to EU Marco Polo Programme, the external cost (e) per tkm is 0.035 and 0.009 €/tkm by road and SSS mode, respectively. Table 2 and 3 show data from old and new "modally-shifted" routes.

Table 2: Old Route

OLD ROUTE						
Sections number	**Sections Description**	**Mode of transport**	**Nr. of trailers**	**Nr. of tones (W)**	**Distance Km (L)**	**Tkm (F)**
1	Collections Portugal	n/a	n/a	n/a	n/a	n/a
2	**North Portugal- UK**	**Land**	**12.400**	**287.432**	**2.486**	**714.555.952**
3	UK deliveries	n/a	n/a	n/a	n/a	n/a
4	UK collections	n/a	n/a	n/a	n/a	n/a
5	**UK - North Portugal**	**Land**	**6.850**	**158.783**	**2.486**	**394.734.538**
6	Portugal deliveries	n/a	n/a	n/a	n/a	n/a

Table 3: New "modally-shifted" route

NEW "MODALLY-SHIFTED" ROUTE						
Sections number	**Sections Description**	**Mode of transport**	**Nr. of trailers**	**Nr. of tones**	**Distance Km**	**Tkm**
1	Collections Portugal	Road	12400	287432	132	37941024
2	**North Portugal- UK**	**SSS**	**12.400**	**287.432**	**1.550**	**445.519.600**
3	UK deliveries	Road	12400	287432	218	62660176
4	UK collections	Road	6850	158783	218	34614694
5	**UK - North Portugal**	**SSS**	**6.850**	**158.783**	**1.550**	**246.113.650**
6	Portugal deliveries	Road	6850	158783	132	20959356

The environmental (& social) benefit that Sea-Road service would promote as a "new modality shift" was 27.134.334€ (see appendix1- Marco Polo environmental and social benefits Formulas and calculations). According to these figures and the Marco Polo subsidy attribution criteria, the maximum subsidy that Sea-Road would benefit was 1.906.230 €: **Fshift =** 953.115.240 tkm then the Slimit=**S**= 953.115.240 tkm * (1€/500 tkm) = 1.906.230 €

Subsidy and shifted traffic - Environmental Efficiency
Environmental efficiency (R_S) is given by the environmental benefit of the new modal shift, divided by the maximum subsidy of the project, i.e., RS **=** B/S **=** 27.134.334 € / 1.906.230 € = 14,234 €. On the other hand, the environmental efficiency of the subsidy (R_T) is given by the environmental benefit (B) divided by the tkm shifted: R_T = B/ F_{shift} = 27.134.334 € / 953.115.240 tkm = 0,028469 €/tkm.

Environmental efficiency of the subsidy of this project is 14,2, meaning that for each Euro of subsidy spent, the benefits to society are 14,2 Euros. Environmental efficiency of the shifted traffic volume is 0,028469 Euros per tkm, meaning that society benefits with circa three cents for each ton of freight shifted away per kilometer of the old "road" route.

As pointed out by the project partners, the Sea-Road project was an interesting concept that was put into practice in 2006. That year, 2 venture capital companies joined the initial associated companies (5 forwarders, 1 haulier and 1 ship agent) and decided to set up the new service. Timing, though, was the worst possible due to various circumstances: 1) The service started in October; with adverse weather conditions ships suffer when crossing the Biscay Gulf, and some cargoes were damaged due to rough sea. 2) The chartering rate of this type of ships (Ro-Ro) was very high due to the strong demand and scarce quantity available. 3) Fuel costs started to increase heavily, and all those costs divided by the number of trucks made survival very difficult due to the limited capacity of the ship (82 trailers); making break-even impossible to achieve. There was also less cargo to move and principally there was less support from the UK. Shippers were running out of time and costs were running high. The concept of the project, namely the inclusion of the Zeebrugge call that was abandoned (as mentioned above) did not guarantee the full return cargo on the southbound leg. The service stopped in March 2007 due to complete financial failure. The Marco Polo financial support was never transferred because the service did not last enough time to be validated.

CONCLUSIONS
We presented the Sea-road project submitted to the Marco Polo programme. The project was sustainable and proved to be a greener project, with lesser environmental and social impact, and was aligned with the Baird (2005) service attributes pointed out in section 3. Findings, based on interviews with the promoters of the project, are the following: 1) there is no awareness of SSS

and intermodal green and social benefits; 2) the manufacturers and logistics agents want effortlessness and the road mode is still the easier choice and are not aware that being green could be an added value and a marketing strategy to increase competitiveness; 3) the programme subsidy would only be available to the promoters if the project had lasted the Marco Polo minimum time service, which proved to unbearable in such a capital-intense activity; 4) the three years spent on designing, drawing the business and feasibility plan and its implementation was too long. In the meanwhile market conditions changed due the fuel price, economic recession, exports/imports decrease, which increased costs and difficulties in achieving the 70% full cargo in both legs; 5) due to financial constraints, the implementation was not according to design and feasibility project; the Zeebrugge call was abandoned and consequently the return cargo (at least 70%) was not ensured; 6) this kind of Ro-Ro service is highly capital intensive and, demands for strong partnership and cooperation of all stakeholders; 7) this was a private project and as two of partners eventually abandoned the project, making the project unsustainable from a financial point of view; 8) this was a new concept in Portugal and the partners, especially the haulier and the shippers, as well as other stakeholders: customs authorities, ports, etc. lacked awareness, and were not sensitive to the potential added value of greener strategies. This shows that SSS can only be made more attractive by creating the necessary intermodal platforms, heavily taxing road transport, which is inevitable on the long run, and raising the sector's awareness of the need for greener policies.What can be learned from the failure of the project is that: 1) this kind of service show to be highly dependent on economical conditions; 2) awareness of green issues is very poor, mainly due to the fact that there are virtually no associations, private or otherwise, to promote and raise public awareness of the need to address environmental issues; 3) the Marco Polo programme has acknowledged this, as can be seen in a greater effort that has been put in promoting SSS services, and Sea Motorways, as well as increasing financing and changing the criteria for eligibility; 4) financial support has to be made available earlier - in capital-intensive activities costs can easily become unbearably heavy and the timings used in analyzing the projects submitted and granting the subsidy have to be substantially shortened.

Considering fuel price increase in the past years (40% over the last three years), representing a 450% increase in the cost of Portuguese road transport in the past 10 years for the same productive capacity, in addition to payment of MAUT and other taxes for circulation in EU members, which represent an increase of road cost of 0,13 Euro/km, one expects green logistics to be a factor pushing hauliers to shift to intermodal transport.

On the other hand, the Portuguese government has shown willingness to address the sustainability of Portuguese intermodal transport. The promotion of inter-modality, partnerships and cooperation with others EU members, especially Spain (accounting for 35% of your exports in 2008), and a stronger involvement with Spanish logistics platforms, have been priority issues. Huge investments are being made in ports such as Leixões and Aveiro, among others, to promote inter-modality, and to integrate these with rail infrastructures and main road links.

A greener approach to transport is still in its eve, and industry and logistic operators have already started using their compliance with quality and environmental certification, the adoption of green strategies, such as using intermodal transports and reducing road traffic, etc., as marketing strategies. Nevertheless a lot has still to be done. The services provided must be made easier to use and more attractive to the end-user, hence the need for a greater integration and cooperation between the different stakeholders. Higher education institutions may also have a very important role to play in raising the general public awareness, as they address green logistics issues in their syllabuses. SSS, and Ro-Ro in particular, must be acknowledged as a common activity, it has to be strongly supported and promoted on all occasions as a viable alternative to road transport.

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Appendix1 – Marco Polo environmental and social benefits Formulas and calculations

$$F_{old} = \sum_{Section=1}^{i} F_{old,i} = \sum_{Section=1}^{i} W_{old,i} * L_{old,i}$$

$F_{old,2} = L_{old,2} * W_{old,2} = 2.486$ km * 287.432 t = 714.555.952 tkm
$F_{old,5} = L_{old,5} * W_{old,5} = 2.486$ km * 158.783 t = 394.734.538 tkm

Thereof being road transport $F_{old,[r]} = 1.109.290.490$ tkm

$$C_{old} = \sum_{Section=1}^{i} C_{old,i} = \sum_{Section=1}^{i} e_{old,i} * F_{old,i} \quad \text{and} \quad e_{old(1-i)} = 0{,}035 \text{ €/km}$$

$C_{old,2} = F_{old,2}$ * 0,035€/km = 714.555.592 * 0,035 = 25.009.458 €
$C_{old,5} = F_{old,5}$ * 0,035€/km = 394.734.538 * 0,035 = 13.815.709 €
C_{old} = 38.825.167 €

$$F_{new} = \sum_{Section=1}^{k} F_{new,k} = \sum_{Section=1}^{k} W_{new,k} * L_{new,k}$$

$F_{new,1} = L_{new,1} * W_{new,1} =$ 132 km * 287.432 t = 37.941.024 tkm
$F_{new,2} = L_{new,2} * W_{new,2} =$ 1.550 km * 287.432 t = 445.519.600 tkm
$F_{new,3} = L_{new,3} * W_{new,3} =$ 218 km * 287.432 t = 62.660.176 tkm
$F_{new,4} = L_{new,4} * W_{new,4} =$ 218 km * 158.783 t = 34.614.694 tkm
$F_{new,5} = L_{new,5} * W_{new,5} =$ 1.550 km * 158.783 t = 246.113.650 tkm
$F_{new,6} = L_{new,6} * W_{new,6} =$ 132 km * 158.783 t = 20.959.356 tkm

Thereof, road transport $F_{new[r]} = 156.175.250$ tkm
and the total transport chain $F_{new} =$ 847.808.500 tkm

$$C_{new} = \sum_{Section=1}^{i} C_{new,k} = \sum_{Section=1}^{i} e_{new,k} * F_{new,k} \quad \text{and} \quad e_{new\,[r]\,(1-i)} = 0{,}009 \text{ €/tkm}$$

$C_{new,1} = F_{new,1}$ * 0,035€/km = 37.941.024 tkm * 0,035 € = 1.327.936 €
$C_{new,2} = F_{new,2}$ * 0,009€/km = 445.519.600 tkm * 0,009 € = 4.009.676 €
$C_{new,3} = F_{new,3}$ * 0,035€/km = 62.660.176 tkm * 0,035 € = 2.193.106 €
$C_{new,4} = F_{new,4}$ * 0,035€/km = 34.614.694 tkm * 0,035 € = 1.211.514 €
$C_{new,5} = F_{new,5}$ * 0,009€/km = 246.113.650 tkm * 0,009 € = 2.215.023 €
$C_{new,6} = F_{new,6}$ * 0,035€/km = 20.959.356 tkm * 0,035 € = 733.577 €
C_{new} = 11.690.833 €

Modal shift: $F_{shift} = F_{old(R)} - F_{new(R)}$ =1.109.290.490– 156.175.250= 953.115.240 tkm
Environmental benefits: **B =** $C_{old} - C_{new}$ then **B =** 38.825.167- 11.690.833= 27.134.334€

INNOVATIONS IN LAST-MILE LOGISTICS: THE RELATIONS WITH GREEN LOGISTICS, REVERSE LOGISTICS AND WASTE LOGISTICS

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ABSTRACT

Purpose
The aim of this paper is to study in detail the relationship between innovative concepts in the last-mile part of the supply chain and its direct and indirect environmental effects on green logistics, reverse logistics and waste logistics. Speaking about "innovations in logistics", those four topics are nowadays real "buzzwords" but the relationships between those four and their impact on each other are not often taken into account.

Design/ Approach / Methodology
During the research process of this paper, three complementary methodologies were used: first of all, the relevant literature was reviewed. Second, several interviews with logistical experts from several different sectors (private, public, …) were done and third, the concept of the Green Logistics Triangle was analyzed during an expert meeting about innovations in logistics.

Findings
This paper identifies that the relationships between green, last-mile, reverse and waste logistics need to be taken more into account when screening a supply chain for innovative optimization than nowadays. This is the fact for academic studies as well as for public entities and private companies. The Green Logistics Triangle is a framework that attempts to simplify, visualize and identify several different direct and indirect relationships between the four former mentioned parts of the supply chain.

Research limitations/ implications
This paper is the result of a preliminary research part for a research project/paper with the aim of screening the supply chains (using the Green Logistics Triangle) and categorize them in the characteristics (ex. Costs, time, frequency, punctuality, environment, …) that are most common in innovative adaptations in logistics. This makes it possible to screen, as mentioned before, the direct and indirect relationships between last-mile, reverse, waste logistics and green logistics and in a further stage to look more in detail to common characteristics.

Practical Implications
One of the major aims of this paper it that is should be useful for academic research as well as for private companies and public entities.

Originality/ Value
The value of this paper can be described as an attempt to put more stress on intra sub-logistical direct and indirect links which have significant implications on each other. Nowadays these relations are not often taken into account in papers.

KEYWORDS: Innovation, green logistics, reverse logistics, last-mile logistics, waste logistics, home deliveries

Paper Type: Research paper

INTRODUCTION

Until the end of the former decade, the supply chain was a purely technical "subject" to arrange the flows of goods from natural resource locations over production facilities to customers and companies. Logistics decisions were taken only on a technical level. However, during the last decade, there has been a trend to put logistics at a more strategic business level in companies, which resulted in measures to optimize the chains. Simultaneously with the worldwide trend of environmental awareness, some important effects have taken place.

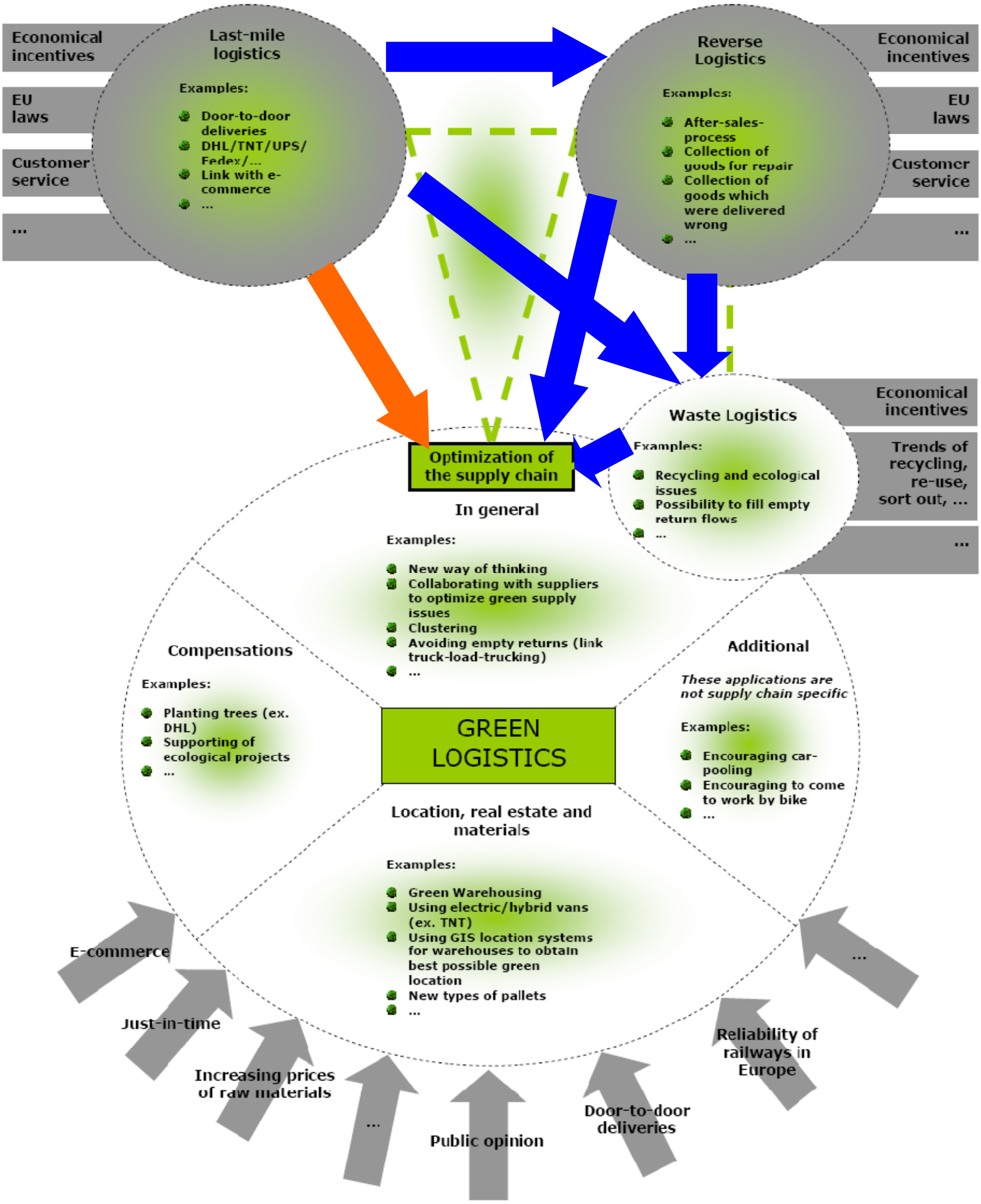
For the future, most forecasts predict that green logistics will become one of the most important concepts in logistics, if not "the" most important. This will not only be the result of several "green logistics labels" or "carbon footprint labels", but it will most probably be the result of economic decisions affecting the entire supply chain, which can result in environmentally friendly effects. Examples of this are measures to reduce oil consumption, to reduce waste and to promote recycling of goods. The awareness of the companies and customers about the fact that "green decisions" can go "hand-in-hand" with positive cost-benefit results is growing. Interrelations between sub flows in logistics with green effects will become increasingly important, as it will be stated further on in this text.

The following paragraphs will describe some of these innovative trends and concepts in logistics using the 'Green Logistics Triangle Diagram'. This diagram/framework has been made in an attempt to identify and illustrate the most important (inter-)relationships between the different possible drivers of green logistics[1]. The various building blocks of this diagram will be further explained. In this article, the focus will be on the relation between last-mile logistics and green logistics and on the interrelation environmental effects that last-mile logistics can create on reverse logistics and waste logistics.

The following framework is an attempt to simplify, visualize and identify the logistical relationships and interrelationships as described above. The fact that changes in a specific sub flow (last-mile part, waste part or reverse part) can have significant effects on each other and can imply important environmental impacts, is not taken into account often. These environmental impacts (positive as well as negative) can be strengthened. If for example a change in the last-mile has a direct environmental effect, then it is not unthinkable that it also has, for example, an impact on the reverse part of the supply chain as well. This implies direct effects in the reverse part of the chain and **indirect environmental** effects in the complete supply chain.

[1] The different concepts mentioned below feature several definitions. As a result, the definitions mentioned are the ones which are used by the Department of Transport and Regional Economics of the University of Antwerp, although they are not exhaustive. They have been built on past research results, both internal and external. The definitions will provide a consistent framework for the remainder of the paper.

GREEN LOGISTICS TRIANGLE FRAMEWORK
Fig. 1: Green Logistics Triangle



Source: Gevaers, Van de Voorde, Vanelslander (2008)

Definitions
Green Logistics is the combination of every kind of measure, action or goal in the entire supply chain which affect the supply chain in an environmentally friendly way (Gevaers, Van de Voorde, Vanelslander, 2008). This can be a side effect as well as the goal of that specific measure. As a result, the link between the several logistic flows is of major importance. For example, by reducing waste for economic reasons, this will have most probably also a positive effect on the environment and as a result, it is clearly linked to green logistics. In an attempt to split up green logistics, four

major types of measures affecting the 'greenness of logistics' can be described. These are: optimization of the entire supply chain, compensation for environmental damage, location – real estate – materials and additional measures which are not only dedicated to logistics. This paper focuses on the part "optimization of the entire supply chain".

'The last mile' is the last stretch of a door-to-door delivery to the final consignee who has to take reception of the goods. (Gevaers, Van de Voorde, Vanelslander, 2008). Reverse logistics is the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or for proper disposal (Reverse Logistics Executive Council, 2009). Waste Logistics consists of that part of the supply chain which collects waste goods with the eye on the selection of the most economic-environmental choice for these goods: redistribution, reprocessing, scrapping or dumping (Gevaers, Van de Voorde, Vanelslander, 2008).

It should be clear that there is an obvious link between green logistics on the one hand, and waste, reverse and last-mile logistics on the other. The latter three logistics concepts can be considered as related with the "optimization of the whole supply chain[1]". Increased efficiency in each of these three concepts can create a decrease of clogging effects of logistics. As stated above, this article will focus on the direct and indirect[2] environmental effects of last-mile logistics.

INNOVATIONS IN LAST-MILE LOGISTICS AND ITS DIRECT AND INDIRECT ENVIRONMENTAL EFFECTS

"The last mile problem"

The last mile of the supply chain is considered one of the most, or even "the" most, expensive and difficult parts of the supply chain. The most important problems are the following ones. First of all, for home deliveries, the high degree of failed deliveries due to the "not-at-home" syndrome is an important problem, which implies extra costs and extra kilometres and emissions. A second problem that can be mentioned is the fact that door-to-door deliveries can create a high degree of "empty running[3]". A third important problem is the problem of security when delivering a parcel if a signature is not needed. This can result in discussions between supplier and consignee. Another problem is that for some regions, the critical mass of goods is too little to make a profitable and efficient routing plan. The fact that most of the door-to-door deliveries are done by small vans implies that the carbon footprint per kg is higher if compared with transport by a bigger truck. A last important problem is the fact that home deliveries imply a significant higher rate of return compared to traditional shopping.

During the last decade, special attention has been paid to the former mentioned problems in the last-mile and as a result, some remarkable innovations to optimize the last mile were launched. Some of these innovative concepts will be described in the following paragraphs, focussing on the direct and indirect environmental effects. To start with, a small description will analyze the existing research about the environmental impacts of the last mile.

The last mile and its environmental effects

Since the increased awareness of green and environmental issues in global economies, an increase in research[4] about the impacts of home deliveries on the environment can be noticed, especially focussing on the carbon footprint of home deliveries. However little attention is paid on the one hand to the indirect effects of last mile deliveries and on the other hand to the comparison between the environmental effects of traditional shopping and those of home deliveries. The only "overall" academic research paper that was found during this research process for this paper about

[1] Upper quadrant in the Green Logistics Triangle.
[2] Interrelationship with waste and reverse logistics. The direct relation between last-mile logistics and green logistics are visualized by the orange arrow, the indirect effects are visualized by the blue arrows in the Green Logistics Triangle.
[3] Driving with almost empty trucks or vans.
[4] Academic research as well as private research.

this comparison, was the following one: "*Carbon auditing 'the last mile': Modelling the environmental impacts of conventional and online non-food shopping"* (Edwards, McKinnon and Cullinane, 2009).

The results of this paper make it clear that the environmental effects of home deliveries depend on several parameters. The most important parameters mentioned by this article are: drop density, rates of failed deliveries, distances covered and the type of vehicle used. In a second stage also the rate of unwanted returns[5] and the method of returns can have significant impacts on the environmental footprint of home deliveries. The conclusion of this article was the following: "*On average, when a customer buys fewer than 24 items per traditional shopping trip (or fewer than 7 items for bus users) it is likely that the home delivery will emit less CO2 per item purchased."* (Cullinana, Edwards, McKinnon, 2009). Although, this conclusion was made up under some important assumptions[6].

The following paragraphs will describe some innovative concepts of home deliveries and for each of these concepts special attention will be paid to their direct and indirect environmental effects. The effects of the following concepts will be described on a qualitative base. Quantifying these effects is a basis for further research.

SOME INNOVATIVE CONCEPTS

Collection points

One of the main reasons for the high last-mile costs in the business-to-consumer market is the high degree of 'not at home' deliveries, as stated earlier in this article. This implies a significant cost increase and a lot of avoidable fuel consumption. Due to this fact, some new concepts have been developed in the logistics markets. Starting from the year 2000, companies who had to deal with last-mile deliveries, realized that clustering of goods in collection points could save money. These cost saving are intuitively clear: on the one hand there are cost savings by occurring expensive 'not at home' deliveries and secondly, clustering of goods implies a higher load factor for the truck and van fleets. Moreover, a lot of fuel is saved (with a reduction of emissions as a direct environmental effect) for the supplier. Reverse flows can also be clustered in collection points. The Kiala Company is an example of a company that tries to cluster goods for several companies by using a network of about 4,660 collection points in Europe. These collection points are mostly located in shops with long opening hours, such as bookshops, petrol stations, etc. The shops who participate in the Kiala program, receive a payment for each parcel using the Kiala system that passes through the shop. Around mid 2008, Kiala distributed around 78,000 parcels a day using collection points. In Germany, Deutsche Post World Net is also using kiosks or "Parcel Pack Stations" for parcel distribution. Although, these kiosks are more developed for collection of goods, rather than to deliver the goods to the final customers. These kiosks are unmanned. Parcel company GLS has set up a comparable network using the name "GLS Packet shops". And especially in the UK, several networks of collection boxes[7] have been set up. Two examples of collection points are below.

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[5] Link with reverse logistics

[6] *These assumptions are:*

- The car-based trip was solely for the purpose of shopping (no other activity was undertaken during the course of the trip);
- The purchase ordered online was delivered successfully first time;
- The shoppers were satisfied with the purchase and did not return the item;
- Home deliveries and shopping trips were made over average distances;
- No allowance was made for different types of road network or traffic conditions;
- Only the last mile and not the upstream supply chain has been considered in the analysis (although reference has been made to previous studies of the relative environmental impact of upstream activities).

[7] A network of collection boxes can be compared with a locker room where goods can be stored, but with this difference that these lockers are used to store the parcels delivered by couriers. From the moment that a courier has put a parcel in a dedicated box/locker, the customers can collect this parcel. The collection box can be opened with a dedicated code, which the customer will receive by e-mail once the parcel is put in the box/locker, for each parcel.

Figure 2: DHL Packstation

Figure 3: Shop with GLS Parcel service

Source: DP-DHL (2009)

Source: GLS Group (2009)

To summarize, from the point of the supplier, the last-mile delivery has a **direct** positive environmental effect, but one has to keep in mind that the consumer has to make a trip to the collection point while this is not the case using home delivery methods. This last consumer trip can make the difference between a positive and a negative environmental impact comparing collection points and home deliveries, when screening the whole last-mile from distribution centre to the consumer. An indirect positive environmental effect from using collection points is the fact that this type of distribution channel makes it possible to cluster reverse flows in those collection points and in a second stage to combine these reverse flows with the forward flows. As a conclusion, referring to the green logistics framework, collection points can imply **direct** and **indirect** positive environmental effects.

Scheduled milk-tours

As a result of the booming e-commerce and the possibility to deliver goods at home within a specific timeframe, a high degree of empty-running can be the result of dedicated deliveries due to the sometimes very narrow timeframes. One possibility to reduce the level of empty-running is implementing "scheduled milk-tours". As stated by the County Council of Hampshire (UK) "A *'home delivery' schedule could encourage people who live in the same street to choose the same time and day for their delivery, in return for a discounted delivery charge. This would reduce the number of miles and the number of vans needed to make deliveries."* This method reduces the number of specific dedicated trips to deliver only one parcel within a specific timeframe, because a milk-tour on specific hours in a specific area can pool more parcels in the same tour in that area/region. One major remark is that until now, no quantitative academic research is done concerning the environmental effects of using milk-tours with specific hours instead of classic home deliveries.

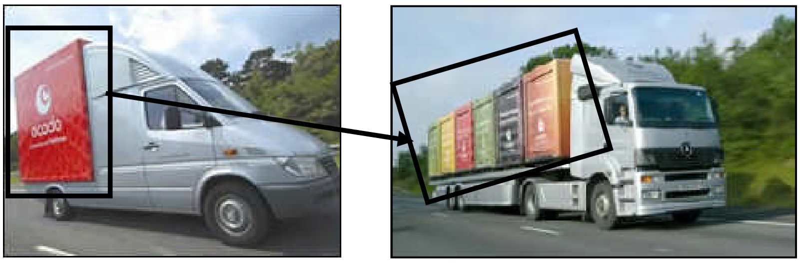
Logistics company areas cooperating for last-mile deliveries and clustering

As said in the former part, clustering is a possibility to lower the last-mile costs and its environmental impact. "The Last-Mile Logistiks Network" in Germany (Former Ruhr Area) is an example of an industrial estate where companies cluster/pool goods in an attempt to deliver the goods in joint delivery tours. This network is a corporation of several small, medium as well as big companies. The direct and indirect effects are comparable with the ones of collection points: reducing carbon emission due to clustering and optimizing the reverse flows, also with reduction of carbon emissions as a result in most cases.

Ocado.com uses small containers

Ocado.com is a pure e-commerce company that uses a dedicated innovative supply chain for home deliveries. Ocado.com uses small boxes of around 0.2 to 0.5 TEU, and they can put 6 of these boxes on a trailer. Each box is filled in the warehouse with goods ordered by each specific region. By using these boxes, Ocado.com was able to prevent a high degree of empty running. The boxes are delivered to the regional distribution centers, but due to the fact that all the goods are already sorted-out in these boxes, an important time-gain is obtained. On a long trailer/truck, around five to six of these boxes can be loaded, and traditional vans can load one of these boxes. The direct environmental effects are result of optimization of truck and van routing by using equipment that can be loaded on trucks as well as on vans. The indirect effects are a result of combining forward flows with reverse flows, which reduces the amount of driven empty kilometers.

Figure 4: Ocado Box



Source: Ocado.com (2008)

Innovative packaging
Last-mile logistic companies use a lot of packaging material for protecting the content of the parcels. Some home delivery companies have already changed totally from disposable boxes to innovative reusable boxes with standardized measures. This has a direct environmental effect looking from last-mile point of view because using standardized measures can make it possible to optimize loading and unloading activities. In most cases, this increases the number of parcels that can be loaded in a van. An indirect effect that can be mentioned is the reduction of packaging waste. Former mentioned company Ocado.com is using biodegradable bags and has set up a system that makes it possible that bags can be returned for recycling to Ocado.com. Also the four worldwide integrators[8] are doing research to innovative and environmental "friendlier" packaging methods.

Hybrid Vans
When focusing more on new technologies for "greener" home deliveries, the development of hybrid vans can be mentioned. Several van and truck producers are developing or have already entered the market with hybrid[9] technologies. These technologies make it possible to reduce carbon emissions with a significant amount, and in very dense urban areas, these vans can switch totally on electric power. A large number of courier companies are considering or have already implemented such hybrid vans.

CONCLUSION
To conclude, the supply chain is evolved from a purely "technical entity" in companies to a strategic value chain where many interrelations interfere with each other. Since the increased attention for the environment, focus on green logistics is grown strikingly. However, not very often the interrelation with sub logistical flows as last-mile, reverse and waste logistics are taken into account when speaking about green logistics. A specific framework, the Green Logistics Triangle, was used to illustrate the direct and indirect relations from the different sub flows on each other and on green logistics. This paper focused on the direct and indirect environmental effects of the 'last-mile' of the supply chain. To end with, some examples of innovative last-mile concepts were introduced and described. These concepts were analyzed focusing on direct as well as on indirect

[8] TNT, DHL, UPS and FedEx
[9] Gasoil-Electric

effects. The focus was on qualitative data, but when available, quantitative data was also taken into account.

The overall conclusion of this article is that when analyzing the supply chain on its environmental performance, not only direct effects need to be taken into account, but also indirect effects have to be analyzed and taken into account.

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ACTIVITY BASED LIFE-CYCLE MANAGEMENT FOR GREEN LOGISTICS

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ABSTRACT
In this research, we introduce an activity based lifecycle management system for analyzing accurate product lifecycle and product value. The research applies Radio Frequency Identification (RFID) and Product Lifecycle Management (PLM) concept to manage life span of a product. Product value can be evaluated by life span of a product and activities occurred during its life span. In order to calculate product value, we applied an activity based cost management. In our research, cost management consists of three costs: manufacturing cost which is decided at producing stage, price which is included manufacturing cost, service cost and margin and present value which comes from real life span of a product.

Keywords: Activity Based , Life Cycle, Green Logistics

INTRODUCTION
Recently environmental aspect of logistics has been getting more attention since relating regulations become stricter and customer requirements are increasing. With the increasing concern on environment, it is imperative that companies shift their logistics goal from traditional 'just-in-time (JIT)' based logistics management to green logistics management. Generally green logistics applies green principles to all the stages of traditional forward and reverse logistics, i.e. throughout product lifecycle, starting with product design, material sourcing, manufacturing processes, delivery of the final product to the consumers, after sales, product return, remanufacturing/ reuse and recycling.

In this paper, we introduce the management solution for a product life cycle after sales. The proposed idea is to find out more accurate product life span and value with the aid of Radio Frequency Identification (RFID) Device. Accurate product life cycle management can bring intelligent decision for high quality customer service and also enhance the efficiency of resource.

PREVIOUS RESEARCH
PLM is the process of managing the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal (CIMdata, 2009). PLM integrates people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise (PLM Technology Guide, 2009). Dunk (2004) introduced the concept of Product Life-Cycle Cost, which used the technique of creating an object through a well planned blue print and then customizing the item to the favour of the consumer. Somers and Nelson (2004) applied to life-cycle to solve the variety of traditional system implementation (Somers and Nelson, 2004). Overall PLM has touched the basis in a number of different areas and has been developed

specifically to fit the needs and demands of consumers. The PLM should address all the stage of lifecycle of a product which includes Beginning Of Life-Cycle (BOL), Middle Of Life-Cycle (MOL), End Of Life-Cycle (EOL). Cao et al. (2007) applies RFID to the lifecycle stages of automotive industry. Jun et. Al. (2007, b) composed new business model for suitable life-cycle services. Choi et al. (2008) developed new design methodology for efficient consuming. Seliger et al. (2003) developed a new hardware that called Life-Cycle Unit (LCU) for reducing resource consumption. Chouinard et al. (2005) constructed new supply loop that included the reverse logistics ideas within the supply chain management (SCM).

Activity-Based Costing (ABC) is a costing model that identifies activities in an organization and assigns the cost of each activity resource to all products and services according to the actual consumption by each: it assigns more indirect costs (overhead) into direct costs. In this way an organization can establish the true cost of its individual products and services for the purposes of identifying and eliminating those which are unprofitable and lowering the prices of those which are overpriced. In a business organization, the ABC methodology assigns an organization's resource costs through activities to the products and services provided to its customers. It is generally used as a tool for understanding product and customer cost and profitability. As such, ABC has predominantly been used to support strategic decisions such as pricing, outsourcing and identification and measurement of process improvement initiatives. There is some research where traditional activity based costing was used trace the cost factor of activities (Pirttila and Hauaniemi, 1995). Peacock and Tanniru (2005) calculated the gross income of IT investment by activity based costing. Koltai et al.(2000) introduced flexible manufacturing system that was composed by activity based costing.

GREEN LOGISTICS

Green Logistics cover not only reverse logistics but also forward logistics with environmental perspective. It addresses all the phases of product life cycle. One of the key benefits of green logistics is the improvement of resource efficiency. Green Logistics Oriented Business Environment (GLOBE) has been supported by the Ministry of Knowledge Economy in South Korea (www.globe.re.kr). Aims of this project are constructing an intelligent green logistics solution and service.

Figure 1 shows the basic architecture of GLOBE Solution Architecture.

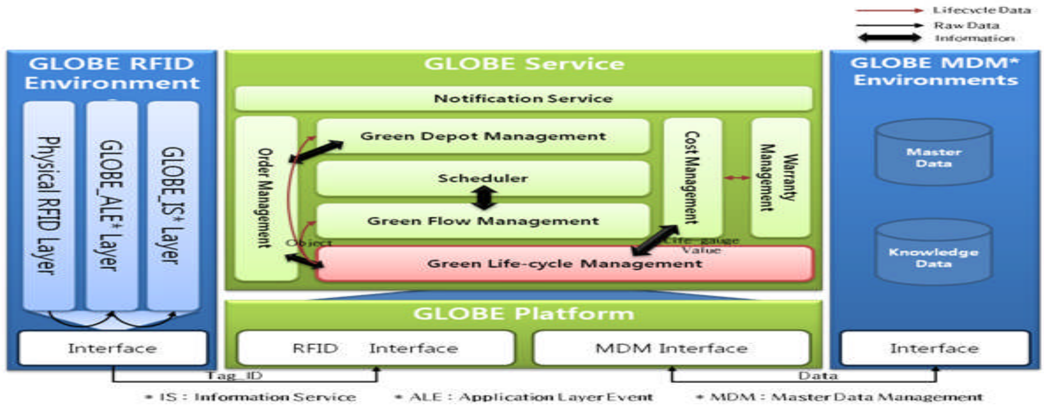

Figure 1. GLOBE Solution Basic Architecture

ACTIVITY BASED LIFE-CYCLE MANAGEMENT IN GREEN LOGISTICS

Activity based lifecycle management applies the concept of activities to the lifecycle management that was not considered in traditional lifecycle management. Here, we defined an activity as a kind of action or factor that can influence to the object in the environment and a system user can change the activity's property and definition. There can be two types of activities: one is scheduled activity and another is unscheduled activity. Scheduled activity can be predicted but unscheduled activity cannot be predicted. To control the object's life, we design the concept of life-gauge that is the parameter for calculating the value of objects. An object can have an appointed life-gauge and real life-gauge. Manufacturer (or demander) can calculate the appointed a life-gauge for a pre-given period to use (e.g. period of circulation) without the environmental effects and turbulences. But real life-gauge calculates the life cycle of every object considering their usage.

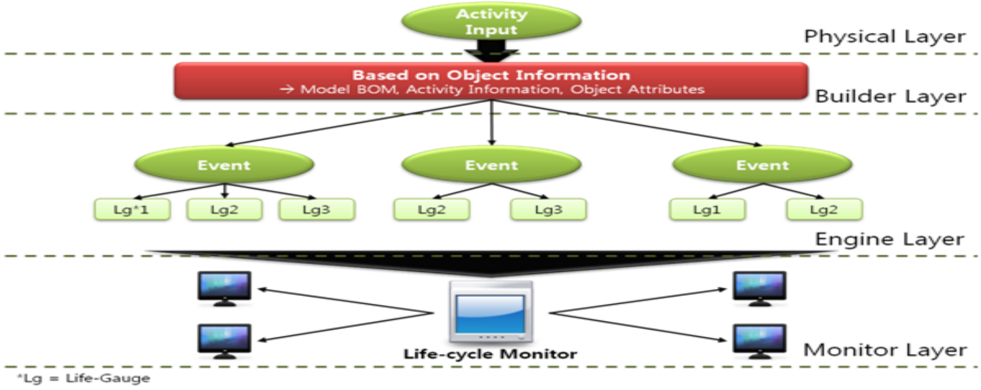

Figure 2. Activity Based Life-Cycle Management Architecture

Figure 2 and 3 show the architecture of activity based lifecycle management system and operation of green lifecycle management in our research, respectively.

CONCLUSION

The aim of our research is to present activity based lifecycle management. We developed a new model that is based on activity based life-cycle management. Positive activities can improve lifecycle of a product while negative activities decrease the lifecycle of a product. Life gage is a kind of dashboard system for such life cycle information.

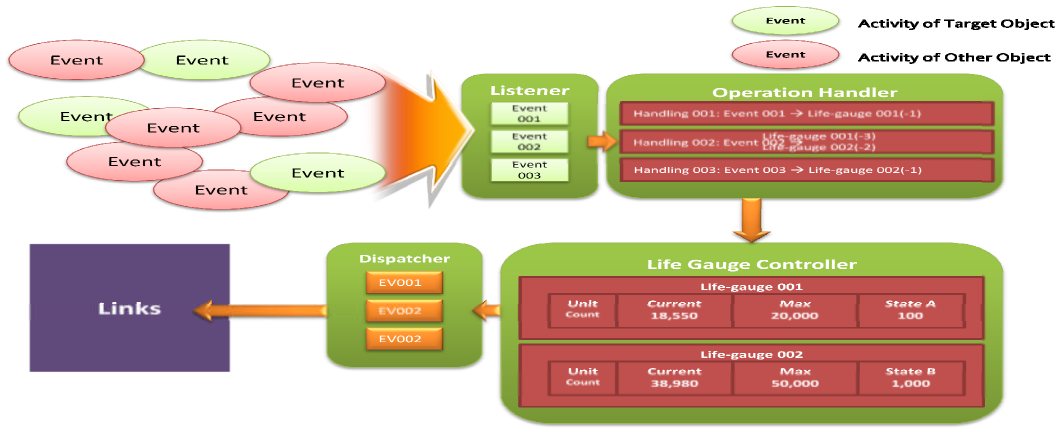

Figure 3. Operation of Green Life-Cycle Management

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COORDINATING PARISIAN URBAN TRANSPORT

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ABSTRACT

A large research project has been initiated by the French government gathering together a consortium of industrial firms (transport companies, intermediaries, software companies) and institutional researchers to study the issues regarding traffic jams, fuel consumption and pollution; initially from a micro-perspective, but rapidly to encompass the logistics needs of several sectors. The project has been designed to explore the sharing of total transport capacity with other vendors via a market portal which it is hoped will also reduce the pollutants across Paris, and later in other French cities.#

Importantly the portal will handle legal issues (in-transit responsibility for others' goods) as well as promoting new models for routing that will take into account real-time congestion to minimise fuel consumption and pollution over a multi-modal delivery system for multiparty operators. A further issue to be addressed is that of honestly sharing the available capacity in this new scenario – a system envisaged as similar to the route/capacity sharing in the airline industry. The duration of project is 3 years; the first trial will be realised in Paris and its suburbs and could yield results in the first 18 months.

INTRODUCTION

Few can have avoided hearing about "climate change" over the last decade. There were the Kyoto (1997) and Bali (2007) meetings held by the United Nations Framework Convention on Climate Change – soon the delegates will meet again, this time in Copenhagen (December 2009) to agree further measures. The warnings of *The Stern Report* (Stern, 2007) indicated that if we collectively 'do nothing' the planet will be in grave danger but for relatively little cost to our collective GDPs we can all contribute to a better future: this report shocked decision makers across the globe. In addition, the Intergovernmental Panel on Climate Change (IPCC, 2007) in their last report *Climate Change 2007: The Physical Science Basis* assessed the current scientific knowledge about the natural and human drivers of climate change. The IPCC report has many facets and is generally modest and low-key: it did not therefore create impact even though it offers grave warnings about the effects we all have upon the climate.

Turning to national issues we note the UK was once heavily dependant on fossil fuels for its electricity generation but now only about 22% of its generation comes from coal; thus electricity generation remains the main source of UK pollution, with road transportation and housing as the next major sources. However as a consequence of many factors, some based on resource availability, others on political arguments to be energy independent, the individual sources of pollution of each nation are dissimilar (IPCC, 2007) even if one takes into account the life-cycle 'costing' of the source of pollution (Lim, 1997; POST, 2006). France currently is almost totally dependent for its electricity on nuclear fuels (84%) and/or hydro-electric generation (6%): even the household electrical bills of EDF (Electricité de France) proclaim its 'green credentials' noting only 4% of its electricity is generated from coal thereby yielding a pollution loading of ~50 gmCO_2eq/kWh. In contrast, the UK creates 891 gmCO_2eq/kWh from its electrical generation (WNA, 2007). Therefore, in France, the pollution from road transport and housing assume a much greater proportional significance than in the UK where electrical generation is the largest cause of

CO_2 pollution loading. Thus, in France, there is a somewhat heavy government pressure on the transport sector, though to be fair, pressure has been exercised since 1968[10].
In July 2007, the "Grenelle Environment Forum" (Press Release, 2007) focussed on the French ecology, development, and sustainable infrastructure with the aim of mobilising companies to place their activities and development within a sustainable perspective. Government decisions now take the environment into consideration: as a result, "… all major public projects and all public decisions shall henceforth be assessed by including their climate cost and carbon footprint." This revolution in the mode of governance has been applied immediately to transport policy.

Measures have been taken to achieve the objective of a 20% reduction in French CO_2 emissions by 2012 through new regulations with a hoped-for transition of road transport to alternative transport. As an aid, waterway and railway transport will be developed (+25% volume of freight in each mode) which would remove 3 million lorries from the road by 2020. However, as with many governments' announcements, the French government has made several rules, suggestions and laws with different actionable dates. As a result its avowed goals for the mitigation of pollutants is unlikely to be met (Réseau Action Climat France, 2001). This action group maintains a scathing view today[11].

This paper outlines one major initiative concerning the transport infrastructure of Paris. This project draws together the multi-modal supply of goods to the city by air, water, rail and road under a scheme to optimise logistics spatial use while minimising pollution.

INSTANTIATION OF THE PROJECT
Taking a word from the domain of Artificial Intelligence this project inherits and caries forward concepts from the recent Grenelle meetings in order to optimise many aspects of Parisian logistics and to minimise pollution therein. In meetings sponsored by ADEME (the French Environment and Energy Management Agency) one of its discussants 'confessed' to having spare capacity in its local logistics chain; and once having 'confessed', others followed suit. ADEME suggests the load factor of lorries across France does not exceed 67%, and that lorries travel empty for 20% - 30% of their trips. Further, as all the logistics managers were very concerned at the high costs of fuel in 2008, and knowing its inevitable rising trend over the past years they were also concerned to reduce their individual consumptions and thus reduce incidentally the loading of CO_2 and other polluting greenhouse gases, notwithstanding any pending regulations on individual fuel consumptions of their logistics motive power (new engines having to conform to EU Regulations Euro 5, and later 6 and 7).

It is understood that well-organized urban logistics are essential for the effective supply dynamics of goods to cities. Thus an optimal organisation of logistics services for goods in urban areas would serve three types of interests:

- *Economic interest*: this project aims to improve economic performance. Its software platform will allow logistics companies to convert their vacant space, negatively impacting their own storage spaces and means of goods transport from sources of additional cost to sources of value and a competitive edge. Taking advantage of the total overcapacity of logistics infrastructures, massing flows and creating value by pooling vacant capacities with other companies are becoming strategic challenges for companies. Delivery characteristics will be improved with regard to both their cost and their geographic and time-frame coverage, which ultimately benefits the end clients. This new logistics services allows companies to benefit from new economic opportunities – for instance by allowing coverage of markets hitherto inaccessible or allowing initiatives hitherto restricted to local targets which will promote new jobs.

[10] A conference bringing together the government, local authorities, trade unions, business and voluntary sectors to draw up a plan of action of concrete measures to tackle the environmental issue. The name "Grenelle" comes from the first conference bringing all these players together which took place in May 1968 in the Rue de Grenelle, Paris
[11] See http://www.rac-f.org/IMG/pdf/Analyse_synthetique_Grenelle_1_apres_1ere_lecture_AN_et_Senat.pdf

- *Environmental interest*: the pooling of logistics services will directly bring about a reduction of adverse effects. By promoting alternative means of transport, by massing flows, by optimising logistics by reducing the number of circulating vehicles, and by calculating the impact of logistics on the environment, the project will bring about a reduction in emissions and noise pollution.
- *Urban planning interest*: the project will improve the urban context. An optimisation of the use of roadways by massing flows and pooling logistics resources will generate an improvement in the overall fluidity of traffic and thereby reduce accidents due to the transport of goods. In addition, the project platform will achieve better use of the urban space both in terms of geographic coverage and optimisation of current logistics resources.
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These economic, environmental, and urban planning stakes will serve the interests and improvement challenges of institutions in their role as public players. The project, by cooperation with local institutions and communities, will handle changes in legislation and rationalisation of urban development planning by optimising the use of roadways in conjunction with intelligently using railway and waterway capacity to reduce roadway traffic intensity. The pooling of logistics services will make it possible to improve the quality of the environment for private citizens and businesses alike; that is, by a decrease in congestion, polluting emissions, noise, and accidents. Lastly, the economic stakes of the project underscores the economic development and dynamics of cities resulting from an optimisation of logistics services and coverage of the specific needs of SMEs, craftsmen, merchants, and local initiatives.

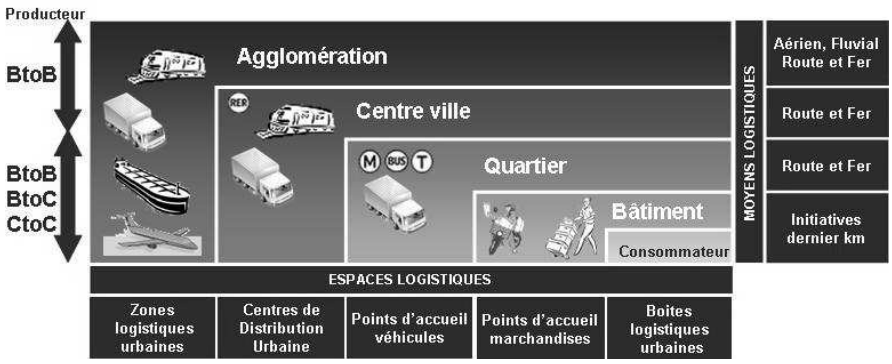

Figure 1: Consolidation characteristics affecting Paris

URBAN LOGISTICS RESOURCES

For a city like Paris these cover a wide area incorporating long distance deliveries by air, rail, road and river. Once goods arrive near Paris traditionally they are transshipped to new carriers who break the goods to smaller pallet groupings and dispatch these to local delivery points and thence by local servers to individual premises and individual customers. However the traditional carries or major players have their own providers of vehicles (of many types) and logistics spaces, but even they have made betterments lately:

> The pooling of resources and transfer from roadway mode to alternative transport modes still rely on local initiatives. Monoprix, for example, has added a multimodal dimension to its logistics delivery plan in order to reduce environmental impacts. The logistics resources used by Monoprix include waterway transport, railway transport, and roadway transport. In 2006, 83% of its goods arriving in Le Havre travelled over the Seine. In 2008, non-food products and non-alcoholic beverages took the RER railway network and are then carried by their own vehicles over the last kilometre. Source: from detail in the full research proposal.

The Monoprix example illustrates that Paris has several delivery corridors – and in fact as mentions they include also the airlines. Figure 1 illustrates the interplay between providers and logistics spaces moving from B2B, B2C and finally even C2C goods movements:

The lead industrial partner was in fact a distributor of newspapers. Once having a wide readership and thus needing an extensive and reliable distribution chain it has suffered recently (like most newspapers globally) from a diminution of demand as individuals use newer technology to access ‘news’ such as their mobile phones or tablet PCs. Yet this firm has to maintain its supply chain even though its delivery units (river for paper; road and rail for deliveries) suffered from lowered load factors with steadily rising delivery costs. They were therefore willing to co-operate with others in the project accord to better use their total logistics spaces.

LIMITATION OF AGGLOMERATION TOOLS

In the logistics sector, e-commerce applications such as Freight Exchange allow shippers to find goods and avoid empty return trips. Freight Exchange, however, is limited to establishing connections and does not allow users to manage pooling projects in advance. Nor does it allow one to simulate and choose between various opportunities. For these exchanges, in the Parisian project sense, the only evaluation criterion for sharing roadway transport capacity is cost. Freight Exchange do not give any indication of the CO_2 footprint nor the number of kilometres travelled. The needs expressed by companies through various planning meetings confirm the limitations of current freight exchanges and/or portals and they emphasise the timeliness of developing a tool for pooling and massing logistics capacities while considering economic and ecological assessments.

According to the work of PREDIT[12], existing information systems are now unable to keep up with changes in logistics business models or the intensification of data exchanges. In addition, 70% of information exchanges still do not take place in real time and only 9% of logistics specialists are equipped with an Electronic Data Interchange (EDI) system. According to those experts, a cooperative information system would allow numerous companies to take a step toward logistics pooling and integration into collaboration networks.

The development of an operational tool to regulate the supply and demand of all logistics services and to optimise allocations, such as the one being proposed in the Parisian project, is a crucial business success factor. To ensure its success it is essential to combine technological innovation with strong, neutral, and impartial governance.

At the present time there is considerable opacity in logistics operations preventing co-operations. Expensive data has been collected and is strongly guarded in the commercial interests of each operator. In the ADEME meetings it was as surprise to find managers confessing to warehouse space, low loadings of vehicles and the costs of running their operations. Of course they could see that this project, once running might alleviate their individual problems, but they are uneasy about the need for honest transparent declarations of capacity, costs and managerial ability (by implication) since these data reflect instantly on their profitability and indeed on their stock market valuations. The project managers constantly stress data privacy while also noting that it is only through managed and optimised global data that an operator can judge a proposed plan. The project managers also stress the governance aspect as it has a broad reach; including the legal responsibility for the pick-up and handling of other operators’ goods in once own vehicles or storage space. Financial responsibility and governance will also be addressed as many finely nuanced cash flows will be managed by the project’s software.

TECHNICAL INNOVATIONS

In order to meet the needs of businesses and changes in decision-assistance criteria, there is a fundamental need to develop a new tool. No tool currently marries the ability to take financial, organisational, and environmental impacts into account simultaneously. Thus the project software platform, consisting of innovative technologies, will be the first tool offering this three-fold combination.

[12] See their aims, documentation, publications and so on at www.predit.prd.fr

FUNCTIONAL ASPECTS

With the aim of improving management and rationalising logistics services for goods in urban areas, the software platform must be capable of identifying, uniting, promoting, and pooling supply and demand.

The platform takes three aspects into consideration:

- *Multiple players*: the target scope must cover all players concerned by the logistics of goods in cities.
- *Multiple resources*: it must integrate all available resources. All means of shipping and warehousing goods are to be considered as a solution to the demand for goods logistics services.
- *Multiple products*: the various types of goods transported imply special logistics specificities. This aspect therefore needs to be taken into consideration in the optimisation of logistics pooling.

To ensure the success and longevity project it is essential for the software platform to meet the following functional challenges:

- Have a design that continuously adapts to the capacities, financial and environmental factors of the integrated businesses.
- To take into account all the analysis and simulation needs of businesses.
- To ensure ease of use that is relevant for all players.
- To integrate requirements for security and confidentiality assurance not only to the businesses but also tax and regularity regimes.

MAJOR FUNCTIONS

The project will develop the 'operating system' for regulating the supply and demand of logistics services and optimising allocations. In order to cover all needs, the software platform must perform four major functions:

- *Management of repositories*: to ensure the accuracy of the scenarios and the pooling of logistics services it must integrate financial, capacity, and environmental constraints. The supply of data on changes in demand and capacities must be dynamic. Repository MANAGEMENT is therefore a structural function.
- *Simulation and optimisation*: it must provide key decision-making elements for possible pooling decisions. Simulation must therefore include an estimate of the projected vacant space, evaluation of organisational, financial, and environmental performance, and management of the associated risks. This must be available for all actors in the system.
- *"Carbon" assessment*: it must deduce the economic, ecological, and energy costs from the scenario simulations in order to meet the needs of logistics companies – including their carbon offsets.
- *Pooling*: to ensure optimised pooling and "win-win" cooperation between players it must automatically optimise the pooling, opportunities and requests, negotiations, and pricing between the parties involved, and do so dynamically in such a way as to take into account contextual changes. The management of associated services—that is, arbitration, transaction data storage, invoicing, and follow-up will provide a sizable organisational and administrative benefit across the whole system enabling individual firms to optimise their stocking, spatial and administrative systems.

To meet the functional needs the software platform must fulfil the following technical requirements:

- Ensure information security.
- Use existing and future [public] data and physical networks.
- Ensure the adaptability, longevity, and maintainability of the software platform.
- Guarantee availability and service levels, and offer high-performance response times.
- Provide the various players with very easy-to-use interfaces.

TECHNICAL OUTLINE

While it is not possible at this stage to be precise about the final configuration of the project and its physical deployment some aspects are becoming clear. There is a need to provide

- *Place de Marché* (PM) [market place] for pooling and negotiating logistics capacities.
- *Business Process Management* (BPM) to optimise planning and forecasting for "win-win" cooperation.

These two modules are illustrated as an integrated system in Figure 2.

The *Place de Marché* is used to organise and manage logistics service pooling exchanges. This module is used to create value by massing flows and optimising the use of unused capacities. Consisting of auto-decision-making functionalities, Place de Marché can:

- Consolidate offers and requests for logistics service capacity,
- Link pooling opportunities to requests via transactional arbitration in an automated and optimised fashion,
- Negotiate prices in real time in a transparent, equitable, and automated way by estimating the value of the vacant spaces on the market, but also other characteristics such as the CO_2 footprint and kilometres travelled.

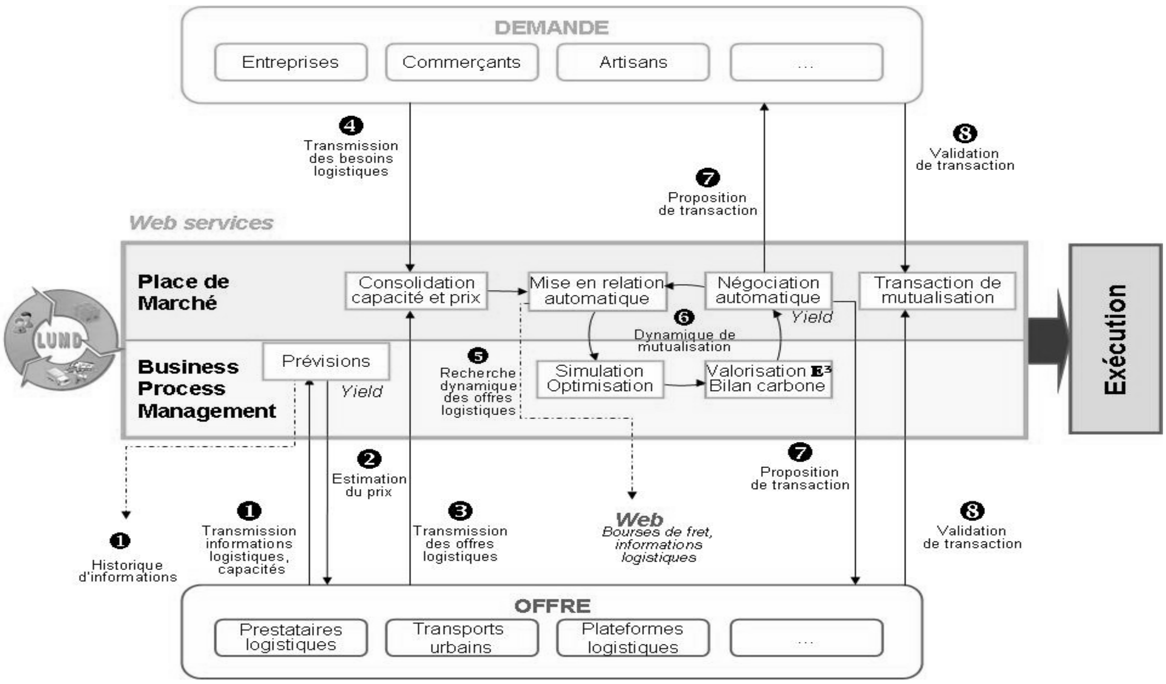

Figure 2: Core modules: Market Place and BPM

The *Business Process Management* module is based on an ontological proposition of logistics pooling. Using standards of business process notation, such as BPMN, BPEL, and UML, the ontology makes it possible to define a meta-model for describing pooling strategies, data exchanges, and business process management. The Business Process Management module consists of the cooperation between holistic multi-agent systems (MAS) and optimisation, simulation, and decision-making assistance techniques. Drawing from many disciplines (e.g. software engineering, artificial intelligence, distributed and concurrent programming, etc.), MASs are recognised as an effective means of designing self-adaptive communicating systems (adaptive memory programming, etc.) endowed with intelligence—that is, capable of responding to foreseen and unforeseen situations. Numerous models of agents, environments, interactions, and organisations will be developed and often combined within the same MAS (cognitive aspects, interaction protocol, collective decision, self-organisation mechanism, etc.) for logistics pooling management.

PERCEIVED ISSUES

As with all large scale software projects there is much promised. Soon however individual modules will be proved and merged so that simulations can be made with a view to giving early oversight of the potential solutions to the actors in the Parisian logistics system. By planning iterative developments it is hoped that individual differences can be ironed out early in the development phases, rather than having a solution imposed later which may be proved to be unworkable.

Nevertheless there are many hurdles to overcome, not least breaking through the present opacity – the natural reticence about discussing secure commercial data openly with ones competitors. This has always been an issue in co-opetition environments wherein some aspects of a firms' product range is combined with that of a competitor so they may co-operatively reach some market segment, yet in other product lines they remain competitors (Brandberger & Nalebutt, 1996).

Until the Parisian actors see that transparency really can work they will remain sceptical. And if the governance managers are weak the whole project will be at risk. These managers are not only to be product champions, but also to be governors "with teeth" who can lay down rules and see that they are maintained by the Parisian logistics community. For the moment all actors are looking forward to a solution being provided for an increasingly difficult Parisian delivery problem.

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DO CORPORATE GOOD GUYS PAY OFF THEIR GOOD DEEDS IN GREENNESS?

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ABSTRACT
Purpose
The purpose of the study is twofold: first, to explore whether a linkage between environmental effort and financial performance exists; second, to investigate if firms with more environmental efforts show a more significantly positive relationship between environmental performance and financial performance than those with less green efforts.

Design/methodology/approach
The study adopts correlation analysis of a sample comprised of 51 European companies from 14 industries across 15 countries to investigate the possible relationship between firm environmental performance (includes three measures: sustainable value, sustainable value margin, and return to cost ratio) and financial performance.

Findings
The paper does not find a positive relationship between firm environmental performance and financial performance. Both the Pearson correlations and Spearman's rho are statistically insignificant for both the full sample and the carbon-intensive sectors.

Originality/value
The paper provides a new perspective on the relationship between firm environmental performance and financial performance in monetary terms by taking a broader view at the environmental outcomes. While past studies only measure firm environmental performance based on damaging impacts to the environment, this research also considers the efficiency of resource use by the firm.

Keywords: Environmental performance, Financial performance, Green, Sustainable value.

Paper Type: Research paper

INTRODUCTION
A number of measures to assess corporate contributions to society have been proposed over the past, namely the reputation index, content analysis of company publications, and more recently, some published social indices. In this article, we focus on firm environmental performance and its relationship to firm financial performance. To this end, suitable measures of environmental performance and financial performance are needed. This study adopts several readily available commonly used measures of financial performance. As to the environmental performance measures, sustainability value (SV) by ADVANCE (2006) is used because it not only considers a firm's damage to the environment, but also how efficiently the firm creates value from natural resources.

The purposes of the present study is twofold: first, to explore whether a linkage between environmental efforts and financial performance exists; second, to investigate whether firms with more environmental efforts show a more significantly positive relationship between environmental performance and financial performance than those with less green efforts.

METHODOLOGY
Our sample consists of 65 European companies included in the ADVANCE Project (2006) funded by the EU and participating corporations. The project reports the value-based eco-ratings and relevant data of these 65 European companies from 2001 to 2003. Considering the lag effect on firm performance, financial performance data of these firms is collected by the authors from their annual reports from 2001 to 2007. Fourteen firms are dropped from the sample due to the

unavailability of their annual reports. The final sample used in our analysis comprises 51 European companies from 14 industries across 15 countries. A Chi-square test is performed to verify whether dropping firms from the original sample alters the sample distribution.

Using data from the ADVANCE Project, three proxies, including sustainable value, sustainable value margin, and return to cost ratio are adopted to capture the green management efforts of the companies. Readers are encouraged to refer to the project source for details. From an opportunity cost perspective, sustainable value represents the value that is created or lost through the use of a set of different resources by a company. Seven environmental resources are taken into account: (1) Carbon dioxide (CO_2) emissions, (2) Nitrogen oxide (NO_x) emissions, (3) Sulphur oxide (SO_x) emissions, (4) Emissions of volatile organic compounds (VOC), (5) Methane (CH_4) emissions, (6) Waste generation, and (7) Water use.

The EU15 is used as the benchmark. Sustainable value has been applied to economic, environmental, and social resources and has been practiced in the financial markets for many decades. Usually, large companies are expected to have larger sustainable value figures. Therefore, considering the size effect, two indicators are used: (1) sustainable value margin and (2) return to cost ratio. Four financial performance measures are used in our study. EBIT/Assets – the textbook measure of profitability relative to total capital employed by the firm – is used to measure firm performance, and has been commonly employed in previous studies (Denis and Denis, 1995; Eberhart, Maxwell and Siddique, 2004; Huson, Malatesta and Parrino, 2004). Other accounting performance measures: earnings per share (EPS), returns on assets (ROA), and returns on equity (ROE) are also used in the analysis. Correlation analysis (both Pearson correlation and Spearman's rho) is applied to capture the possible relationship between environmental performance (e.g. sustainable value) and financial performance.

RESULTS

Table 1 presents the descriptive statistics of environmental performance and financial performance. The mean and median values of the return to cost ratio are 1.24 and 0.53. Comparing with the benchmark (the EU15), they are 1.24:1 and 1:1.89 respectively. A firm with a return to cost ratio of 1.24:1 uses its resource 1.24 times more efficiently than the EU15 on average, while with a return to cost ratio of 1:1.89 uses its resources only about half as efficiently as the benchmark. The sustainable value margin is spread widely, with substantially different values for mean and median (-138.70 and -24.70) and a large standard deviation (327.50). The sustainable value and EPS show similar patterns which may be due to that data being collected from a wide variety of countries and industries.

Table 2 Descriptive statistics of environmental and financial performance

	Mean	Median	25th Percentile	75th Percentile	Std. Deviation
Sustainable Value	-13,125.07	-575.78	-8,614.67	1,727.31	34,133.59
Sustainable Value Margin	-138.70	-24.70	-145.00	16.90	327.50
Return to Cost Ratio	1.24	0.53	0.16	2.10	1.30
EBIT/Assets	0.06	0.05	0.02	0.09	0.05
EPS	99.50	1.65	0.24	10.09	370.97
ROA	0.03	0.03	0.01	0.05	0.05
ROE	0.05	0.07	0.02	0.15	0.16

Notes: Sustainable value is represented in millions of Euros. EPS denotes the diluted EPS.

Table 2 demonstrates the correlation coefficients of green measures and financial performance. Panel A shows the coefficients of both Pearson correlation and Spearman's rho based on the full sample. The Pearson correlation of the sustainable value and EBIT/Assets is significantly negative. However, since the sustainable value does not take the firm size into account, the sustainable value margin may be a more appropriate measure than sustainable value. It can be seen that the correlation coefficient of sustainable value margin and EBIT/Assets is insignificant. The remaining Pearson correlations and all Spearman's rho are all insignificant. The results reveal that there is no relation between firm environmental performance and financial performance. Considering the possible lag effect on financial performance, the authors also compute one-year to four-year lag effects of environmental efforts using the financial performance data during the periods of 2002 to 2004, 2003 to 2005, 2004 to 2006, and 2005 to 2007, respectively. The results are not included in Table 3 since they are similar to those without considering the lag effect.

Taking the nature of industry into account, Panel B displays the correlation coefficients for carbon-intensive sectors. Not surprisingly, the result is similar to Panel A since the carbon-intensive sectors take up a large portion of the full sample. The empirical results suggest that a significant relationship between firm environmental performance and financial performance is not found within the carbon-intensive sector.

Table 3 Relationships between firm environmental and financial performance

	Pearson Correlation				Spearman's Rho			
Panel A: Full Sample	EBIT/Assets	EPS	ROA	ROE	EBIT/Assets	EPS	ROA	ROE
Sustainable Value	-0.21*	0.09	-0.08	-0.08	-0.14	0.00	-0.03	0.01
Sustainable Value Margin	0.16	0.13	0.10	0.01	-0.02	-0.03	0.02	0.01
Return to Cost Ratio	-0.14	-0.01	-0.17	-0.14	-0.12	-0.05	-0.06	-0.05
	Pearson Correlation				Spearman's Rho			
Panel B: Carbon-Intensive Sectors	EBIT/Assets	EPS	ROA	ROE	EBIT/Assets	EPS	ROA	ROE
Sustainable Value	-0.24*	0.11	-0.08	-0.10	-0.13	0.19	-0.01	0.04
Sustainable Value Margin	0.17	0.17	0.12	0.00	-0.01	0.21	0.03	0.06
Return to Cost Ratio	-0.13	0.06	-0.15	-0.15	-0.09	0.20	-0.02	0.02
	Good Performers in Return to Cost Ratio				Bad Performers in Return to Cost Ratio			
Panel C: Progress and Regress	EBIT/Assets	EPS	ROA	ROE	EBIT/Assets	EPS	ROA	ROE
Sustainable Value	-0.24	0.18	-0.08	-0.11	-0.12	0.17	0.07	0.00
Sustainable Value Margin	0.32	0.18	0.26	0.14	0.10	0.14	0.00	-0.10
Return to Cost Ratio	-0.05	-0.04	-0.03	0.01	-0.23	-0.23	-0.31	-0.26

Notes: * indicates that the correlation is significant at the 0.05 level (2-tailed).

The results for good performers and bad performers in return to cost ratio are both insignificant which is consistent with the previous Panels. In other words, no matter whether the firm makes progress or regress in green measures, a relationship between its environmental performance and financial performance cannot be found.

CONCLUSIONS

The current study attempted to identify whether the good-heartedness of firms meet with recompense based on data from 51 European companies of 14 industries across 15 countries. The research findings in this study suggest that corporate good guys do not necessarily reap the rewards of their green efforts. The finding applies to both the full sample and the carbon-intensive sectors. The result of this study also suggests that green efforts may not be the reason why some companies are suffering. Simply put, acting green may have nothing to do with the underperformance of these companies. There may be other issues associated with these companies that cause their underperformance.

This paper uses a new measure for firm environmental performance which takes into account the efficiency of resource use by companies. In this paper, we adopt the eco-efficiency concept to construct a broader measure of environmental performance. Although the relationship between firm environmental performance and financial performance could not be found in this study, we believe that environmental performance should not be measured solely on the damage done to the environment. While a relationship between firm environmental performance and financial performance could not be found, managers and researchers may still benefit from this study.

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REAL TIME ASSIGNMENT OF CO2 EMISSIONS IN TRANSPORTATION PROCESS -A SYSTEM DEVELOPMENT AND ANALYSIS OF INFORMATION SYSTEM WITH RFID-

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ABSTRACT
This paper aims at a development of the structure of the information management system for environmental logistics to measure CO_2 emissions caused by distribution activities with high accuracy. The conducted research technique is developed from an information model consisting of "The information system to get the data of fuel consumptions" and "Radio Frequency Identification (RFID)-Tag information system". The information management system is developed and verified in this paper based on the proposed concept which makes it possible to grasp the CO_2 emissions by each transported goods unit. This system contributes to show how amount is loaded by each owner in their transportation activities and bring a new marketing paradigm in which the customers can choose the goods based on the information not only their prices but environmental loads per good or owner.

Key words: Environmental Sustainability and Green Logistics, Supply Chain Management

Introduction
As recent situation, 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 2008, Japanese Government tried to introduce the "Carbon-Footprint System" in a hurry. This is an attempt that starts displaying the volume of CO_2 emissions through all processes from the raw material procurement to disposal. However, the Japanese "Carbon-Footprint System" cannot clarify the encouraging CO_2 information for the each environmental activity because the CO_2 calculation method used in this system is based on the past and static data. The volume of the CO_2 emissions differ by each trip condition such as traffic, delivery routes, weight of goods and types of trucks, etc., and each trip condition also depends on dynamic behaviors among owners, drivers and retailers. To realize this direction, it is necessary to grasp the volume of CO_2 emissions caused by their delivery or transportation activities in real-time.

An information model to calculate the detailed CO_2 emissions in real time was reported by Yoshifuji et al. (2008). Based on the model, this study aim to develop the concept and build up the proposed information system which collect the data of transportation conditions automatically in the each transportation activities and calculate the CO_2 emissions at same time, and to allocate the CO_2 emissions to related transportation goods in real-time. Figure 1 shows the direction of development of the proposed information system in view of the synchronization and accuracy for the observed CO2 volumes per good. The system proposed in our research contains the following three subsystems:

1) "The information system" to get the data of fuel consumptions by the truck in each driving status.
2) "The RFID-Tag information system" to get the data of loads transported by the trucks.
3) "The calculation system and database" to unify all information and to allocate CO_2 emissions to each transportation goods.

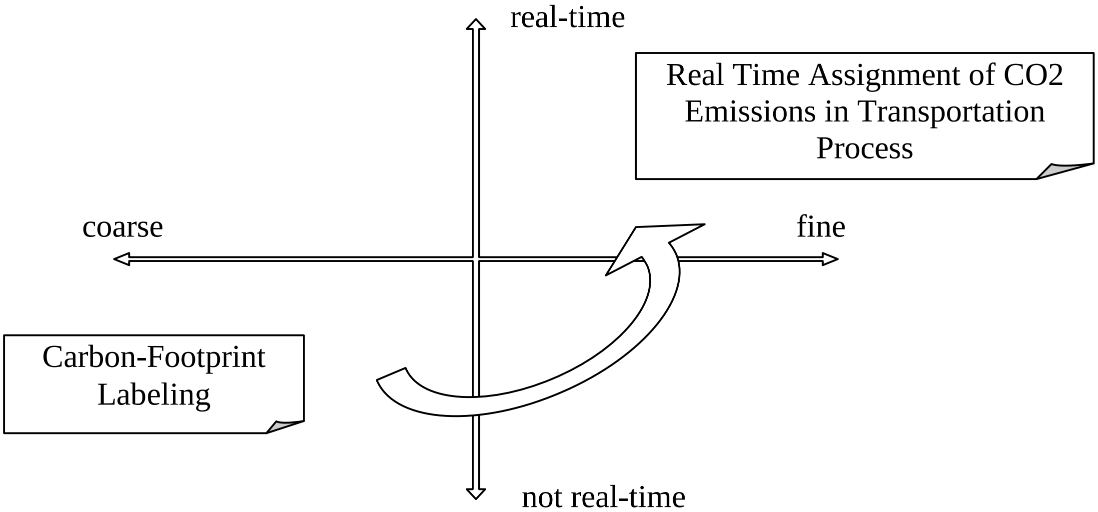


Figure 1: The direction of development of the proposed information system

First of all, the information system on the truck keep on record of the delivery route and the amount of fuel consumption and calculates the CO_2 emissions in real-time by using the fuel gauge. The fuel gauge and the information system is developed to measure the fuel consumption in more detail and in real-time at each time of loading or unloading. Secondly, for this object, this system needs to grasps clearly the loading and unloading time, therefore, the RFID-Tag read-write equipment is used. The RFID systems of 2.45GHZ belt is examined from the viewpoint of usage condition and requested specifications. Thirdly, the above two systems are integrated. By using the collected information on the database, it is possible to allocate the CO_2 emissions to each goods by each transportation section at real-time as necessary. This part is the most characteristic point in this system. Then, the volume of CO_2 which is allocated per good is useful from the viewpoints of both management of transportation activities and marketing strategy to get the new customers. By using the information of the CO_2 emissions by each good, it becomes possible for customers to choose their delivery method from the supplier, for examine, the route delivery or the direct sending by each good, depending on its environmental loads.

Specifically, the difference of allocated CO_2 between the conventional method and the proposed method is clarified. Then we give a deep consideration about the causes of the differences in consideration of the transportation weight, its frequency of loading and unloading, and other system characteristics. In order to clarify the proposed system, we demonstrate how to measure the transportation data of a transportation companies and owner companies by using this proposed system and evaluate the fairness of allocation of the CO_2 emissions. From the test experiments, the effectiveness of the proposed system is shown.

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 CO_2 emissions by using the advanced fuel gauge. For this system, the existing advanced fuel gauge named "TRU-SUM" (*1) is introduced 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 driving-time and stopping-time with a manual operation by a driver or deliverer (Figure 3). One of future developments should have 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 in Japan. This is "Run analysis software" made for administration, cost management and security management of distribution activities.

The travel information obtained from Table 1 is as follows: Truck Number, Time Stamp, and Fuel Consumptions. This system clarifies the data of fuel consumption of the truck and driving status and enables to acquire the necessary information to capture the CO_2 emissions by the owner.

Moreover, in the case of the route delivery, it is expected that the environmental impacts allocated to the owners will change depending on the round route. Therefore, additional information processing should be considered for allocating the fuel consumption by each delivery methods and contracts.

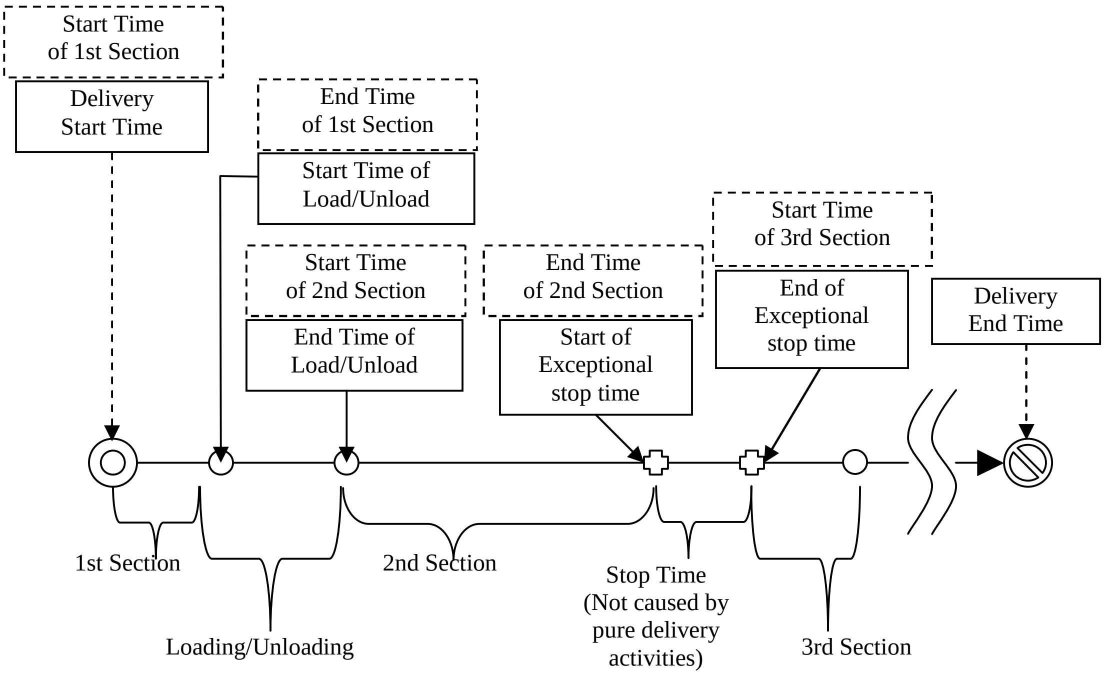
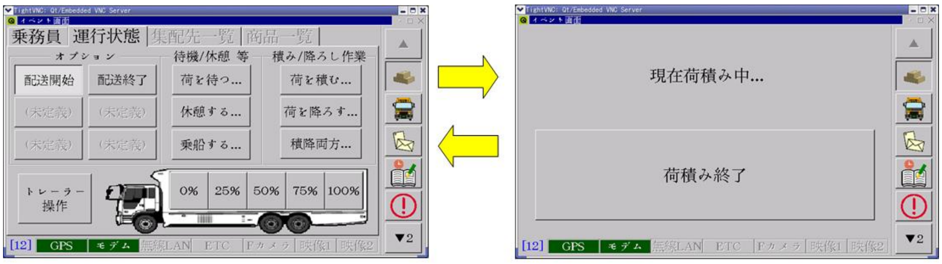


Figure 2：Timing to get the data of the fuel consumption of truck and driving status (Case: Direct sending)



	A	B	C	D	E	F	G	H	I	J	K
1	677	1	2008/2/19 8:59	51	2000648	7823214	2	1.3	0.84	1	1
2	677	2	2008/2/19 9:10	13	2000648	7823214	2	5.9	3.8	1	1
3	677	3	2008/2/19 9:25	14	2000648	7823214	2	5.9	4.45	1	2
4	677	4	2008/2/19 9:45	7	2000648	7823214	2	16	5.14	1	2
5	677	5	2008/2/19 10:00	8	2000648	7823214	2	16	5.59	1	3
6	677	6	2008/2/19 10:40	15	2000648	7823214	2	36.8	5.93	1	3
7	677	7	2008/2/19 11:00	16	2000648	7823214	2	36.8	6.75	1	4
8	677	8	2008/2/19 12:00	52	2000648	7823214	2	60	7.23	1	4
9											

Figure 3: User Interface for Driver

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

2) "The RFID-Tag information system" to get the data of the loads transported by trucks

This system captures 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 4. By reading owner information and goods ID, each loading/unloading information is grasped in real time according to the timing of loading/unloading. The two types of RFID systems of 950MHz and 2.45GHZ belts are examined. The appropriate frequency belt has to be chosen in consideration with the communication range, its accuracy and other conditions. Through the practical experiments, another issue remains how to choose the optimal frequency belt of the RFID-Tag system in the future.

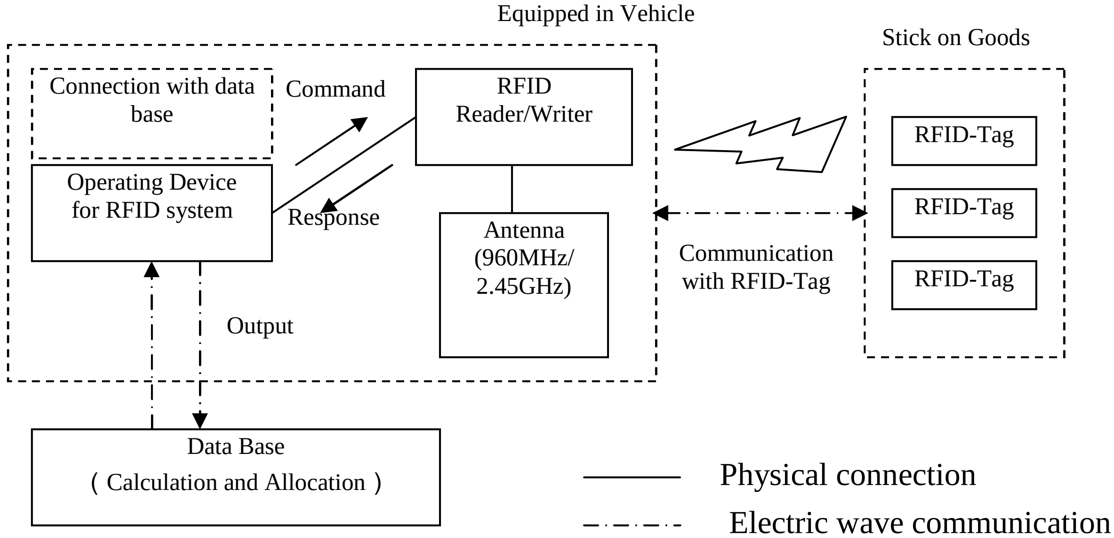


Figure 4: Communication between the data base and RFID-Tag

< Necessary equipment as for one vehicle in this system (Figure 5)>

・ 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 their luggage information is recorded. 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 antenna 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 the operation of 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 5: Necessary equipment as for one vehicle in this system

3) "The calculation system and database" to unify all information and to allocate CO_2 emissions to owners

Finally, the information from these two systems is integrated. By using the collected information on the database, the CO_2 emissions should be allocated to each good by each transportation section in real-time as necessary. Figure 6 shows the whole image of this system. “The information system for getting the data of fuel consumptions of truck and driving status” and “The RFID-Tag information system for getting the data of loads transported by trucks” are connected by the Ethernet communication.

We developed the information model that could measure the CO_2 emissions caused by distribution activities and allocate it in detail by using the fuel system and the IC tag system. It is shown that the amount of CO_2 emission with which each luggage should be burdened can be grasped individually by calculating CO_2 emissions in the delivery activities on real time.

By constructing this system, it enables to grasp information on the amount of the CO_2 emissions and the luggage related to the delivery in real time, as well as understands the amount of CO_2 emissions per good individually. The ideal system is appropriately switchable to share the CO_2 emissions according to the difference delivery method such as the route delivery and direct sending.

Experiment

The effectiveness of the proposed system is examined by investigation of the difference between proposal and a conventional way. In this experimental evaluation, we use a simulation data of driving, load and unloading activities which is acquired from the real transportation (Figure 7). Table 2 shows the result of CO_2 emissions which are calculated by the proposed system.

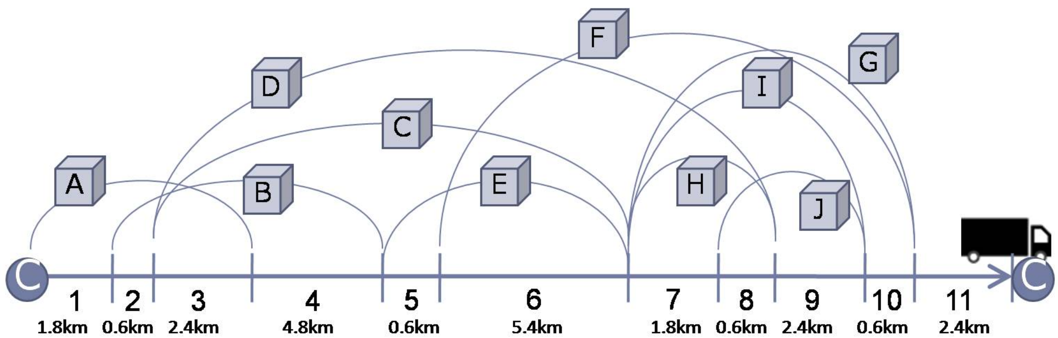


Figure 7: Experiment condition (mixed loading)

Table 2: Experimental result (CO_2)

section

item

	1	2	3	4	5	6	7	8	9	10	SUM
A	1098	300	348	0	0	0	0	0	0	0	1746
B	0	198	228	546	0	0	0	0	0	0	972
C	0	0	402	954	264	594	0	0	0	0	2214
D	0	0	96	228	60	138	84	30	0	0	636
E	0	0	0	0	120	270	0	0	0	0	390
F	0	0	0	0	0	402	240	96	306	414	1458
G	0	0	0	0	0	0	120	48	156	210	534
H	0	0	0	0	0	0	264	108	0	0	372
I	0	0	0	0	0	0	366	150	468	0	984
J	0	0	0	0	0	0	0	84	270	0	354

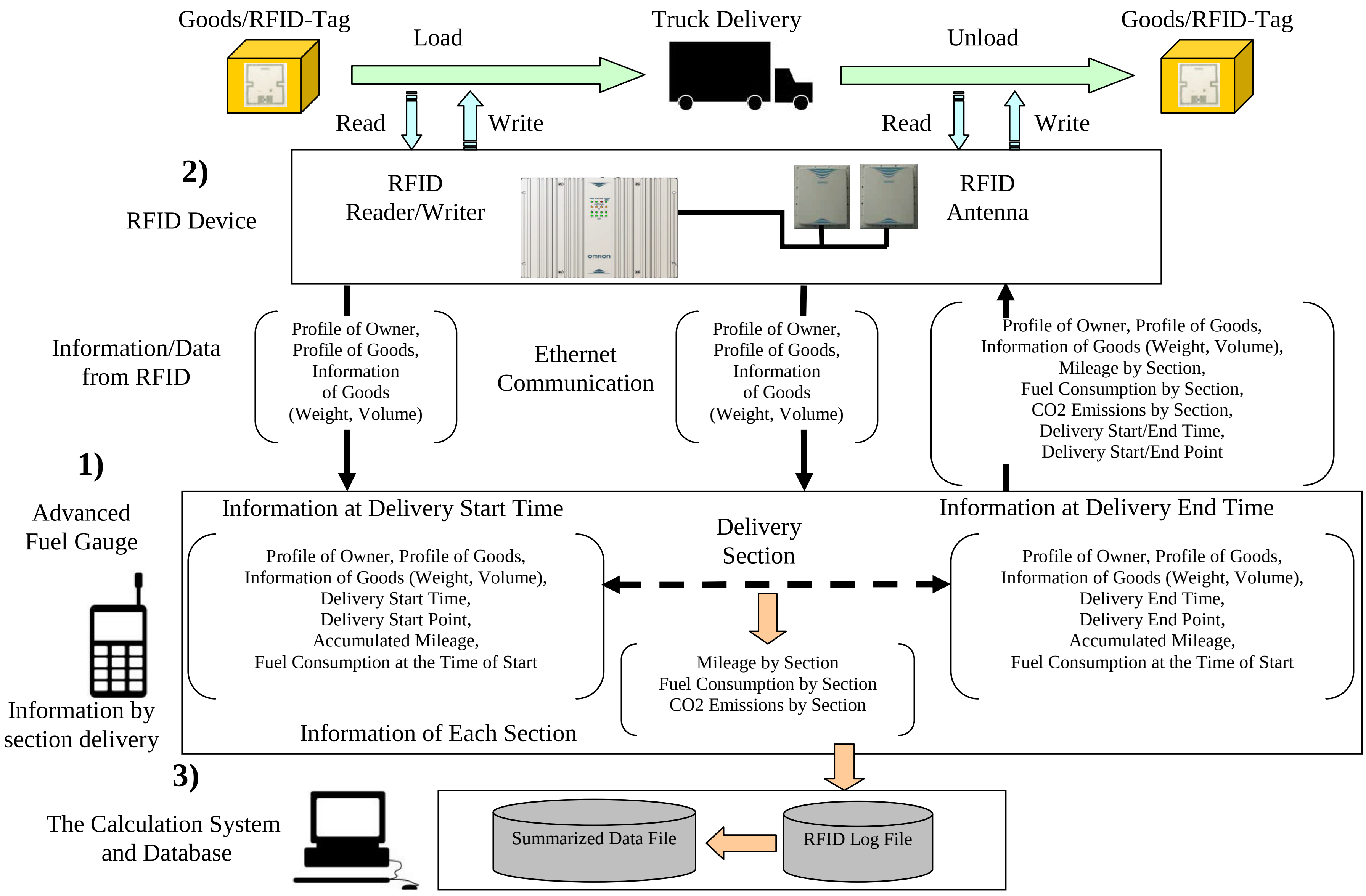


Figure 6: Whole image of this system

Finally, we examine the difference of allocated CO_2 emissions between the proposed system and the ton-km method which is one of the well-known conventional ways in green logistics. Figure 8 shows the CO_2 emissions of each section.

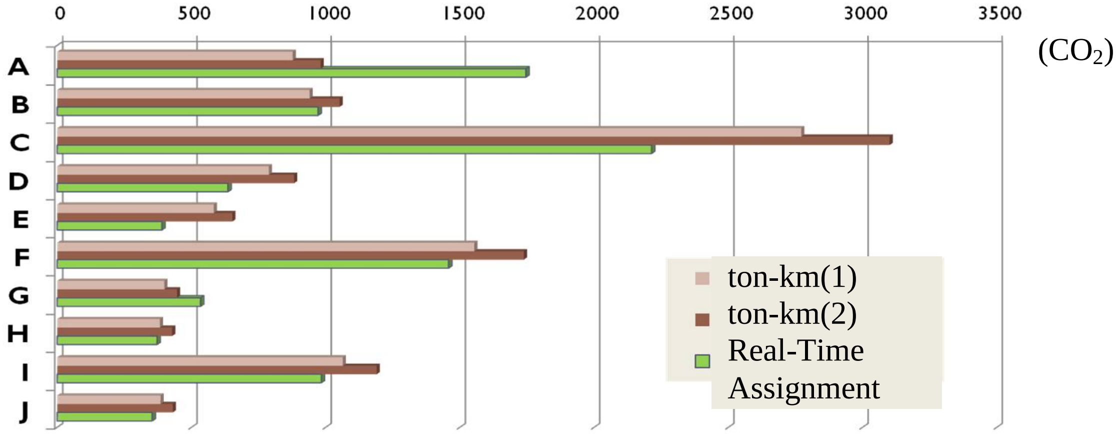


Figure 8: Result of each assignment (CO_2)

We developed the information model to grasp the CO_2 emissions caused by distribution activities and to allocate it to each luggage in detail by using the fuel system and the IC tag system. It is shown that the amount of CO_2 emission with which each luggage should be burdened can be grasped individually by calculating CO_2 emissions in the delivery activities on real time.

By constructing this system, it enables to grasp information on the amount of the CO_2 emissions and the luggage related to the delivery in real time, as well as understands the amount of CO_2 emissions per good individually. The ideal system is appropriately switchable to share CO_2 emission according to the difference delivery method such as the route delivery and direct sending.

CONCLUSIONS

This paper developed the real time assignment system of CO_2 emissions for truck transportation. The amount of CO_2 emission per goods individually can be calculated on real time through the system and may be useful for business activities. This system makes it possible to get the information of CO2 emissions which can be individually grasped for driving sections, transported luggage, and owner of the goods on real time. In comparison with the conventional ton-kg method, the proposed way is effective for detailed estimation of CO_2 emission caused by transportation activity on real time. This CO_2 information can be used for several purposes in business design.

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REAL TIME ASSIGNMENT OF CO2 EMISSIONS IN TRANSPORTATION PROCESS - A PROCESS IMPROVEMENT BY INFORMATION SYSTEM WITH RFID -

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ABSTRACT
For environmental logistics and transportations, it is necessary to grasp and estimate CO2 emissions for each product and assign to owners of their items. The carbon footprint is one of the methods and well known, where CO2 volumes through all logistics processes are statically predetermined and printed on each product before the actual transportations have not been done.
In view of the transportation process, the actual CO2 emissions of each item should be determined by measuring the actual fuel consumptions of the trucks for transporting it. The CO2 emissions are different by each trip condition such as traffic, routes, weight of goods and types of trucks, and the trip condition depends on dynamic operations among owners, transporters and retailers. However, it is not easy for them to improve their operations environmentally because they cannot know the CO2 volumes in real time.

This study develops a fuel gauge with an IC tag system, and tries to grasp and assign the CO2 volumes to each transportation item in real time. First, the real time grasp and assignment method is proposed using an IC tag system with a fuel gauge. Next, the experiment is prepared and carried out, and the real time process and result is shown and demonstrated for grasping and assigning the CO2 volumes by each transported item. Finally, the potential benefits and promoted KAIZEN activities are summarized for owners, transporters, retailers and consumers, and the CO2 assignment of the empty vehicle is further considered.

Keywords: Environmental Logistics, Fuel Consumption, Transportation Process KAIZEN, RFID

INTRODUCTION
For transportations in environmental logistics, it is necessary to grasp actual CO2 emissions by each product and assign to owners of their items. The carbon footprint (for example, Sundarakani (2008)) is well known, where the CO2 volumes through all logistics processes are predetermined and printed on each product before the actual transportations have not been done by calculating and assigning the total CO2 volumes of the process statically.

In view of the track transportations, the actual CO2 emissions of each item are obtained if and only if by measuring the actual fuel consumptions of the trucks during the transportations. This is because the CO2 emissions in the transportation process are different by each trip condition such as traffic, routes, weight of goods and types of trucks, and also the trip condition depends on dynamic operations among owners, transporters and retailers. However, it is not easy for them to improve their dynamic operations from the viewpoint of the environmental aspect because they cannot know the CO2 volumes in real time.

This study develops a fuel gauge with an IC tag system (Yoshifuji et al., 2008), and tries to grasp and assign the CO2 volumes to each transported item in real time. The outline of this paper is as follows: Section 2 introduces an IC tag system connected to a fuel gauge, and proposes the real time grasp and assignment method of the CO2 emissions for transportations. In Section 3, the experimental process and result are shown and demonstrated to grasp and assign the CO2 volumes by each transported item in real time, and the potential benefits and promoted KAIZEN activities are summarized for owners, transporters, retailers, and then consumers. Finally, Section 4 further considers the treatment of the CO2 assignment for the empty vehicle, and Section 5 summaries this paper and proposes future studies.

METHOD OF REAL TIME GRASP AND ASSIGNMENT OF CO2 EMISSIONS FOR TRUCK TRANSPORTATION BY RFID INFORMATION SYSTEM

This study uses a fuel gauge with an IC tag system (Yoshifuji et al., 2008) for the transportation system, and tries to grasp and assignment of CO2 volumes to each transported item in real time. The system consists of a fuel gauge for trucks, IC-Tags for each item, RFID reader and writer, RFID antenna, and each IC tag which can be labelled on each item.

In the experiments, a truck virtually runs on the fuel gauge system using a travel data simulation. The system records the distances between each section, and calculates the actual fuel consumptions depending on dynamic traffic conditions and the CO2 volumes for each section. When transported items are loaded/unloaded, an operator actually holds the IC tags labelled on the items over the antenna. The actual data such as the fuel consumptions, mileages and CO2 volumes for each section in the information system is read and written to the IC tag on the unloaded item. At the same time, the assignments of the CO2 volumes among the items are carried out for each section based on mileage and weights of items. The procedure of the experiments by the system is as follows:

(1) A transportation data such as the speed, fuel efficiency and travel time for each section is made to input on a travel data simulator.
(2) By using IC tags and an antenna, an item data such as owner codes, goods codes and their weights are written to each IC tag of the item.
(3) The transportation data is registered into the fuel consumption system, and a truck virtually runs and transports items on the fuel gauge system.
(4) The truck stops for loading/unloading the items and runs for their transportation on the system. The IC tags of the items are actually held over the RFID antenna connected to the IC tag reader/writer by an operator, and the CO2 volumes data are calculated and written to the IC tag on each unloaded item.
(5) After the transportation, the total data such as the fuel efficiency, distances, and CO2 volumes per item are also taken from the system.

Table 1 An experiment input data of items and transportations

Item/Tag No.	Owner code	Item code	Weight of item [kg]	Section 1	Status	Section 2	Status	Section 3	Status	Section 4	Status	Section 5
1	4	13	5	Empty	L	T	U	-	-	-	-	Empty
2	5	14	5		L	T		T	U	-	-	
3	6	15	5		L	T		T		T	U	
			Distance of Section [100m]	13	-	9		10		10	-	15
	T: Transportation, L: Loading, UL: Unloading											

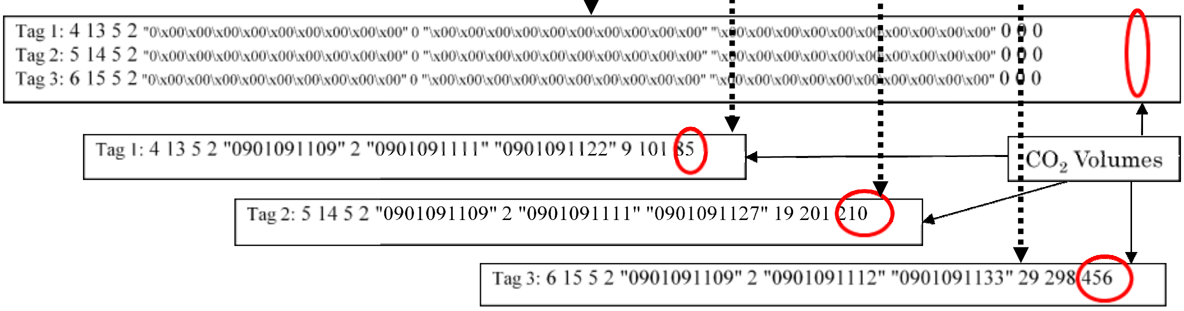

Figure 1 An example recode on IC tags for real time grasp and assignment of CO2 volumes in the experiment

Table 2 A system output of CO2 volumes summary for each section in the experiment

Trip ID	2009/1/9 11:09		2					
Owner code	0	4	5	6	Distance	Fuel consumption	CO2 Volumes	Total weight
Goods code	0	13	14	15	[100m]	[ml]	[g-CO2]	[kg]
Total Assignment	769	85	210	456	57	604	1522	30
Section 1	334	0	0	0	13	133	334	0
Section 2	0	85	85	85	9	101	256	15
Section 3	0	0	125	125	10	100	251	10
Section 4	0	0	0	246	10	97	246	5
Section 5	435	0	0	0	15	173	435	0

EXPERIMENTAL RESULTS FOR REAL TIME GRASP AND ASSIGNTMENT OF CO2 EMISSTIONS

According to the experiment procedure in Section 2, an experiment with the fuel gauge with the IC tag system is done to examine the system function. Table 1 shows an experiment input data of items and transportations for the experiment. There are 3 types of transported items #1, 2 and 3, and the weight of each good is the same and set as 5 [kg]. First, an empty truck starts to run from his garage to a distribution center to pick up goods as the section 1, stops and loads the 3 items at the end of the section 1. Next, it goes to the 1st destination for the item #1 with the rest goods as the section 2, stops and unloads it at the end of the section 2. After that, it goes to the next destinations again, stops and unloads one of their goods at the end of the sections repeatedly. After the all items are unloaded, the truck becomes empty and goes back to his garage. Figure 1 shows an example recode on the IC tags for the real time grasp and assignment of the CO2 volumes in the experiment. When the items were loaded at the end of the section 1, the all data on their IC tag was zero for the CO2 volumes. During the trip, the information system with a fuel gauge always grasped the CO2 volumes for total and each section in real time. The CO2 volumes by each section were assigned to each item when one of their items was unloaded. Table 2 shows the system output of the CO2 volumes for each section in the experiment. This data are obtained when the trip is done. The all CO2 volumes for each item are calculated by each section including the empty truck for picking up and going back from/to his garage. Based on the experiment, the potential benefits and promoted KAIZEN activities by this system are summarized in Table 3.

Table 3 Summary of potential benefits and promoted KAIZEN activities by the proposed RFID system

Participants	Potential benefits	Promoted KAIZEN activities
Owners (Manufacturers)	● understand quantitatively actual environmental loads by each item with different mileages and weights	● develop small and light products ● promote local production for local consumption ● choose transporters in view of not only low fares/short lead times but also low CO2 volumes ● choose environmental delivery services such as cooperative and milk-run logistics
Transporters	● understand when and what kind of KAIZEN activities are effective in real time ● show not only fares/lead times but also environmental activities for transporters and retailers	● dynamically select and change transportation routes considering traffic conditions in real time ● develop and operate lower CO2 driving ● propose environmental

	• bring lower fuel costs by lower fuel consumptions	delivery services such as cooperative and milk-run logistics for owners based on the actual CO_2 volumes
Retailers	• show actual CO_2 volumes by each item for consumers at their stores • hold environmentally conscious consumers on their markets	• choose products at their stores in view of not only low fares/short lead times but also low CO_2 volumes • choose local production products for local consumption
Consumers	• see the actual CO_2 volumes by each item • know what the same items individually have different CO_2 volumes depending on delivery timing and the KAIZEN activities • improve to satisfy environmentally consciousness	• choose products in view of not only low prices but also low CO_2 volumes for transportations • choose products with lower CO_2 volumes among the same ones • choose local production products for local consumption

CONSIDERATIONS FOR CO2 ASSIGNMENT OF EMPTY VEHICLES

By using this information system, the actual CO_2 volumes of the empty vehicles for picking up goods and going back to his garage are also calculated. However, it still remains how to deal with and assign the CO_2 volumes during the empty.

Figure 2 shows an example of the CO_2 assignment with and without the empty vehicle in the experiment. The CO_2 volumes for the empty vehicle is 769 [g-CO2] in the experiment, and is not considered in the case without the empty vehicle. On the other hand, the CO_2 volumes in the case with the empty vehicle are assigned to the transporter only, to the owners only by mileages and weights of their items, and to the both transporter and owners.

In the scenario of the both transporter and owners assigned, the volumes before the picking up goods in the section 1 is 334 [g-CO2] for the transporter assigned, and ones after the delivery in the section 5 is 435 [g-CO2] for the 3 owners assigned based on mileages and weights. In the view of the social impact, this scenario is better than the others because many participants try the environmental efforts. Also, to use neighboring transporters is promoted for the owners of their items.

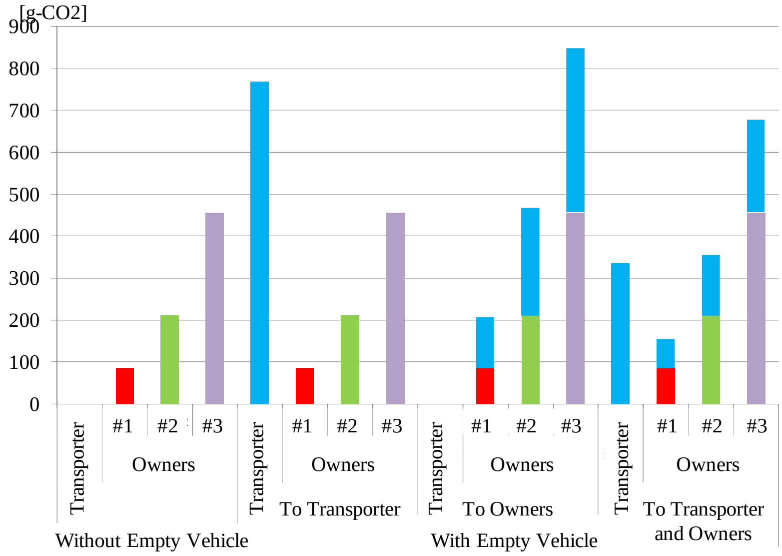

Figure 2 An example of CO2 assignment with and without the empty vehicle in the experiment

SUMMARY AND FUTURE STUDIES

This study developed an IC tag system with a fuel gauge, and proposed a real time grasp and assignment method of the CO2 volumes by each transported item. Throughout the experiment, the real time grasp and assignment of the CO2 volumes were demonstrated by each item, and the potential benefits and promoted KAIZEN activities were summarized. Also, the CO2 assignment for the empty vehicles was considered. Future studies should carry out a further experiment by using an actual truck operation, compares to the simulated transportation process, develop a display method for the CO2 assignment by the empty vehicles, etc.

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GREEN SUPPLY CHAINS: CLOSING THE LOOP, A CASE STUDY OF THE BIO-ENERGY INDUSTRY.

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Keywords: Supply chain performance, reverse logistics, biomass fuels biomass power station, timber industry.

ABSTRACT
Purpose
The purpose of this paper is to present the key findings from an investigation of the supply chain using renewable resources to generate electricity that supplies the national grid. Closed loop supply chains have been linked with measuring performance of reverse logistics channels (Fleischmann et al, 2003). Here, reverse channels add value by utilising product returns and end-of-life products but, in this case, the closed loop model is applied to investigate the sustainability and performance of the supply of renewable materials to fuel biomass energy plants.

Introduction
The study investigated the organisation of a commercial biomass power station using timber chip at Western Bio Energy Ltd based near Port Talbot in South West Wales. Carbon dioxide emission from fossil fuels is regarded as a major contribution to global warming. The underlying impetus of reducing green house gas emission forms part of the Welsh Assembly Government's Environment Strategy for Wales (2006) and Low Carbon Wales (March 2007) by seeking to reduce dependence on fossil fuels and encourage use of alternative forms of energy. One such initiative is the biomass power station developed by Western Bio Energy Ltd., which is fuelled by wood chip. Timber chip derived from trees during growth has fixed a proportion of atmospheric CO_2. The CO_2 released during its combustion results in a theoretical no net increase in CO_2. Biomass is a renewable source of energy and therefore the plant will increase the proportion of clean energy produced in the Port Talbot area, thereby reducing the overall CO_2 production by replacing the CO_2 that would have been derived from fossil fuels. To supply sufficient fuel, Western Bio Energy Ltd has contracted with Forest Enterprise for wood chip supplies and for sale of electricity to a licensed electricity supplier. A key feature of the plant is that it will only use clean wood material from coniferous forests and sawmills. Approximately 40% of wood material will come directly from UK-based forestry and the remaining 60% will be provided by local sawmills in the form of 'clean' waste wood.

Overview of the literature and the growth of interest in reverse logistics
Interest from academics in developing seamless supply chains adds to the importance, but complexity of logistics provision. Much of this attention has been directed to studies in environmental logistics, and in particular, reverse logistics, (Dowlatshahi, 2000; Srivastava, 2007). Central to this area is to understand the differentiation between the forward and reverse channels of logistics provision, (Sarkis, 1995; Thierry et al., 1995; Kopicki et al., 1993; Pohlen and Farris, 1992 and Stock, 1992). This body of literature takes its origins outside the renewable energy industry, but nevertheless models for

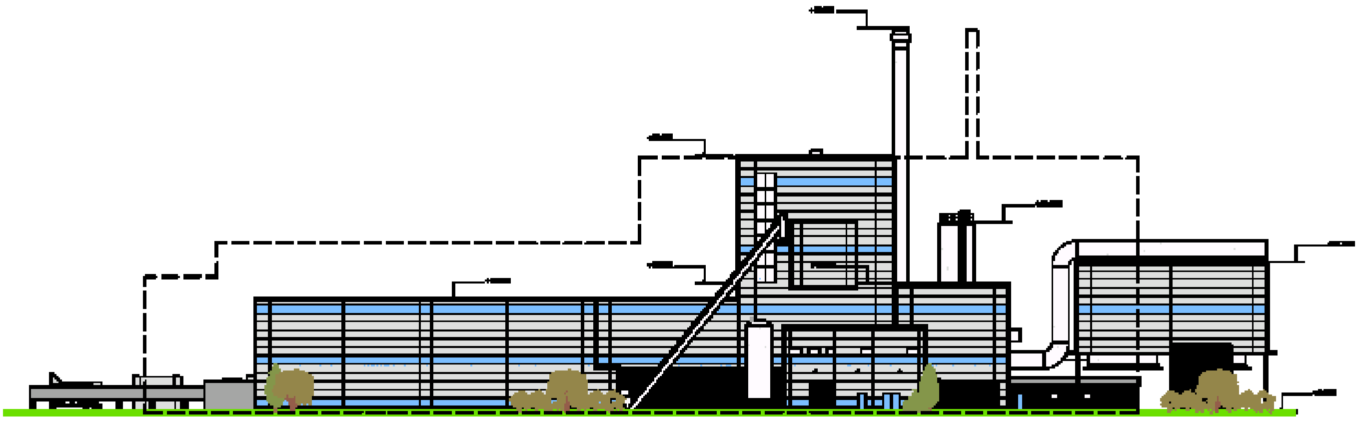
measuring performance emanating from these studies are pertinent to understanding performance characteristics in renewable energy supply chains.

Performance measures help manage complexity and competitiveness of many logistics' and supply chain functions but, there are sound arguments against generic; 'one-size-fits-all' approaches cited in Neely (1995), Folan and Browne, (2005). However, identifying which performance measures to adopt for a company can prove challenging and it is this that makes attempts to define closed loop supply chains a difficult one, particularly where there are both qualitative and quantitative measures to consider. Categories include time, cost, quality and efficiency (Chow et al., 1994). Whilst time, cost and quality are easy to quantify and define, efficiency is not, as it has ambiguous and diverse meanings depending on what aspects of logistics and the supply chain are observed. For example, Caplice and Sheffi (1994) measured efficiency as productivity, whereas Mentzer and Konrad (1991) discussed efficiency as time and resource utilization; Johansson et al. (1993) aligned efficiency with service. Kallio et al., (2000) recognized different applications to measuring performance and developed a framework of performance measurement determined by logistics function that such metrics could apply.

According to the Kallio et al (2000) paper there is a distinction between those performance measures used for operational processes and the metrics applied to measure total performance throughout the whole supply chain. This has particular resonance for methodologies used to measure performance in reverse logistics as the Kallio study was skewed towards the forward features of logistics channels. Wang et al. (2008) considered qualitative approaches in attempts to identify and align performance measures of transport and retail supply chains. Their application of action research and case study made use of reflective practice. This is further supported in the literature given in Checkland, (1981) and Westbrook (1995). Similar methodologies were applied to investigate the supply chain of a CHP plant using biomass given in this paper. Closed-loop supply chain channels identified in Fleischmann et al. (1997) are used to organize the distribution and scheduling of both the forward and reverse flow of goods between manufacturers and customers. Whilst scheduling and distribution of the forward channels are well understood and documented in the literature, the same cannot be attributed for the reverse flow of goods from the end user. This has given the logistics industry and academics alike a set of problems in knowing how to predict demand of the reverse flow of goods moving back through the supply chain. This is seen as one of the major challenges to contemporary logistics research and practice, particularly in the light of the Forrester Research Group that predicted an increase in the volume and cost of product returns as a result of growth in Internet sales. Academics have sought to identify what the 'reverse' logistics process exactly means since this area has evolved from a number of diverse directions. Guide et al. (2000) distinguished reverse and forward channels in the supply chain, in particular those characteristics pertaining to environmental design, logistics and forecasting methodologies which, focus on quantitative modelling, (DeBrito et al., 2003). Attention to understanding the uncertainty in recovery, replacement processes associated with transportation and collection of used products are found in Meyer (1998; 1999); Andriesse, (1999) and Toktay et al., (2000). Jayaraman et al., (2008) used simulation case study techniques and applied this method to model a series of estimations of quantitative elements of reverse channels such as cost and revenue that involved cost of dispositioning and marketing. Factors associated with their simulation model are unique to the reverse supply chain (Jayaraman et al., 1999; Guide et al., 2000). What makes the renewable energy so interesting to study is that it takes into consideration all 'sustainablility' factors associated with the supply chain. The term 'sustainability' needs a definition but in this paper, sustainability identifies with risk, social, economic, political and environmental factors in the biomass supply chain.

Case Study and Background to the Biomass Power Plant
Since 2004 the Western Log Group, a local forestry company, has been involved in a European Union funded project to build a biomass energy plant. The project was commissioned to build an advanced combustion 14 MW_e (net.) biomass power plant at land adjacent to the BOC Works at Margam. In their proposal for funding, the project's renewable energy credentials enabled the Group to secure a grant from the Welsh Assembly Government, through EU Structural Funds, together with £4.65 million from the DTI under the Bioenergy Capital Grant Scheme. Eco2 was brought into the project in August 2004 as a joint venture partner. Western Log Group Ltd and Eco2 Ltd formed Western Bio Energy Ltd with a responsibility for the delivery of the project.

Figure 1: Schematic Illustration of Biomass I based at Margam in Port Talbot



Source: Western Wood Energy Project Pamphlet

The site covers 2 hectares consisting of the power plant, wood chipping and storage facilities and vehicle manoeuvring areas. An annual output of more than 100 million kWh of electricity is generated and connected directly into the local distribution network for consumption in the Port Talbot vicinity.

The electricity generated by the plant provides power to approximately 30,000 homes with around 69,000 local people benefiting from supply of electricity produced by biomass. Figure 2 depicts the external view of the conveyor for wood chips from the timber silos and figure 3 shows a cross-section of the boiler system.

[13]Figure 2: Conveyor for wood chips from timber silo

THE SPREADER STOKER/TRAVELLING GRATE BOILER CONCEPT

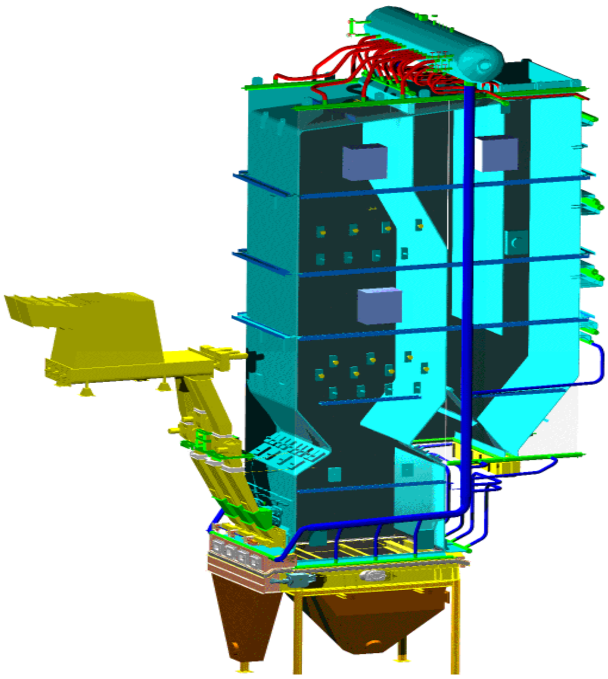


FIGURE 3: CROSS-SECTION OF BIOMASS BOILER

Source: Western Wood Energy Project Pamphlet
Construction of the plant was managed by Aalborg Energie Technik (AET), a Danish based engineering company that develops, designs, engineers and builds complete biomass fired CHP plants up to 100MW.

[13] Source: Christine Lloyd , December 2007

The project was run by a consortium of AET, Burmiester and Wain Scandanavian Contractors (BWSC) overseen by the Steering Committee in phase 1 and Western Energy Ltd during phase 2. Figure 4 illustrates the organisation of first and second phases. Plant operations for the next five years is managed by these two companies. Western Biomass Operating Company currently employs 33 people from the local area who operate and maintain the plant.

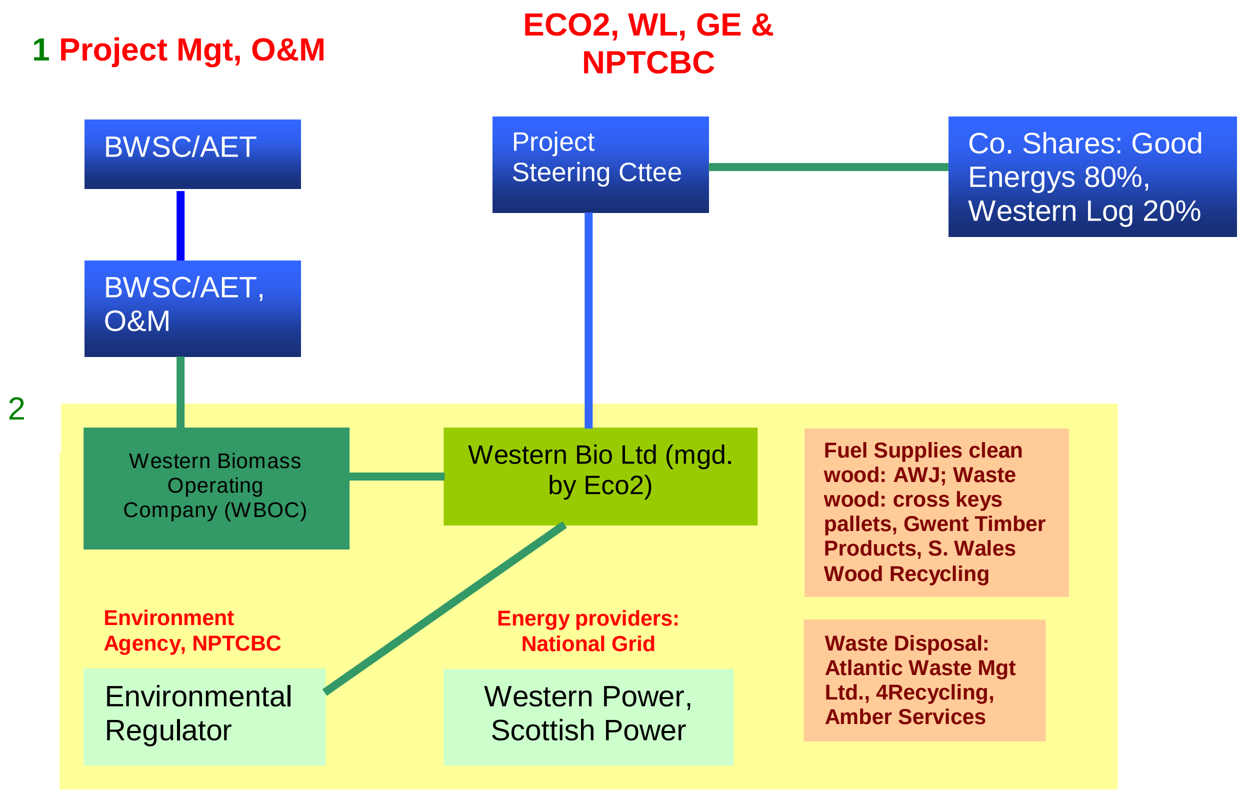


Figure 4: Phase 1 & Phase 2 Development of the CHP Bio Mass Plant

The first phase included management and construction of the initial project. The partners, comprised construction, public and private organisation stakeholders, which created the company, Western Bio Ltd. Western Biomass Operating Company are responsible for the day-to-day maintenance and operations of the plant. Phase 2 comprises production of electricity for sale to the national grid since October 2008. Prior to the plant going live, agreements for the sale of electricity were negotiated for five years in the first instance with Western Power and Scottish Power. The company is regularly audited and inspected by the Environment Agency and local government. Arrangements with waste management companies ensure that the ash produced as waste is disposed of through accredited companies. During the time of writing, Western Energy Ltd is involved with their project managers, the construction companies and private/public sector partners in dealing with different aspects of the business.

Supply of biomass fuels to this plant is that it only uses clean wood material from coniferous forests and sawmills identified in the introduction. This amounts to approximately 40% of wood material is supplied from UK-based forestry and British sawmills provide the remaining 60%. A. W. Jenkinson, one of the largest timber producers in the UK based in Cumbria will be a key supplier of British wood chip. Timber is transported logs or clean waste wood and chipped on site.

Key Findings and conclusion

Examples of optimisation models in planning the supply of raw materials and decision making analysis in biomass CHP plants are provided by Gunnarsson et al., (2004) which considered wholly the supply side of the timber required and energy expended in the operations of CHP plants based in Sweden. However, what had been omitted from the Gunnarsson paper were factors associated with risk and trade offs against other industrial competitors. The decision to locate the Western Log group in its current location was more to do with political decisions that aided the funding process than it was to do with access to timber supply. Furthermore, project management was critical to the determination of this particular supply chain. Carlsson and Rönnqvist (1999) suggested a supply chain model for the Swedish timber industry and proposed linear models for the whole production cycle, which included the complete time line for harvesting, transportation, storage and processing of timber. Their model was effective in identifying costs, but only in part as it did not include costs associated with processing bi-products and waste, in other words, the reverse logistics and supply chain. Without a robust business model as described in the case study CHP plant given in this paper, finance from the main funding bodies would not have been awarded and this included sustainable supply of timber having secured agreements with timber and forestry suppliers for the foreseeable future. This has resulted in competition between biomass fuel supply and previous supply to the construction and paper industry for the same sources in timber and sawmill residue. The company's supply chain includes both the forward and reverse channels and has led to lowering CO_2 emissions but this does not mean they are carbon neutral as there are other challenges that application of this form of renewable energy has to overcome. These are inflexibility to change to other forms of bio mass to produce energy. The climate in the UK is fairly humid and therefore timber supplied possesses a high moisture content which has to be regulated (40-55%). Supply lead-time on timber bio mass currently is 12 months, which increases risk of supply. Steam emission is a potential source of heating for domestic use is currently wasted due to lack of infrastructure and facility to capture this resource. There is a lag between the adaptation of technology for renewables and infrastructure with which to maximise its potential use, (Evans et al., 2009). Rao and Holt (2005) reported an increase in environmental legislation that has influenced and shaped existing supply chains. 'Green' supply chain management can be integrated into existing practice and reports some success on better performance that included social and economic prosperity in addition to environmental factors directly associated with the supply chain. It appears that environmental improvements are supply chain-led and therefore closed loop systems are even more fundamental to success or failure of supply chain resilience and sustainability.

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SUPPLIER SELECTION CRITERIA IN DIFFERENT PROJECT ENVIRONMENTS: AN EMPIRICAL STUDY

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ABSTRACT
Research in identifying the relative importance of criteria used to select a preferred supplier has, for the most part, relied on subjective lists of criteria being presented to respondents. This paper is a summary of the research conducted by the authors to quantify the importance of nine common criteria used in an actual evaluation and selection of a contractor/supplier. Unique choice sets were constructed, each comprising 3 tender evaluation outcomes (alternatives) described in terms of all criteria, but with varying levels. Respondents simultaneously evaluated all three alternatives within each choice set and selected the most preferred. Utility estimates for each criterion level were determined as was the overall contribution made by the individual criterion. Results indicate past project performance, technical expertise and cost are the most important criteria in an actual choice of contractor with organisational experience, workload, and reputation being the least important.

INTRODUCTION
Tender evaluation and contractor selection continues to be an area of significant importance and interest to organisations responsible for delivering project outcomes. Occurring early in the project lifecycle, it is perhaps one of the most critical undertakings performed by clients, the effectiveness of which is directly related to project success and the achievement of specified objectives (Alsugair, 1999; Holt, et al. 1994; Lopes and Flavell, 1998). The environment for making judgments about suppliers and their ability to deliver is complex, comprising high levels of ambiguity and uncertainty, competing stakeholder values and complicated relationships as a result of multiple conflicting objectives (Hatush and Skitmore, 1997a; Keeney and Raiffa, 1976; Ng and Skitmore, 2001; Watt, et al. 2009). Further complications arise in identifying suitable and relevant criteria and assigning appropriate weights, all of which are likely to vary as a function of many factors, least of which are the organisational objectives and experience of the evaluator.

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

The importance of the criteria used to evaluate and select contractors or suppliers has been examined under various industrial purchasing situations. These include the supply of professional management services and procurement of capital equipment and systems, through to the delivery of large scale projects (Alsugair, 1999; Cardozo and Cagley, 1971; Dempsey, 1978; Dickson, 1966; Hakansson and Wootz, 1975; Hatush and Skitmore, 1997a; Hensher et al. 2000; Holt, et al. 1994). Criteria included those in which evaluators could gauge contractors and their likely performance across key project dimensions; relevant experience, track record, quality, expertise, capability, cost, safety record, and capacity to name a few. In terms of the their importance in evaluating and selecting contractors, these studies showed that no individual criteria or group of criteria are consistently reported as being more important than others.

Despite the comprehensive nature of these studies, none except that provided by Hensher et al. (2000) studied how clients actually choose contractors. All relied on attitudinal surveys in which respondents were asked to directly and independently rate the "perceived importance" of specified criteria. Ranking studies, whilst useful in identifying relevant criteria do not represent an actual tender situation. The iterative nature and mechanistic process in which respondents consider and rank individual criteria within a defined group provides little insight into the decision making behaviour. An actual choice of contractor requires evaluators to consider each contractor simultaneously as a function of all specified criteria and their assigned weightings.

Our research uses a Discrete Choice Experiment (DCE) in which respondents simultaneously evaluate the characteristics of contractors as a function of the level or value assigned to individual criterion. The main advantage of the approach is that respondents do not rate the importance of specified criteria directly. Rather, each alternative within a set is considered wholistically. The structure of the experiment is such that no individual tenderer (alternative) dominated across all criteria, necessitating respondents to make conscious trade-offs.

Next sections of the paper outline the research design methodology followed by an analysis and discussion of the relative importance of the criteria used in evaluating contractors. The final section summarises and concludes the article, along with suggestions for future research.

RESEARCH DESIGN METHODOLOGY

An empirical study to investigate the contractor evaluation and selection process for the delivery of projects and the importance was used for contractor selection which is an industry specific task. The sample group included Engineering Project Contract Management (EPCM) companies known to have experience in delivering large scale projects or in the provision of management services. The population included several international organisations and Australian companies within the mining and exploration, construction, defence and aerospace, manufacturing and processing and telecommunications sectors. Executives, programme and project managers and engineering managers were identified and contacted by telephone or e-mail seeking their participation in the survey.

In all 288 prospective respondents were identified, of which 255 agreed to participate. A questionnaire and covering letter setting out the research objectives and a brief description was distributed between September 2007 and April 2008. Of the 255 respondents who agreed to participate, and after some follow up, 222 completed surveys were returned, giving a response rate around 87%. Respondents, when initially contacted, expressed a genuine interest in the research topic, which is believed to be the main factor contributing to such an unusually high response rate.

The survey instrument comprised of two main sections. The first asked respondents to describe their organisation and the industry sector within which they work, along with their experience, role, and characteristics of projects they had previously worked on over the past ten years. In addition, respondents were also asked to describe a previous project in terms of budget, schedule, industry and complexity. This served as a reference project for the Discrete Choice Experiment (second) component of the study. It ensured the experiment was context-dependent relative to each respondent and that results could be generalised.

The Discrete Choice Experiment contained 1 block of 16 scenarios, or choice sets, each comprising 3 alternatives that represented a typical tender evaluation outcome. Each alternative was defined in terms of eight criteria (attributes) identified from research undertaken by Watt et al. (2009), plus tendered price, giving a total of nine attributes. Prior to implementing the survey, a pilot study was conducted to ensure clarity and understanding of the questionnaire, comprehension of the Discrete Choice task and to suggest improvements where necessary. Fifteen senior managers from the construction, defence and mining industries were interviewed all of who suggested minor formatting changes to enhance clarity. Two (2) respondents suggested including definitions for each of the nine (9) criteria to remove any ambiguity. Average time to complete the survey was approximately 30 minutes with respondents indicating no difficulty in performing the task.

Analysis and modelling utilised the Multinomial Logit based on the technique of maximum likelihood estimation as described in Louviere and Timmermans (1990) and McFadden (1986). Estimates were initially calculated for all levels of all criteria relative to their lowest (base) level and the model log-likelihood recorded. The process was repeated a further nine times after removing, in turn, one criterion and all its associated levels. This provided a common metric where the difference in log-likelihoods between the full model (all criteria included) and those absent a given criteria, quantified the relative effect of each attribute on the dependent variable, choice.

Relevant criteria were identified from previous research undertaken by Watt et al. (2009). The resulting design structure is represented in Table 1.

Table 1
Design Structure - Criteria (Attributes) and Defined Levels

Criteria/Attribute	Level 1	Level 2	Level 3	Level 4
Organisational Experience	< 2 years	2 to < 5 years	5 to < 10 years	> 10 years
Project Management Expertise	Low	Satisfactory	Very Good	Excellent
Tendered Price	10% Below Tender Average	5% Below Tender Average	5% Above Tender Average	10% Above Tender Average
Technical Expertise	Poor	Marginal	Above Average	High
Past Project Performance	Unsatisfactory	Average	Good	Very Good
Company Standing (Reputation)	Not Known	Neutral	Reputable	N/A – Not Used
Method/Solution	Mostly Feasible	Established, not Proven	Established and Proven	N/A – Not Used
Client-Supplier Relations	Average	Good	Excellent	N/A – Not Used
Workload/Capacity	Few Projects, Excess Capacity	Several Projects, Adequate Capacity	Many Projects, Limited Capacity	N/A – Not Used

A full factorial design for the structure provided in Table 1 represents 82,944 ($4^5 \text{ x } 3^4$) possible combinations and requires many thousands of choice sets to capture all parameter estimates and interaction effects.

RESULTS AND DISCUSSION

Respondent data was collected for both the general and discrete choice experiment components of the study. The first elicited data that described the participants, industry, experience, and role within the organisation, along with information on projects they had previously managed. In addition, respondents provided details of a project they had previously managed or conducted a tender evaluation on. Data from the discrete choice experiment was also captured and recorded. This required respondents to evaluate 16 independent tender evaluation outcomes comprising three alternatives, and select the most preferred.

General results

Two hundred and twenty two completed questionnaires were received from two hundred and fifty five individuals who agreed to participate in the study. Most respondents represented organisations that either provided project based services and support to clients, or an organisation directly contracted for the delivery of a major project. The client perspective, comprised respondents in which they, or their organisation, were recipients of a service or outcomes of a project. Representation between the provider and client perspective constituted approximately 79% and 21% of participants, respectively.

The main roles and functions reported were executives, project directors, programme and project managers, collectively representing approximately 87% of respondents. The largest category comprised Program and Project Managers representing 45% of respondents, followed by Executives, Directors, and General Managers with 25%, then Project Directors with 17%. The remaining categories, Engineering Operations Management, Engineering and Other represented 5%, 3% and 5% respectively. Example roles and functions within the category labelled “Other” included Business Development Manager, Procurement Manager, Sales Manager and Field Services Manager.

Five categories relating to the respondents years of experience were used in the study; 0 to 2.99, 3 to 4.99, 5 to 9.99, 10 to 19.99 and 20 years or greater. Respondents with less than 10 years experience constituted approximately 22%. The remaining 78% with 10 years experience or greater included the two sub-categories, 10 to 19.99 years and 20 years or greater. Respectively each accounted for approximately 43% and 34% of respondents.

Construction, Defence and Aerospace, Infrastructure and Energy, Manufacturing and Processing, and Mining and Exploration were represented equally with approximately 17.56%, or 39 of the 222 respondents, for a collective 87.8%. The Telecommunications and Information Technology category was the next largest represented with approximately 5%, or 11 respondents. The two categories of Biotechnology and Pharmaceutical, and “Other” were the least represented, with each comprising ~ 3%, or 7 of the 222 respondents. Industries in this latter category included, Banking and Finance, Medical and Environmental. Two respondents (1%) provided no reference industry, and recorded as Not Provided (NP).

Discrete Choice Analysis

Each the 222 respondent evaluated 16 individual Choice Sets comprising 3 alternatives, for a total of 10656 observations. A Multinomial Logit model (MNL) was specified and Maximum Likelihood Estimation (MLE) used to determine the utility estimates for all levels of criteria (attribute) under consideration. The results show a clear preference ordering, in that the utility estimates increase as the level of a criterion improves. For example, consider the criterion of Past Performance and the four discrete levels assigned for this study. Tenderers represented by the base (reference) level, “Unsatisfactory” are the least preferred, as one would expect. However, as the level of Past Performance or delivery record increases, so to do the utility estimates. Tenderers with “Very Good” past performance are the most preferred. Similarly, for Tendered Price, the base level representing "10% Below Tender Average" is the most preferred, with the least preferred being "10% Above Tender Average." For Technical Expertise, utility increases with increases in levels of expertise until utility is maximised at level 3, "Above Average". At this point, increasing the applied level of technical expertise provides a marginal decrease in utility, inferring that the primary consideration is for the contracting organisation to have at least "Above Average" technical expertise.

The difference in utility provided with increasing levels applicable to Method/Solution and Workload/capacity is significant. For Method/Solution, the preference for tenderers who have established approaches and/or systems (Existing and Proven) is higher than those in which equivalent approaches and/or systems exist, but are yet to be proven. With regard to "Workload/Capacity", the negative utility indicates less desirability for contractors with many projects and little available capacity over tenderers who have some projects under contract, but also have additional capacity. For Organisational Experience the gain in utility between the two highest levels is marginal, suggesting that those organisations with 5 years experience or more is all that is relevant in an evaluation. Similarly, for Project Management Expertise, the additional utility afforded by moving from "Very Good" to "Excellent" is also marginal, but doubles in going from "Satisfactory" to "Very Good", suggesting that the desirability of tenderers with anything other than "Satisfactory", is the primary consideration.

In terms of Client Relations and Company Standing (Reputation), again the result shows an increase in utility as the level of the attribute increases. In both cases, the utility estimate doubles, or almost so, as the level increases from the base (reference) level through the mid, to the highest level. This suggests higher importance is placed on reputable tenderers with an excellent client relations record, therefore reflecting a higher probability of choosing a tenderer to which these higher levels of the criterion are applied.

The results show greater importance is placed on past performance, or track record, technical expertise, cost and management, indicating that respondents are likely to assign more weight to these during an actual evaluation. Specifically, Past Project Performance and Technical Expertise are the two most important criteria followed by Tendered Price and Project Management Expertise. In addition, Project Performance and Technical Expertise are almost of equal importance, but twice that of Tendered Price and three times more important than Project Management Expertise. The collective importance of these four criteria exceeds 85%, whilst the remaining five (organisational) contribute less than 15%.

CONCLUSION

Tender evaluation and contractor selection for the delivery of major projects and services is acknowledged as a complex undertaking that embodies many uncertainties. The criteria used for making judgments about potential suppliers and their ability to deliver are varied and many, and often traded-off on the basis of multiple conflicting objectives. The research reported here investigated the contractor selection process to establish the relative importance of common criteria used in the actual choice of contractor.

The study used an experimental design approach as an alternative to attitudinal studies in which respondents rate, directly, the perceived importance of each in the context of contractor selection. The technique generated groups (choice sets) of three alternatives each comprising the same nine criteria, but with different levels. The design structure ensured no individual contractor (alternative) dominated across all criteria. Respondents considered, simultaneously, each contractor from each group and selected the most preferred.

Parameter estimates for all levels of the nine criteria were established using the Multinomial Logit Model. The model log-likelihood was also recorded with all criteria and levels included, and again after each criterion and its associated levels were removed. This provided a basis in which the relative importance of the criteria could be established. Results were statistically significant, indicating past performance, technical expertise, and cost are amongst the most important in the actual choice of contractor and organisational criteria were considerably less important. In particular, Past Project Performance and Technical Expertise were of almost equal importance, but twice that of Tendered Cost. These coupled with Project Management Expertise and Tendered Price contributed to a combined importance in excess of 85%, whereas organisational criteria contributed less than 15%.

The results provide an important contribution to the topic of contractor evaluation. In particular, our research emphasises the importance of common criteria used in an actual choice of contractor, and draws on novel techniques used by other disciplines. The specific importance values, relative to each criterion, can be used to guide the development of weighting schemes in evaluation systems. Accordingly, better alignment between the expectations of client organisations and tenderers, particularly with respect to experience, capability and performance are expected to be established.

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THE RELATIONSHIPS AMONG GLOBALIZATION, SUPPLY CHAIN INTEGRATION, AND BUSINESS PERFORMANCE: EVIDENCE FROM TAIWAN MANUFACTURERS

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ABSTRACT
This study conducted an empirical study upon the major manufacturers in Taiwan to further understand the relationships among globalization, supply chain integration, and business performance. Findings indicate that supply chain integration with customers can positively moderate the relationship between market globalization and productivity performance. Although external integration with suppliers positively moderates the relationships between market globalization and financial performance, such effects do not exist between production globalization and performance. Similarly, internal integration also has no positive moderation effects on the relationships between globalization and performance. Accordingly, the moderation effects of supply chain integration on globalization and performance were only partially proved from our observations.

INTRODUCTION
The integration of supply chain involves with the construction of horizontal linkages and vertical linkages between chain partners. As optimizing the linkages amongst value activities should improve business performance across supply chain (Frohlich and Westbrook, 2001), supply chain integrations have become important issues for companies to enhance their competitive advantages. In the meantime, a growing number of companies choose to spread their manufacturing processes across different countries to benefit from local opportunities such as cheap labour/material costs. This kind of movement is one of the important processes of company globalization (Fujita and Thisse, 2006). From the theoretical perspective, supply chain integration focuses on the building of strong partnerships through collaborative technology, whereas company globalization emphasizes the relocation of company's major activities such as marketing, R&D or production into different geographic regions. Because both approaches are influential strategies for companies, many studies have discussed the effects of supply chain integration/globalization on business performance. For example, research from Anderson and Katz (1998), Frohlich and Westbrook (2001), Heikkila (2002), and Kim (2006) have provided evidences that higher integration yields better firm performance. Meanwhile, there are evidences showing that firm performance is positively influenced by globalization (Grant, 1987; Scully and Fawcett, 1994; Thoumrungroje, 2004). Nonetheless, there is lack of papers investigating the relationships among supply chain integration, globalization, and business performance. Because the complexity of supply chain integration could be affected by the degree of globalization, further understanding of their mutual effects has its importance. Consequently, this study tries to examine the moderation effect of supply chain integration on globalization and performance. When supply chain integration positively moderates the relationships between globalization and performance, it implies that the optimal performance caused by globalization can be improved by the technique of supply chain integration. Under the environment of limited resource, investigation of moderation effect can help companies to trade off the strategies of supply chain integration and globalization.

The remainder of this paper is organized as follows. The hypotheses are presented in section 2 and the methodology is described in section 3. In section 4, empirical findings on Taiwan's manufacturers are discussed to understand the moderation effects between supply chain integration and globalization on firm performance. Section 5 concludes our investigations.

HYPOTHESES

As information technology helps to remove the barriers of trade and investment, firms seek international markets for more sales opportunities (Scully and Fawcett, 1994). To understand the relationships between globalization and performance, Grant (1987) surveyed the manufacturers in British and found that the degree of multi-nationality is positively related to their profitability. He also found that the increases in overseas production could positively increase their sales and profitability. Thoumrungroje (2004) also proved that firm performance is positively influenced by global market opportunities. Although literature has provided evidences that globalization have positive effects on firm's growth, its moderation relationship with supply chain integration on performance is little addressed. Related study from Geringer et al. (2000) indicated that there is a nonlinear, inverted U-shaped relationship between product diversification and performance. Narasimhan and Kim (2002) showed that supply chain strategy modifies the relationship between diversification and performance. Capar and Kotabe (2003) found that there is a U-shaped curvilinear relationship between multi-nationality and performance in service firms.

To further investigate the issues of moderation effects, our major hypothesis is to test whether supply chain integration can positively moderate the relationship between globalization and performance, where a curvilinear relationship between globalization and performance exists. Based on the research of Grant (1987), Scully and Fawcett (1994), and Thoumrungroje (2004), this study categorized strategies of globalization into production globalization (PG) and market globalization (MG) to reflect its different facets. Besides, supply chain integration was classified into internal integration (II), supplier integration (SI), and customer integration (CI) according to the studies of Pant and Ravichandran (2001), and Zailani and Rajagopal (2005). We also consider the performance of productivity and finance, and evaluate their relationships with supply chain integration/globalization. Therefore, our first hypothesis can be divided into 12 sub-hypotheses with the considerations of PG, MG, II, SI, CI, productivity performance, and financial performance.

METHODOLOGY

According to the hypotheses described above, we considered the moderated multiple regression model with performance measurements as the response variable. Financial performance was evaluated by profit margin and return on assets (ROA), while productivity performance was measured by gross profit per employee and unit labour cost. Three scopes of supply chain integration (II, IC, IS) and two aspects of globalization (PG, MG) were introduced as predictor variables. To evaluate the moderation effects, our model also contains PG^2, MG^2, IC×PG, IC×MG, IC×PG×MG, IC×PG^2, IC×MG^2, II×PG, II×MG, II×PG×MG, II×PG^2, II×MG^2, IS×PG, IS×MG, IS×PG×MG, IS×PG^2, IS×MG^2 as predictor variables. Accordingly, there are 4 moderated regression models with response variables of profit margin, ROA, gross profit per employee, and unit labour cost respectively.

To measure the degree of production globalization, PG was computed by two entropy measurements PG_1 and PG_2,

$$\mathrm{PG}_1 = \sum_i [P_{1i} \times \ln(1/P_{1i})]\,,\ \mathrm{PG}_2 = \sum_i [P_{2i} \times \ln(1/P_{2i})]\,, \quad (1)$$

where P_{1i} is the ratio of import amount from the i-th foreign subsidiaries to the total sales of parent company, and P_{2i} is the ratio of a manufacturer's foreign holdings (focus on manufacturing) in region i to the total number of subsidiaries (Qian, 1997). The higher the P_{1i} and P_{2i} are, the higher the degrees of production globalization are. On the other hand, market globalization (MG) is also described by two entropy measurements MG_1 and MG_2,

$$\mathrm{MG}_1 = \sum_i [M_{1i} \times \ln(1/M_{1i})],\ \mathrm{MG}_2 = \sum_i [M_{2i} \times \ln(1/M_{2i})], \qquad (2)$$

where M_{1i} is the proportion of sales attributed to global market region *i* (Kim et al., 1993), and M_{2i} is the ratio of a manufacturer's foreign holdings (focus on sales) in region *i* to the total number of subsidiaries. Similarly, the higher the M_{1i} and M_{2i} are, the higher the degrees of production globalization are. Because the levels of supply chain integration are hardly assessed by company reports, we designed a questionnaire including 29 questions (Lancioni, 2000; Stank et al., 2002; Narasimhan and Kim, 2002; O'Leary-Kelly and Flores, 2002; Patterson et al., 2003; Pagell, 2004) for managers to evaluate their performance on supply chain integration. The inferences upon these predictor variables in moderated regression model can help us to understand the test results of our proposed hypotheses.

EMPIRICAL FINDINGS

The moderation relationships described in section 2 were empirically examined against Taiwan's manufacturers whose total assets were above 1 billion N.T. dollars, because large companies are more likely to practice supply chain integration or globalization. From the *business directory of Taiwan*, there are 310 manufacturers satisfied the criterion of total assets. Questionnaires were distributed to these qualified manufactures for the information of supply chain integration. A total of 76 samples were returned and 58 of them were further analyzed after discarding incomplete or invalid responses. Data of financial performance, productivity performance, production globalization, and market globalization were collected and transformed from the annual reports of sample manufacturers.

As the globalization is classified into MG and PG, we start with the discussion of moderation effect of supply chain integration on MG and performance. Table 1 summarizes the coefficient estimates related to supply chain integration (II, IS, IC) and market globalization in our proposed models, whose response variables are profit margin, ROA, gross profit per employee, and unit labour cost respectively. Because the coefficients of MG are significantly negative, MG plays adverse influence on performance. Meanwhile, the interaction term II×MG is significantly positive for productivity performance but $\mathrm{II}\times\mathrm{MG}^2$ is significantly negative for productivity performance. It implies that internal integration negatively moderates the inverted U-shape relationships between market globalization and productivity performance. Similarly, coefficient estimates of IS×MG and $\mathrm{IS}\times\mathrm{MG}^2$ indicate that IS also negatively moderates the inverted U-shape relationships between MG and productivity performance. Managerial implication suggests that market globalization manufacturers with high degree of internal integration and supplier integration could decrease their productivity performance. On the other hand, customer integration positively moderates the U-shape relationship between market globalization and productivity performance because coefficient estimate of IC×MG is significantly negative and $\mathrm{IC}\times\mathrm{MG}^2$ is significantly positive for productivity performance. Thus, market globalization manufacturers could increase their productivity performance if their integrations with customers are high. Besides, table 1 shows that IS×MG and $\mathrm{IS}\times\mathrm{MG}^2$ are significantly positive for profit margin. Both coefficient estimates have similar effects on ROA too, though IS×MG is not statistically significant. Findings imply that supplier integration positively moderates the inverted U-shape relationship between market globalization and financial performance. Therefore, market globalization manufacturers with high degree of supplier integration could increase their financial performance.

Table 1. Coefficient Estimates of Supply Chain Integration and Market Globalization in Moderated Regression Models

	Productivity Performance		Financial Performance	
	Gross Profit per Employee	Unit Labour Cost	Profit Margin	ROA
IC	3.160^{**}	2.300^{**}	0.368	-0.273
II	-0.062	-0.683^{*}	0.968^{*}	0.924^{**}
IS	-0.617	-0.145	-0.897^{**}	-0.083
MG	-3.559^{**}	-4.418^{**}	3.332^{**}	4.024^{**}
MG^2	8.804^{**}	10.591^{**}	-6.825^{**}	-8.187^{**}
IC×MG	-15.066^{**}	-9.866^{**}	-2.660	-1.189
IC×MG^2	19.198^{**}	15.332^{**}	-12.604	-18.923
II×MG	2.932^{**}	3.065^{**}	-0.726	-0.561
II×MG^2	-5.764^{**}	-6.870^{**}	-22.317	-18.805
IS×MG	4.125^{**}	2.210	6.804^{**}	3.861
IS×MG^2	-13.025^{**}	-10.790^{**}	2.649^{*}	5.032^{*}

Next, let's discuss the moderation effects of supply chain integration on production globalization and performance. Table 2 displays the coefficient estimates related to supply chain integration and production globalization in our proposed models. Because almost all of the corresponding coefficients are insignificantly related to performance, supply chain integration seems not to moderate the relationships between production globalization and performance.

Table 2. Coefficient Estimates of Supply Chain Integration and Production Globalization in Moderated Regression Models

	Productivity Performance		Financial Performance	
	Gross Profit per Employee	Unit Labour Cost	Profit Margin	ROA
PG	-3.293^{*}	-0.791	-1.891	-1.026^{*}
PG^2	-0.528	0.821	5.895	2.022
IC×PG	3.075	-1.935	0.221	0.979
IC×PG^2	-1.183	1.011	-3.402	-2.829
II×PG	-1.531^{**}	0.139	-0.216	-0.458
II×PG^2	1.048	0.560	-0.445	-2.277
IS×PG	-0.361	1.914	-0.840	-0.901
IS×PG^2	-4.087	-7.967	11.115^{*}	10.839^{*}

Finally, table 3 summarizes the coefficient estimates of II×PG×MG, IS×PG×MG, and IC×PG×MG. Because IC×PG×MG is only significant on profit margin, we can conclude that the moderating effect of PG on the curvilinear relationship between MG and profit margin is significant as the level of customer integration increases. Similarly, the moderating effect of PG on the curvilinear relationship between MG and gross profit per employee (or ROA) is significant as the level of internal integration increases, because II×PG×MG is statistically significant on gross profit per employee and ROA. Finally, the significant coefficient estimates of IS×PG×MG on profit margin and ROA suggest that the moderating effect of PG on the curvilinear relationship between MG and financial performance is significant as the level of supplier integration increases.

Table 3. Coefficient Estimates of Supply Chain Integration and Production Globalization in Moderated Regression Models

	Productivity Performance		Financial Performance	
	Gross Profit per Employee	Unit Labour Cost	Profit Margin	ROA
IC×PG×MG	-2.415	6.641	7.402*	6.681
II×PG×MG	2.672**	1.116	1.562	3.069**
IS×PG×MG	7.987	9.054	-14.699**	-16.256**

CONCLUSIONS

This study proposes the models to evaluate the moderation effects of supply chain integration on globalization and performance. Generally speaking, the moderation effects of supply chain integration on globalization and performance were only partially proved from our observations. All approaches of supply chain integration even show no moderation influences on production globalization and performance.

Our empirical findings indicate that market globalization manufacturers with high degree of supplier integration could increase their financial performance. They can also increase their productivity performance if their integrations with customers are high. Our models can help manufacturers to adjust or design their supply chain and globalization strategies for better performance. Although empirical study only applied to the manufacturing industry, other sectors can adopt our models to understand the moderation relationships among supply chain integration, globalization, and performance.

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UNPACKING RELATIONSHIP QUALITY AND ITS LINK TO SUPPLY CHAIN PERFORMANCE – A REVIEW

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ABSTRACT
This paper aims to advance the understanding of relationship quality in supply chains; and in particular to advance the understanding of its link with supply chain performance. A multidisciplinary literature review was undertaken to identify journal articles on relationship quality from the supply chain management, operations management, marketing, service management, organization studies and applied psychology literatures. The paper reveals significant ambiguities in the conceptualization and empirical assessment of relationship quality. Although relationship quality is widely recognized as a higher order, multi-dimensional construct there is little agreement within or between the disciplines reviewed over the dimensions that comprise it. Secondly, and most importantly, this paper finds that empirical evidence for the connection between relationship quality and supply chain performance is inconclusive. Thirdly, this paper suggests that findings in the marketing, service management, organization studies and applied psychology literatures, provide fresh perspectives on the inconclusive link between relationship quality and supply chain performance.

The paper provides some implications for practitioners interested in enhancing the performance of inter-organizational relationships. The paper indicates that managers should avoid focusing on interventions designed to solely improve relationship quality. Managers, instead, should consider addressing supply chain performance more directly, for example, by introducing performance measurement systems in supply chains.

INTRODUCTION
Supply chains comprise all activities associated with the flow and transformation of goods from the raw material stage through to the end user (Handfield and Bechtel, 2002). A key assumption within the supply chain management literature is that effective supply chain management is not primarily about optimising individual activities of functions of the supply chain, but about their coordination and particularly, managing the relationships between these functions while aligning their different interests (Chen and Paulraj, 2004; Christopher, 1998; Larson and Halldorsson, 2004; Van Donk and Van der Vaart, 2007). Indeed, it is widely believed that effective management of inter-organisational relationships contributes significantly to supply chain performance (Fynes et al., 2008; Fynes et al., 2004; Fynes et al., 2005a; Fynes and Voss, 2002; Fynes et al., 2005b,c; Parsons, 2002). Despite the intuitive appeal of this argument, this paper reveals (1) a lack of conceptual clarity surrounding the relationship quality construct, and (2) that the methodological link between relationship quality and supply chain performance has not been conclusively established so far.

METHODOLOGY

A literature review was undertaken by a multidisciplinary team comprising people with expertise in supply chain management, operations management, marketing, service management, organisation studies and applied psychology. Keyword searches were undertaken for 'relationship quality' using the online resources ISI Web of Science® and Google ScholarTM. These searches were focused to identify journal articles only from the above disciplines. Moreover, only papers specifically concerned with definitions, antecedents, consequences, and dynamics of relationship quality in inter-organisational contexts were considered for further investigation. In total, 68 articles were identified: 20 from supply chain and operations management; 23 from marketing; 4 from service management; 18 from organisation studies; and, 3 from applied psychology. A key objective of this multi-disciplinary approach was to unpack the concept of relationship quality by comparing and contrasting how it has been characterised within and between these disciplines.

FINDINGS

This section begins with a critical review of the supply chain and operations management literatures. Thereafter, we consider how insights from marketing, service management, organisation studies and applied psychology can enhance our understanding of relationship quality and its links to supply chain performance.

Supply chain management and operations management

Within the supply chain and operations management literatures the majority of research investigating the link between relationship quality and supply chain performance has focused at the dyadic level. Specifically, the buyer-supplier relationship has received the most attention (Cox, 2004; Cox et al., 2004; Goffin et al., 2006; Liker and Choi, 2004). In theory, the natural competitiveness between supply chain members is mitigated by the opportunity to create mutually beneficial relationships, which in turn lead to improved information flows, reduced uncertainty, and, as a consequence, a more profitable and responsive supply chain (Handfield and Bechtel, 2002; Maloni and Benton, 1997). Close buyer-supplier relationships are seen as key in coping with transitions and 'crises', such as unexpected changes in customer demand or communication breakdowns (Bullington and Bullington, 2005). It has been argued that a close relationship should help manufacturers to reduce costs, improve quality and enhance new product development (Goffin et al., 2006). Therefore, it is surprising that there is a dearth of conclusive empirical evidence for the connection between inter-organisational relationship quality and supply chain performance.

A key reason for this is a lack of conceptual clarity surrounding the concept of relationship quality in the literature on supply chains (Huntley, 2006). As Fynes and colleagues (2005a) observe, a variety of different constructs have been offered to assess the efficacy of relationships, including partnership success (Mohr and Spekman, 1994), relationship value (Wilson and Jantrania, 1996), relational capital (Cousins et al., 2006) and relationship quality (Crosby et al., 1990). These concepts are often difficult to distinguish from one another.

Second, where the term relationship quality is used explicitly in supply chain or operations management research it is generally conceptualised as a second-order, multi-dimensional construct. However, there is limited agreement on the dimensions that comprise it (e.g., Roberts et al., 2003). For example, whilst Parsons (2002) argues it encompasses trust and satisfaction, Naude and Buttle (2000) and Fynes and colleagues in unison (Fynes et al., 2004; Fynes et al., 2005a; Fynes et al., 2005c) claim it includes trust, adaptation, communication, and co-operation.

Third, as we highlighted earlier, the majority of research has focused on single dyads, rather than supply chains as a whole, which in fact tend to be supply networks in practice. Moreover, the level at which relationship quality is conceptualised and assessed is often confounded or not made explicit. For example, while some authors view relationship quality as a firm-level phenomenon (e.g., Lau and Goh, 2005) other argue it is an individual phenomenon (e.g., Bullington and Bullington, 2005). Moreover, even when the concern is explicitly with the quality of inter-firm relationships, there are examples where it has been operationalised at an individual level, thereby undermining the validity of the conclusions drawn (e.g., Parsons, 2002).

Fourth, although there have been several attempts to test how the quality of the buyer-supplier relationship impacts on the performance of supply chains (Fynes et al., 2008; Fynes et al., 2005a; Fynes et al., 2005b,c; Ramdas and Spekman, 2000; Tapiero, 2001; Toni and Nassimbeni, 1999) there is little consistency in the measures used to operationalise supply chain performance (see Shepherd and Günter, 2006 for discussion). For example, Fynes et al. (2005a) use quality, delivery, cost, and flexibility, whilst Ramdas and Spekman (2000) consider inventory, time, order fulfilment, quality, customer focus and customer satisfaction. Arguably the most rigorous empirical assessment of the connection between relationship quality and supply chain performance is provided by Fynes and colleagues (Fynes et al., 2005a; Fynes et al., 2005b, c). However, even their research does not demonstrate conclusive evidence for the link between relationship quality and supply chain performance. In their study on customer relationships of 200 manufacturing companies in the electronics sector they use structural equation modelling to test the link between relationship quality and supply chain performance. They found that high-quality relationships resulted in improved product design and reduced costs. Furthermore, adaptation, one of the key ingredients of high quality relationships, was shown to enhance customer satisfaction. However, no links were established with manufacturing quality, flexibility or delivery performance (Fynes et al., 2005b,c).

to the understanding of inter-organisational relationship quality in supply chains. However, there remains considerable ambiguity over the precise definition of relationship quality and its link with supply chain performance and a need to extend existing research beyond the dyadic level

Marketing, service management, organisation studies and applied psychology

The term relationship quality has been referred to in the marketing (Crosby et al., 1990; Dwyer et al., 1987), service management (Hennig-Thurau et al., 2001; Storbacka et al., 1994), organisation studies (Ariño et al., 2005; de Burca et al., 2004) and applied psychology literatures (Settoon and Mossholder, 2002). Studies of relationship quality within these disciplines share several features with those from the supply chain and operations management literatures, but also important additions are provided.

First, a variety of similar constructs have been devised to assess the quality of relationships, including; relational quality (Ariño and de la Torre, 1998), relationship strength (Bove and Johnson, 2001), relationship closeness (Palmatier et al., 2006), relationship equity (Scheer et al., 2003) and interactional richness (Barry and Crant, 2000). As with the supply chain and operations management research, the commonalities and differences between relationship quality, and similar constructs, is not always clear (cf., Bove and Johnson, 2001).

Second, the reader will recall that within supply chain and operations management studies, relationship quality is typically conceptualised as a higher-order construct comprising several dimensions (Fynes et al., 2005a; Fynes et al., 2005b, c; Parsons, 2002). This perspective, quite rightly, builds on the firm belief that no single indicator, such as trust or commitment, can fully capture the quality of a buyer-supplier relationship (e.g. Palmatier et al., 2006). Similarly, contributions from each of these four disciplines commonly treat relationship quality as a multi-dimensional construct.

However, there is disagreement both within and between these disciplines over the dimensions of which comprise it. For example, within the marketing literature, relationship quality has been described as comprising trust and satisfaction (Boles et al., 2000; Crosby et al., 1990), trust and commitment (Bove and Johnson, 2001), trust, satisfaction and minimal opportunism (Dwyer et al., 1987), satisfaction, outcome fairness and willingness to collaborate in the future (Jap, 2001) and trust, commitment and stability (Johnson et al., 2004). In contrast, researchers from organisation studies and applied psychology have argued relationship quality is made up of very different components, including: support, perspective taking and empathic concern (Settoon and Mossholder, 2002).

Third, within these disciplines there have been numerous attempts to link relationship quality to performance metrics. For example, within the marketing literature the connection between the quality of the buyer-seller relationship and various performance measures has been explored, including; suppliers' share of business (Leuthesser, 1997), financial performance (Palmatier et al., 2007a), sales (Huntley, 2006), customer retaliation (Grégoire and Fisher, 2006) and customer loyalty (Palmatier et al., 2006; Rauyruen and Miller, 2007). Similarly, linking relationship quality to customer loyalty has also interested service management researchers (Brown and Chin, 2004; Liang and Wang, 2006). The focus within the applied psychology literature is somewhat different. For example, relationship quality has been linked to supportive exchange relationships (Settoon and Mossholder, 2002). However, in common with the supply chain and operations management literatures, these studies have failed to demonstrate a conclusive link between relationship quality and performance (cf., Palmatier et al., 2007b). For example, Palmatier and colleagues (2007a) reported that whilst commitment was a key driver of financial performance in buyer-supplier relationships, trust and dependence were not.

Despite these limitations, there are two key insights from these literatures which help to explain the inconclusive link between inter-organisational relationship quality and supply chain performance. First, evidence from these literatures suggests there may be non-linear relationships between dimensions of relationship quality, including trust, adaptation, interdependence, cooperation, commitment, and communication (Inkpen and Currall, 2004; Rubin et al., 1994). For example, Rubin et al. (1994) report that high interdependence increases the likelihood of divergence of interests as highly interdependent parties have to deal with a greater number of coordination issues. Furthermore, team research has found task interdependence to undermine job satisfaction and to decrease helping behaviour if the goals of team members are not aligned (e.g., Van Der Vegt et al., 2000; Van der Vegt et al., 2003). Similarly, studies on trust, arguably the most common dimension of relationship quality (Fynes et al., 2005a; Naude and Buttle, 2000) have found that a priori trust in relationships could prevent partners from carefully analysing structural and organisational pitfalls in the business relationship which is likely to undermine the stability and robustness of inter-organisational cooperation (Ariño et al., 1999). They warn that an unwarranted sense of security about the ability of relational quality to safeguard actors in inter-organisational relationships might negatively affect performance. More recently, Langfred (2004) has demonstrated that trust can actually lead to a reduction in performance. His findings show that the more individuals trust each other the less they tend to monitor each other's behaviour. In combination with high individual autonomy this can cause coordination errors, which undermines performance. As Anderson and Jap (2005) observe, close relationships have a dark side as they provide 'an opportunity for covert activities designed to systematically cheat a partner' (p. 78). Second, interpretive studies have shown that although relationship quality is often treated as an antecedent of performance, it is 'both an input to the success of the venture, and an output of the interactions between the partners' (Ariño and de la Torre, 1998, p. 322). These studies emphasise the active role individuals play in shaping network relationships in a specific context (Ariño and de la Torre, 1998; Marchington, 2005; Schultze and Orlikowski, 2004). By stressing the importance of human agency and interpretation, these authors argue that for worldviews to converge, joint learning and sensemaking processes must take place in relationships (Ariño and de la Torre, 1998; Garcia-Canal et al., 2003; Grewal et al., 2007; Zollo et al., 2003). For example, in their longitudinal study of an international joint venture, Ariño and de la Torre (1998) found that relationships deteriorate if parties do not invest considerable effort in sensemaking processes and mutual understanding. Using an interpretive lens thus reconceptualises relationship quality as a dynamic and emergent phenomenon.

DISCUSSION AND IMPLICATIONS

In this paper, a multidisciplinary literature review attempted to unpack relationship quality and its links to supply chain performance by juxtaposing findings from supply chain management, operations management, marketing, service management, organisation studies and applied psychology. Whilst it has been argued that developing high quality relationships is a key lever for effective supply chain management (Chen and Paulraj, 2004; Fynes et al., 2004) this study revealed several caveats with this assumption.

First, an analysis of the supply chain management and operations management literature revealed that evidence for the link between relationship quality and supply chain performance is not fully conclusive. A key reason for this is a lack of conceptual clarity surrounding the concept of relationship quality (Huntley, 2006) and supply chain performance (Shepherd and Günter, 2006). Although relationship quality is widely recognised as a higher order construct consisting of, for example, satisfaction and trust, there is little agreement within or between these disciplines over the dimensions that comprise it.

Second, supply chain and operations management research assumes that dimensions of relationship quality evolve in parallel, complement each other, and positively and linearly impact on supply chain performance. However, evidence from organisation studies suggests that there may be non-linear relationships between these dimensions, which, under certain conditions, can negatively influence some aspects of performance (Ariño et al., 1999; Langfred, 2004).

Third, existing research is focused at the dyadic level rather than the supply chain as a whole and has paid insufficient attention to the fact that relationship quality is a multi-level phenomenon, operating concurrently at the interpersonal, person-to-organisation and inter-organisational level (Fichman and Goodman, 1996; Palmatier et al., 2007b). Unfortunately, research on relationship quality has generally focused on one of these levels leaving researchers with a fragmented understanding of relationship quality. This is problematic as recent research indicates key ingredients of relationship quality, such as trust, to have different meanings at different levels (Ariño et al., 2005).

Finally, although relationship quality is typically treated as an antecedent of supply chain performance, it can alternatively be seen as an output of the interactions between supply chain partners. Understanding of relationship quality and its links to the performance of supply chains can be enriched by acknowledging, and further exploring, the active role individuals play in shaping supply chain relationships in specific contexts. Conceptualising relationship quality as contextually specific, emergent and constantly negotiated between partners acknowledges that the concept is inherently two-sided, relational, dynamic and exists only through joint learning and sensemaking.

Despite the contributions of the paper, it is important to reflect upon its limitations. Perhaps the main risk is that the literature review is not exhaustive. We conducted a review of top rated journals from each discipline but interrogated only two online repositories (ISI Web of Science® and Google ScholarTM). Whilst they are widely regarded as excellent data sources also other databases could have been reviewed for completeness, such as, Business Source® Premier or PsycINFO®. Additionally, further academic disciplines, such as, for example, strategy or economics, could have been considered too.

There are important implications arising from this study for future research into relationship quality in supply chains. First of all, if the unified conceptualisation of the relationship quality as well as supply chain performance constructs reveal to be so challenging, links between specific dimensions of these constructs may be assessed in a first step (eg. trust and flexibility). Moreover, longitudinal, multivariate analyses are required to better establish the existence, and direction, of the proposed links. Indeed, multi-level analyses would be especially beneficial in disentangling relationship quality and its dimensions at different levels. Further, there is an opportunity for interpretive case studies to more fully understand the genesis and rebuilding of relationship quality in supply chain contexts over time.

The absence of a conclusive link between relationship quality and supply chain performance has important implications for practitioners. Specifically, managers should avoid focusing on interventions designed to exclusively enhance partial aspects of relationship quality. Instead, they should consider addressing supply chain performance more directly, for example, by implementing appropriate performance measurement systems (see Shepherd and Günter, 2006). However, it is critical that these performance measurement systems incorporate metrics for different dimensions of relationship quality as evidence suggests that poor quality relationships are likely to result in opportunistic behaviour in the supply chain, which can threaten relationship continuity (e.g. Jap et al., 1999). To mitigate these risks, managers should define thresholds for dimensions of relationship quality, such as trust, commitment and satisfaction and continuously monitoring the state of the relationship over time. Measures to safeguard relationship quality must be adapted to the stage the relationship is at, as the relative importance of dimensions of relationship quality can change over their lifecycle. For example, any sign of distrust could be particularly worrying in early stages of a relationship as no institutional commitments exist to keep a relationship on track. Similarly, the performance metrics should not be limited to lagging indicators such as costs or quality, but include also leading indicators such as number of joint projects, for example (Cordon and Vollmann, 2008).

Relationship quality, as this paper has demonstrated, is a concept replete with conceptual and methodological challenges. However, in bringing together existing knowledge from so many different disciplines, this review has provided important implications for future research and managerial efforts in practice.

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AN INTEGRATED MODEL FOR DESIGNING AND OPTIMISING A EUROPEAN LOGISTICS NETWORK: THE PIRELLI TYRE CASE

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ABSTRACT

Purpose of the paper

The present paper focuses on one of the most important issues in supply chain research: supply chain configuration and optimisation. The aim of this study is to propose a logistics network optimisation model, together with a series of methodological guidelines for obtaining and processing the necessary data, able to deal with real life supply chains problems and to manage a degree of complexity typical of a factual company environment.

Methodology

After an extensive review of the literature on linear programming models for supply chain configuration and optimisation (170 reviewed papers), we developed a mixed-integer linear programming model along with a data mapping scheme and, subsequently, we applied them to a real-life case study, i.e. the European Pirelli Tyre logistics network.

Findings

Based on the comparison of the outcomes of the model with budgetary data for the *as-is* logistics network configuration, the proposed model proved to be accurate and adherent to the actual figures of the considered company. We then solved the optimisation problem, obtaining significant results in terms of savings compared to the *as-is* situation.

Research implications

This paper significantly contributes to the growing debate on the adoption of models and decision support tools for designing and optimising supply chains and logistics networks.

Practical implications

By means of this study, we provide supply chain managers with a decision support tool for optimising the configuration of international logistics networks, able to keep into consideration real-life issues, complexity and constraints. Moreover, the enclosed methodological guidelines drive users in the complex, difficult and time-consuming data gathering and processing activities.

Originality

Our extensive review showed that previous literature is particularly wanting of exhaustive supply chain design and optimisation models, dealing with real-life complexity, practically implemented in realistic contexts and integrated with a data gathering and processing section as well. For this reason, the originality of our proposed approach is represented by the possibility to fill the gaps in the current state of the art, by means of an integrated design and optimisation model, practically applicable by companies.

Keywords: supply chain configuration, logistics network design, linear programming, optimisation models, physical distribution

Paper Type: Research paper

INTRODUCTION

The recent evolutions of the world economy and of the competitive environment, and the current turmoil of the economic climate compel companies to confront a series of ever-growing challenges (Juttner et al., 2007). Indeed, the process of globalisation is changing the supply chain.

Moving from the evidence that the growth of international trade entails a series of managerial challenges, multinationals are faced with strategic decisions regarding the configuration of their logistics networks (Teo and Shu, 2004; Gargeya and Meixell, 2005; Chopra and Meindl, 2007). Consequently, there needs to re-design and optimise the supply chain and the logistics network by means of specifically developed models and decision support tools (Melachrinoudis and Min, 2007; Melo et al., 2008). Considering the increasing pressure on logistics and distribution cost control and reduction, in the present paper we are focusing on the configuration of supply chains (i.e. the

definition of the topological variables of the supply chain, the number of echelons in the supply network, the number of nodes in the network and for each echelon, their capacity, the distance between the nodes in the network and the links and connections between the nodes – Goetschalckx and Fleischmann, 2005; Gargeya and Meixell, 2005; Simchi-Levi et al., 2005).
The objective is to respond to the ever-growing necessity of network optimisation, by proposing a logistics network design model, based on linear programming, able to deal with real life supply chains problems and to manage a degree of complexity typical of a factual company environment. Thus, the model should be able to be applied to supply chains characterised by a relevant number of nodes and with a series of realistic and practical operating constraints. Moreover, we aim at providing a series of methodological guidelines for obtaining and processing the data and information necessary to run the model, since data mapping and processing is considered a very relevant, difficult and time-consuming activity in real-life contexts (Carlsson and Ronnqvist, 2005). We applied the proposed model to a real life case study, i.e. to Pirelli Tyre company, underlining the capability of the model to deal with practical and real world complex problems. Finally, a series of concluding remarks is presented, closing the study and the paper with some insights on potential further research on the topic.

BACKGROUND OF THE STUDY

A logistics network consists of a series of facilities (represented by suppliers, manufacturing centres, warehouses/distribution centres, retail outlets) and of raw materials, work-in-process inventory and finished products that flow between the facilities. The key issues in network design are represented by the definition of the optimal number, location and size of warehouses and/or plants, of the optimal sourcing strategy in terms of which plant/vendor should produce which product and of the best distribution channel in terms of which warehouse should serve which customers. The objective of such a problem is to find a minimal-cost configuration of the logistics network able to satisfy product demands at specified customer service levels. In order to solve this problem, the network design process should be composed by a data mapping section, based on ready-to-be-applied data, and by an optimisation technique, able to provide the optimal network configuration (Simchi-Levi et al., 2005).
Literature has traditionally dealt with this subject through a series of studies developed on the basis of linear programming models, being the latter the most widespread modelling tool (Sridhar et al., 1999; Shapiro, 2001; Gargeya and Meixell, 2005; Chopra and Meindl, 2007). Among the models based on linear programming, most contributions are aimed at designing a logistics network considering a single-period horizon (Melo et al., 2007). However, a multi-period approach is presented by Ballou (2005), who proposed a logistics network design model in which the design parameters change over time in a predictable way. Many authors have been focusing on deterministic models for designing a logistics network (Melo et al., 2007). However, in order to face environmental variance, procedures focused on stochastic programming have been drawn (Santoso, 2002).
Our analysis showed that there are few actually implemented studies, indicating many areas of potential research for the development of innovative and practically applicable facility location models, in a context of logistics network design. The available contributions are mainly with no proved practical application, and with no reference to key issues such as service level constraints. A logistics network design process should be composed by a data mapping section and an optimisation technique to be applied (Simchi-Levi et al., 2005). The relevance of the data mapping section has been widely acknowledged by the reviewed literature (Melachrinoudis and Min, 2000; Carlsson and Ronnqvist, 2005; Simchi-Levi et al., 2005). However, our analysis showed that even among the applied approaches and models, few of them include guidelines aimed at providing the reader with a reference for gathering, mapping and processing the information necessary to run the models. We can surmise that the reviewed papers seldom provide an exhaustive approach to the network design, very often lacking a data mapping section.

THE LOGISTICS NETWORK DESIGN AND OPTIMISATION MODEL

The logistics network design approach we propose in the present paper is based on mixed integer linear programming (i.e. the optimization engine) and includes a data mapping section, providing a series of methodological guidelines for obtaining and processing the data for the model.

The logistics network we are addressing is constituted by a series of product-focused production plants (P_p), a series of Regional Distribution Warehouses (RDW_h, that receive products from plants and ship to international or local customers) and a series of Delivery Points (defined as DP_j), serving end customers and served with a single sourcing policy. The nodes of the logistics network are connected by means of road transport linkages. The engine of the optimisation model is based on mixed integer linear programming (MILP). In particular, given:

- a set of specified P_p originating the logistics flows, with their geographical location;
- a set of specified DP_j to be served, with their geographical location;
- the profile of the demand of each DP_j;
- a set of potential RDW_h, with their geographical location,

the model is aimed at minimising the overall physical distribution costs, fulfilling a required service level, by:

- defining which RDW_h will be activated;
- defining which activated RDW_h will serve which DP_j ;
- assigning coherently the capacity to each activated RDW_h.

Differently from the set of RDW_h, the sets of P_p and of DP_j are considered as given, as well as the presence of a logistics flow between each P_p and each DP_j and the product mix sourced by each DP_j from the each P_p. Thus they will not be included in the group of decision variables. The actual decision variables are represented by the activations of both the RDW_h and the connection linkages between the activated RDW_h and DP_j, while the connection linkages between P_p and RDW_h are not considered as decision variables since these connections are determined by the product mix required by each DP_j to the various P_p.
In fact, in our model we consider a logistics network in which each plant is product-focused and that each DP_j is demanding a range of different products. Consequently, each DP_j will be served by a certain plant if requiring the products the plant is able to provide. We modelled this issue by considering that the demand of each DP_j is fulfilled by each plant according to a certain percentage, defined as m_{pj}. This product mix has to be preserved equal to the current end customers' demand profile also when the location of the RDW_h is re-determined. Then, we modelled the choice of the activation of the connection edges between the various RDW_h and DP_j by means of a Boolean variable, named $k_{h,j}$, whose value is set equal to 1 if the RDW_h serves the DP_j , 0 otherwise. The capacity of the RDW_h will be determined depending on the choice whether to activate a RDW_h and on the number of DP_j to be served (i.e. the number of activated connections). In this way, we can consider the capacity of each activated RDW_h as a result of the sum of the demand of the served DP_j. The objective function is:

$$\min\left(\sum_{h=1}^{H}\sum_{j=1}^{J} cs_{h,j}\cdot d_{h,j}\cdot k_{h,j}\cdot D_j+\sum_{h=1}^{H}\sum_{j=1}^{J} cw_h\cdot k_{h,j}\cdot D_j+\sum_{h=1}^{H}\sum_{p=1}^{P} cp_{p,h}\cdot\sum_{j=1}^{J} m_{p,j}\cdot k_{h,j}\cdot D_j\right) \quad (1)$$

where:

D_j = annual demand of DP_j [ton/year]
$cp_{p,h}$ = primary distribution cost from P_p to RDW_h [€/trip]
cw_h = warehousing cost (handling & housing) of RDW_h [€/kg]
$cs_{h,j}$ = secondary distribution cost from RDW_h to DP_j [€/(kg*km)]
$d_{h,j}$ = distance from RDW_h and the DP_j [km]

The constraints of the MILP model are:

$$\sum_{h=1}^{H} k_{h,j}=1 \quad \forall j \qquad (2)$$

Representing the adopted single sourcing policy.

$$k_{h,j}\le I_{h,j} \qquad (3)$$

Representing the service level requirement where $I_{h,j}$ is equal to 1, if it is possible to serve the DP_j from the RDW_h within the required delivery lead time, otherwise is 0. This constraint leads to the definition of a (h x j) matrix filled with 0 or 1, depending if the considered RDW_h can serve the specific DP_j within a given delivery lead time (e.g. within 24 hours).

PIRELLI TYRE CASE: DATA MAPPING AND INFORMATION PROCESSING

In order to make our approach suitable for real life supply chains, in this section we provide a series of methodological guidelines for obtaining and processing the data necessary to run the model (i.e. data mapping), and we show how they have been applied to the Pirelli Tyre case.

Pirelli Tyre is a multinational automotive tyre manufacturer, headquartered in Italy. Its product range includes a wide variety of tyres, from commodity products to motorsport special tyres, and it can be grouped in three main categories: car, motorcycle and truck. Each of them is characterised by different features, basically regarding quality and density (volume/weight ratio). The current Pirelli supply chain (with reference to the continental Europe only, which represents our focus, together with the replacement market) is composed of 7 product-focused Production Plants, daily replenishing 10 Regional Distribution Warehouses with territorial competence (adopting a single sourcing policy), which in turn replenish over 40,000 Delivery Points. The most important customers in terms of product demand are located in Italy, Germany, Spain, Switzerland and in the UK. Currently, warehousing and transportation activities are outsourced to 6 third party logistics service providers (3PL) which operate in specific geographical areas. The overall warehousing space rented by Pirelli is about 150.000 m^2. The present service level requirements imply that 98% of the orders are fulfilled within the next day.

The data mapping and information processing regard all the information and data necessary to operationalise the MILP engine. In particular, the main issues to be addressed are:

- *Delivery Points DP_j*: in a real life supply chain the number of DP_j could be greater than 40,000, implying an overwhelming complexity as in the Pirelli case. Thus, it is necessary to consider DP_j geographical aggregations (Simchi-Levi et al., 2005). Some geographical aggregation drivers are suggested by literature, and they are basically represented by the ZIP codes and by the NUTS codes (*Nomenclature des Unités Territoriales Statistiques*, Eurostat 1988). Three different levels of aggregation are present in the NUTS codes, based on the number of inhabitants per aggregated cluster. The lowest level of aggregation (NUTS3) corresponds for example in Italy to the province level. For each considered NUTS3 area, its respective centre of gravity is assumed as reference geographical coordinates of each area. The assigned coordinates are representative of the geographical position of the DP_j. Based on the adopted aggregation methodology, it is possible to derive the aggregate demand of all DP_j included in the same NUTS3 area. In the Pirelli case, this aggregation process led to identify 976 NUTS3 areas, representing the clustered demand.
- *Primary distribution cost* ($cp_{p,h}$): since the linkage between P_p and RDW_h is generally performed by means of Full Truck Loads (FTL), for each transportation leg a transportation unit cost (€/trip) is derived by matching the theoretical transport unit cost (expressed in €/km) for a FTL haulage with the actual road transport rates applied by hauliers. Considering the annual number of FTL haulages from a P_p to a RDW_h, obtained by dividing the annual shipment volume (ton/year) by the Full Truck Load capacity (ton/haulage), it is then possible to derive the overall annual primary distribution cost. For Pirelli, the FTL capacity is equal to 13 ton per haulage.
- *Secondary distribution cost* ($cs_{h,j}$): since in the design and optimisation problem the *to-be* configuration of the logistics network could sort a series of different activated RDW_h compared to the *as-is* configuration, it is necessary to derive a cost function to obtain the distribution unit cost from a RDW_h to a DP_j, moving from the actual rates applied by hauliers. A typical road transport rate for secondary distribution is segmented according to different weight ranges and destinations (partially depending on the distance to be covered but also on the specific features of the delivery point to be reached). From this rate, it is possible to derive a function representing the €/kg*km transport rate for deliveries from a RDW_h to the various DP_j to be served. By means of a regression analysis of this function against the distance, it is possible to derive the best fitting curve interpolating the transportation rates in terms of €/kg*km with respect to the travelled distance. It is then necessary to evaluate the goodness of fit of the derived function by means of the coefficient of determination R^2. In the Pirelli case, all the functions were characterised by a R^2 value higher than 0.9. The rate in terms of €/kg*km will be multiplied by the actual distance to

be travelled (from 50 km up to 800 km) and by the volume of products to be shipped, to obtain the overall annual distribution cost to serve the DP_j included in a given NUTS3 area.

- *Warehousing cost (housing and handling at RDW* - cw_h): it is first of all necessary to express the capacity of each RDW_h in terms of annual flow of goods (ton/year). From those data, starting from the inventory turnover ratio and the warehouse occupation rate (ton/m^2), it is possible to derive the required RDW floor space. This value is multiplied by the annual rent fee (€/m^2), gathered from logistics real estate agencies, for each potential RDW_h, in order to obtain the annual housing cost. The annual handling cost is instead calculated considering the materials handling rate (€/kg), gathered from logistics service providers and the annual flow for each RDW_h (kg/year).
- *Service level requirement*: in order to define the catchment area a RDW_h could cover within a given delivery lead time, it is necessary to draw a series of isochronal curves, originated from the geographical coordinates of the RDW_h. This procedure is enabled by course-plotting software which, considering the road network conditions, driver stops and transhipment times, determine the available driving time.

Figure 1. Isochronal curves from Novara RDW (Italy)

For the Pirelli case, we drew the isochronal curves by means of Microsoft MapPoint (see figure 1) for 3 different scenarios of required service level:

– S1: all the delivery points served within 24 hours;
– S2: the main areas only (e.g. Milan) served within 24 hours and the remainders within 36 hours;
– S3: the main areas only served within 24 hours and the remainders within 36 or 48 hours.

THE PIRELLI TYRE CASE: RESULTS

After having completed the data mapping section, it was then possible to solve the optimisation problem for the Pirelli case. We first simulated the *as-is* network configuration to derive the overall logistics cost from our model, based on budgetary data. We obtained a very high degree of accuracy of the outcomes, compared to the actual costs. Then, we solved the optimisation problem by minimising the overall logistics cost function for the three different service level scenarios. In figure 2 we report the results of the optimisation.

The service level requirement influences the total logistics spend. In fact, for a strict service level (S1) the number of necessary warehouses for fulfilling on time the demand remains the same as before. The saving (equal to 4%) arises from a better selection of the RDW_h to be activated and a better combination of the connection linkages between the nodes. Scenario 2 (S2) shows the highest saving (equal to 7%), resulting from the possibility to activate 9 RDW only, due to a less strict service level constraint, which allows broader reachable geographical zones within a longer lead time. Finally, Scenario 3 shows a saving equal to 6%: in this case, a moderate service level constraint allows the exclusion of 5 RDW. However, this entails a significant increase in the distribution costs, for the abovementioned reasons, and the resulting saving is lower than the one obtainable in Scenario 2.
In any of the considered scenarios, the savings are significant and prove the effectiveness of the proposed network design model, with the opportunity to optimise the physical distribution process in different service level scenarios.

Scenario	**Base Case**	**S1**	**S2**	**S3**
Delivery Lead Time [hours]	24-36	24	24-36	24-36-48
Activated RDW_h	10	10	9	5
Warehouse space [%]	100	100	98	94
Primary Distribution Cost [%]	44	43	43	42
Secondary Distribution Cost [%]	33	31	29	32.5
Warehousing Cost [%]	23	22	21	29.5
Total Cost [%]	**100**	**96**	**93**	**94**

Figure 2. Results of the optimisation for the Pirelli Tyre case

CONCLUDING REMARKS
In the present paper, we addressed one of the most important and current issues in supply chain research. After having performed an extensive review of the literature regarding linear programming approaches, we proposed an integrated model, characterised by the presence of the data gathering, mapping and processing procedures and able to deal with real-life and supply chains complexity. We succeeded in applying it to a very complex supply chain, i.e. the Pirelli Tyre European Supply Chain. Based on the comparison of the obtained results with budgetary data, the model proved to be very accurate. Then, we optimised the Pirelli Tyre network, obtaining very significant results in terms of saving, compared to the *as-is* situation, with different scenarios of service level constraints. Consequently, we believe that the proposed model can be profitably applied by supply chain and logistics managers for optimising operating contexts characterised by similar features compared to the considered ones.

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SUPPLY CHAIN AS A VIRTUAL ORGANIZATION: DREAM OR REALITY?

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ABSTRACT
The proposed paper defines the concept of a virtual supply chain (VSC) and indicates how its characteristic features fit into the current business reality. Temporary character of VSC allows for collaboration of firms during specific required ventures. Members of VSC can operate in different dynamic business networks and activate new ones according to emerging business opportunities and specific customers. VSC must have an extensive ITC support to be comparatively independent of location aspects of operations. Operational structures of VSC drive towards horizontal and cooperative relations (especially with logistic service provider) in the networks based on expertise and abilities of their dedicated members. Research indicates that the level of adaptation of firms towards VSC has not been satisfactory yet to guarantee efficient operations.

INTRODUCTION
World business is facing new challenges in the present millennium. Actual economic reality becomes constantly more difficult for companies due to a synergy of larger complexity and growing dynamics of business processes. It results in discontinuity of development of businesses, particularly in the environment troubled by economic recession and current shrinking business opportunities.

Although the new economics and social order is not quite clear yet, it should be worthwhile to revisit the idea of managerial issues of virtual supply chains, that have become an accepted business concept. Virtual organization became one of the symbols of modern economic and social development, however, it still remains one of the least understood and the most discussed concepts. Supply chain can be described as a specific form of a virtual organization with its all characteristics.

Virtual supply chains are frequently identified with e-business, computer communication and digital products. Within the framework of organization theory a virtual supply chain is more than that; it is an organization that is subject to constant changes, demonstrating a specific potential when required, overcoming time and space barriers. Virtual supply chains could be described by such attributes like temporary character, focus on customers, geographical dispersion, intensive support of IT systems, network structure and an extensive use of key competencies of their members.

VIRTUAL ORGANIZATION – WHAT DOES IT REALLY MEAN?
Virtual means imaginary reality. The notion of virtual, in the literal sense of the word, indicates something that only exists in the imagination, and not in the real world.
"Virtual" has become a potent buzzword and is freely applied to many situations and has many meanings. Some authors indicate that because of that "virtual" is in danger of meaning nothing (Watson-Manheim et al., 2002). Overuse of that term results in some serious research problems:

- It does not clearly allow to compare results from different studies, since "virtual" is used in a non-systematic way and describes many different environments.
- There are many problems connected to virtual organizations although they are not always addressed in research and literature with the explicit keyword of "virtual".

Virtual organizations are called "imaginary organizations", held together by trust, synergies of the partners, contract and information technology (Hedberg et al., 1994). They operate without long-term relationships, can be enabled or dissolved easily on a real-time basis.

Virtual corporation seems to be the strategy for structuring and improve the corporation for the coming century (Davidov and Malone, 1992). Organizations find that strategy they can follow to provide increased flexibility in an economic environment of continuous change.

Virtual companies are characterized by a networks of internal and external relations that constantly change.

DISCONTINUITY AS THE MAIN FEATURE OF VIRTUAL SUPPLY CHAINS

Virtual supply chains are "production and distribution systems utilizing a formal physical network structure, and operating through a network of separate organizations" (Chandrashekar and Schary, 1999). There are no permanent members, they are called in for particular projects and may not be visible for other members. Virtual supply chains are not serial chains but rather flexible networks with fast, real-time electronic communication.

Virtual supply chain operates in changing business environment. The virtual supply chain often focuses on the solution to concrete tasks and projects. After solving the task and completing the project, virtual supply chain is dissolved and new one is formed with new combinations of partners. The dominant organization in the chain, called often as a "broker" uses temporary partners for a specific task. The dominant firm replaces fixed connections with flexible ones, based on prior selection of alternatives, that require managers to communicate tasks to members. This form of coordination has been possible only with the extensive use of advanced computer technologies and telecommunication (Townsend et al., 1998).

In that context, the use of the word "virtual" brings the notion of discontinuity, being a gap or a lack of coherence in aspects of operating business such as task, relations with other organizations or location (Watson-Manheim et al., 2002). There are two forms of such discontinuities:

- temporal, when e.g. companies change their old suppliers to the new ones;
- cross-sectional, meaning a lack of coherence in business relations and resulting in conflicts terminating some types of business relationships.

In a virtual organization one or more discontinuities usually appear. As examples one may indicate the following types of discontinuities: temporal business location (e.g. across different time zones), geographic business location, consortium membership (who you do business with), organizational affiliation, cultural business background (e.g. national or professional). Therefore, virtual supply chains often go against establishment of long and close relations between their partner members. However, the virtual supply chain is not quite incompatible with the model of close business partnership. Probably virtual supply chains could be established when the potential members want to make use of their existing, complementary competencies. As opposite, partnership relations would be more typical for situations, where competencies are created during the course of collaboration over longer time periods (Skjoett-Larsen, 2000).

Impermanence of the virtual supply chain creates some specific positive opportunities that distinguish it from more stable arrangements. First of all it is closely oriented towards customers or products. The temporary configuration of functional specialist members is oriented towards rapid response, offering production and distribution flexibility.

The short-term relations and transitory character of virtual supply chains creates also some problems resulting from the discontinuity of operations:

- perception of insufficient level of trust and data security,
- smaller chance for inter-organizational bonding and loyalty,
- more complicated logistics management because of flexibility due to unstable volumes and non-repeating logistics patterns.

The main research question addressed by the paper is: Are average companies prepared to function within the frameworks of such virtual supply chains? Special focus has been put on three main aspects enabling operations of companies within VSC frameworks: level of development of ICT, potential support of p[hysical flows from logistics service providers and general logistics competencies of companies.

METHODOLOGY

That research question will be answered by discussing results of the surveys in companies in the southern part of Poland in 2007-2008:

- first questionnaire was applied for manufacturing, distribution and service companies, investigating such issues as logistics costs, logistics outsourcing practices, evaluation of logistics capabilities, scope of cooperation with suppliers and customers, plans for future development of logistics;
- second questionnaire was common for all responding companies and investigating the current state of application of ICT technologies.

There were 112 respondents to the first questionnaire and 121 respondents to the second questionnaire.

The firms responding to the first questionnaire were more or less evenly spread between manufacturing, distribution and service companies, however, with slightly prevailing group of manufacturing and construction companies. Respondents replying to the ICT questionnaire were companies operating mostly in transport, distribution and logistics. The majority of companies (around 65%) in the first sample belong to the group of small and medium enterprises. They distribute products mainly to the domestic market (72% of companies), 19% of companies sell to the EU and the remaining 9% of surveyed firms beyond the EU with only 2% of companies distributing products outside Europe. More profound analysis of surveyed companies in the sector of transport, forwarding and logistics services indicated that the majority of those companies belong to road transport sector (49%), rail transport (26%), air transport (9%)other logistics services (14%) and cross-docking and warehousing (2%).

The questionnaire tested several variables describing the major aspects of virtual supply chains. On the basis of these variables, the current status-quo presented by the survey's respondents will be discussed. The main gaps between the requirements for proper virtual supply chain and the real conditions of operating businesses will be identified. The final answer to the main research question will also provide some guidelines for the future directions of research in the are of virtual supply chain management.

INTERCONNECITIVITY OF SURVEYED COMPANIES

The extent of the practical use of ICT technology is the basis of operations of virtual supply chains. Almost one half of surveyed companies uses Internet while ordering from their suppliers and offers the same option to their customers. Many of the respondents (44%) do not use Internet for monitoring of the progress of order processing; that is done mostly by courier firms and logistics providers. However, the respondents do not buy nor sell on-line products. Those types of transactions are performed only by 9% of selling companies and 12% of buying firms for the total number of products. Respectively 15% and 10% of surveyed companies do not use any electronic techniques (EDI,ERP, etc.) for sales and purchases of any of their products.

The research clearly indicated that companies apply ICT in their relations with market partners (suppliers, customers, logistics providers) to larger extent than with their contacts with other supporting and government institutions. Almost 1/3 of the respondents were not satisfied with ICT available for communication with these legal institutions, and only 15% expressed their clear positive attitude towards that issue.

The scope of use of ICT technologies in supply chains to a great extent depends on companies' perception of the barriers limiting the possibilities of implementing certain technical solutions. The following barriers have been evaluated through the series of questions:

- barriers for general use of ICT,
- barriers for the use of Internet as a tool for inter-organizational communication,
- barrier for the use of e-commerce fro inter-organizational transactions.

Unfortunately around 60% of respondents could not identify the exact barrier valid for their company. The following barriers for general use of ICT have been identified:

- *High costs*: around 17% of companies admitted that high costs might be the main limitation for implementation of proper computer solutions. Probably the real costs generated by the use of Internet options have never been calculated, since ¼ of the respondents confirmed that the cost issue is not a barrier for wider application of the Internet in their communication process.
- *Requirement for constant learning and permanent skills acquisition*: the employees have to abolish they daily routines and some of them might identify it with loosing stabilization and change of daily work patterns. ¼ of the respondents confirm that if such a negative attitude is present it may easily create a serious barrier against implementation of new ICT.
- *Low skills of the personnel*: 1/3 of surveyed companies identified it as a serious problem. Some 18% of respondents identified also a problem with recruiting proper ICT professionals as another barrier for extensive use of modern computer technologies. At the same time 33% of the respondents declared that inadequate qualification of the employees are not another barrier against wider use of ICT in their companies.
- *Security of computer networks*: According to the opinion of 33% of the respondents it is another barrier. They demonstrated high level of awareness of the necessity of activities preventing them from negative influence of Internet use.

There was no consensus on the following barriers for ICT use:

- *Negative attitude against modern computer technologies*: 34% of surveyed companies indicated that their employees do not present any, and if necessary – they can be persuaded to apply proper practices in that area.
- *Gap between adopted applications and real requirements of companies*: more than the half of respondents could not decide, if a might be another barrier for wider scope of ICT use. Around 23% of surveyed companies indicated that such a gap exists while an equal share of respondents denied it. It might indicate that some of surveyed companies were in favour of ready made commercial applications while others preferred "tailor-made" dedicated ones.
- *Complexity of ICT*: there was no consensus in the opinions of respondents about the impact of the on the scope of its use, however, 28% of companies indicated that complicated technical requirements might constitute such a barrier.
- *Exact benefits of wider use of ICT*: probably firms do not evaluate such benefits, since 61% of the respondents could not identify them. At the same time 22% of surveyed companies declared that lack of such visible benefits does not constitute a barrier for application of computer technologies.

Internet became a robust tool for inter-organizational communication. Around 30% of the respondents indicates that the Internet offers a quick and stabilized communication process off-line and on-line. However, almost one half of surveyed companies did not provide clear answers as to their opinion on the speed and accuracy of Internet connections. It may suggest that such a portion of the respondents do not have adequate practice in more extensive use of Internet as the means for inter-organizational communication.

The research project highlighted also lack of consensus with respects to barriers against more extensive use of e-commerce in inter-organizational transactions:

- *Lack of adequate preparation on the side of suppliers and customers:* around 30% of the respondents claimed it as the major problem. However, the rest of surveyed companies did not explicitly confirmed it, so probably the extent of use of e-commerce depends largely on such factors as size of collaborating companies, industry they represent, the value of turnover, etc.
- *Security issues connected to financial tr*ansfers: almost 36% of the respondents confirmed that these issues do not create any barriers nowadays. Another 20% presented different opinion. However, almost ½ of surveyed companies could not clearly present their opinions about the influence of contract conditions, delivery terms and warranty on the extent of use of e-commerce.

- *Physical delivery in e-commerce systems:* this issue seems to be not quite clear for surveyed companies. Around 60% of them do not realize what kind of barriers may arise on the basis of logistics issues. Only few types of products such as electronic books, graphics, music and other digital files) could be transferred via electronic distribution channels. Other products require traditional physical transfer. More than 60% of surveyed companies was not able to make a statement if the products not fitting their distribution through electronic channels may actually delay the introduction e-commerce. Around 20% of the respondents declared that the type of sold products or services does not create any barriers for e-commerce, while 15% of surveyed companies expressed quite opposite opinion.

POTENTIAL OF THE LOGISTICS SERVICE PROVIDERS

Probably actual transportation systems in Poland are not supporting flows of products resulting from discontinuous flexible business processes. Road transport is the only mode of transport which could be useful and competitive in that field. Rail transport does not provide any alternative solutions for reduction of the scope of use of road transport.

One of the main negative features of Polish transport systems is its poor technological level, especially in the area of intermodal transportation. Actual transport system are based on simple solutions for movement and organization of the whole transport process and it seems to be somewhat irrational in the presence of strong competition on global markets and constantly growing access to telematics.

The level of integration of the Polish Road and rail networks has not been adjusted to the intensity of traffic. Besides infrastructural problems of rail, road, sea ports, airports and logistics centres as well as missing infrastructure for intermodal transportation for efficient operations of virtual supply chains some special arrangements of virtual logistics are needed. They are connected to systematic organization of the flows of main cargo loads. Those processes depend on close cooperation of intermodal transport providers, logistics centres, state administration, customs and sanitary agencies, etc.

Analyzing the types of loads serviced by surveyed logistics service providers one can notice that 40% of their loads consisted of fixed bulk loads, other loads – 25%, general loads – 17,5% and unit loads and express cargo – 7,5%. Geographical structure of work performed by the surveyed logistics providers indicated that domestic market is their main area of operation (72% of transport work), next is the EU market together with Norway, Iceland and Switzerland (23%) and only 0,5% of that work has been done beyond UE and Europe.

The structure of services provided by the surveyed providers indicated that their major occupation was with "pure" transport services (62%), transport and storage services (25%), "pure" storage services (7%). Mixed services such as transport and storage using standardized or individual packaging has been offered only at a very small scale.

On the basis of that data one may expect that the actual offer of the whole transportation and logistics sector does not provide many opportunities for virtual types of businesses with largely diversified requirements and demanding flexibility and accuracy from service providers.

LOGISTICS POTENTIAL OF FIRMS FOR THEIR OPERATIONS IN VIRTUAL SUPPLY CHAINS

Respondents of the survey consistently indicated the important role of logistics (particularly from the point of view of customer service). That opinion was particularly popular among manufacturers (96% of responses). Manufacturers pointed also (60%) that logistics is quite essential tool for achievement of high profit level. Around 75% of respondents declared that they concentrate on the idea of "perfect order" completion with the average order cycle of 16 days and the average rotation of inventories of 14 days. Cash-to-cash cycles on average amount to 9 days, particularly 12 days for manufacturers and 4 days for distribution companies.

All respondents described their logistics potential equal to that of their competitors. Around 67% of respondents were extremely positive about their abilities of adjusting delivery lead times to exact demand of their customers and around 57% of surveyed companies declared large possibilities of reduction of delivery time. Equally large number of respondents (65%) evaluated quite high the abilities of their companies to be flexible and accommodate changing requirements of their customers. At the same time surveyed companies were less optimistic about their systems for information about late deliveries or product modification during delivery process. These two fields probably show some practical shortcomings in the area of capacity management and its operational adjustment to changing requirements of customers.

Respondents indicated two Essentials elements supporting internal integration of their logistics operations:

- Strategic planning based on close cooperation of functional departments in companies (around 59% of respondents)
- Efficient information sharing between departments and employees in a company (around 54% of respondents).

Respondents (58%) indicated also the importance of collaboration with selected suppliers and customers in operational planning and forecasting of the main business processes. That aspect coincided with replies concerning efficient information sharing with suppliers and customers (53%). However, around 15% of surveyed companies did not confirm that they share such information. Only 43% of respondents declared their satisfaction with information systems that they have at their disposal for communication with cooperating partners. The level of dissatisfaction is slightly higher among manufacturers. Such survey results are probably typical for a sample with the large number of companies in the group of SMEs (57% of surveyed manufacturers, 58% of logistics providers and 73% of distribution companies). SMEs suffer from specific difficulties while trying to improve their cooperation within supply chain framework, implement information systems adequate to their requirements and limited financial assets.

CONCLUSIONS

Reported research indicated that surveyed companies are not quite ready to create efficient virtual supply chains. Information and communication technologies seem not to be responsible for that. Even if some shortcomings occur in that field they probably might be immediately eliminated either through additional investment or employees qualifications. Specific barriers against the use of ICT were difficult to be identified.

The most important reasons limiting more frequent adoption of virtuality in supply chain operations lie in the field of traditional approaches adapted by companies in the field of logistics operations. At the same time logistics service providers do not offer diversified and complex services suitable for temporary and discontinuous business. These areas require further exploration with adoption of the concept of virtual logistics, based on shared resources increasing the efficiency of small sized deliveries.

Whenever the physical character of a product is in place, ICT cannot handle it alone. Due to physical character of most of product deliveries wider scope of use of virtual supply chains will be still difficult for long time. Therefore alternative flexible delivery systems should be the subject of further logistics research.

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ROLE OF LOGISTICS SERVICE PROVIDER IN SUPPLY CHAIN BETWEEN MANUFACTURER AND SUBCONTRACTOR

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ABSTRACT

This research focused on studying role of logistics service provider in a Finnish machinery industry supply chain between a manufacturer and a subcontractor. This research was started by searching arguments and industry driven needs for utilizing the service provider in the studied supply chain. Based on the results of the first research phase, a logistics service provider role model was generated. The model includes six different roles for the service provider: *improver of operational logistics efficiency, operational decision maker, value-adder, production maker, supply chain manager and developer, and enabler of business growth*. The developed role model was tested by four logistics service providers´ client relationships. In general, the studied service providers worked on operational tasks between the manufacturer and the subcontractor. This means that they can be placed at the first of two roles mentioned above. One studied service provider made an exception to this general line by operating with some clients as the production maker, the supply chain manager and developer, and even as the enabler of business growth. This indicates that there is potential market demand for service providers even in strategic supply chain management role.

Keywords: outsourcing, logistics service provider, supply chain management

INTRODUCTION

In the 1990´s companies started to focus more and more on their core business areas and simultaneously the amount of outsourcing of non-core business processes started to grow (Prahalad and Hamel, 1990). However, in the 1990´s the main idea of the outsourcing was improvement of operational efficiency. Long term strategic winnings were considered only in rare cases (McIvor et al., 1997).

One typical outsourcing target has been logistics processes. According to Stone (2006) the markets of logistics service providers (LSP) have been growing fast in recent years. Outsourcing of logistics processes improves cost efficiency, but it also makes possible to achieve a new kind of a competitive edge (Rabinovich et al., 1999). In the 1990´s LSPs were mainly resource providers and operative workers, but outsourcing of strategic supply chain management for the LSP was rare (Mentzer et al., 2000). In the 2000´s the LSPs have started to provide for their customers new strategic service models in addition to more general warehousing and delivery services (Hertzin and Alfredsson, 2003).

In the Finnish machinery industry, LSPs are not traditionally widely and deeply utilized logistics processes and supply chain management tasks between the manufacturer and the subcontractor. It seems to be quite a typical that production personnel of manufacturing companies have performed also logistics tasks. The LSPs have been typically used in transporting material from the subcontractor to the manufacturer. However, there are still cases where even the transportation is performed by using manufactures´ or subcontractors´ own trucks and personnel. This research tries to explore this phenomenon to create an impression of current state of logistics and supply chain management outsourcing and possible LSP roles in the future. The study endeavors to answer on following research question: (1) what kind of logistics and supply chain processes the manufacturer and the subcontractor would consider on outsourcing in the near future, and (2) what kind of role LSPs have nowadays if they operate between the manufacturers and the subcontractors in the Finnish machinery industry.

METHODOLOGY

The aim of the research was to find out applicability of the LSP to the Finnish machinery industry supply chain between the manufacturer and the subcontractor and to research different roles of the LSPs in this supply chain. The research was divided on two phases, which were both performed as a multi-case study. In the first phase, the aim was to find arguments for why the LSP could be utilized in the studied supply chain. The arguments were studied by gathering logistics and supply chain management development needs by interviewing five manufacturer-subcontractor cases. Both the manufacturer and the subcontractor were interviewed in every case. The products, operational models and business environments were quite different in different manufacturer-subcontractor cases. None of the studied manufacturers or subcontractors applied LSP services except the transportation services.

Based on findings of the first part of the research the LSP role model was formed. The functionality of the developed model was tested by studying client cases of four different LSPs. At the same time, the current state of the LSP roles in the studied supply chain was tested. The research data was collected by interviewing customer service personnel of the studied LSPs. The manufacturer and subcontractor companies participated in the first part of the study did not have any business relationship with the LSPs participated in second phase of the study.

The limitation of this study is quite a small number of cases researched in the first and second phases of the study. This limits the amount of generalization of the study. Furthermore, the differences in products, working models and business environment of the studied cases can limit the applicability of the study result on other cases. The third limitation concerns on fact that the study was performed only in the Finnish environment regarding only one industry.

FINDINGS FROM STUDY PHASE 1

In this chapter, different arguments are presented why to outsource logistics and supply chain management processes for the LSP. Based on the logistics and supply chain development needs gathered from five manufacturer-subcontractor cases, nine arguments can be nominated: *logistics is a core competence of the LSP, improved cost management, improved cost efficiency by economies of scale, improved flexibility and responsiveness, improved productivity, more efficient logistics infrastructure, secured availability, aligned and transparent information flow, and outsourcing of inventory risk.* In the following, the arguments for outsourcing of logistics and supply chain management processes for LSPs are presented.

1.Logistics is a core competence of the LSP. The performance of the logistics operations in the studied supply chain could be improved by utilizing the LSP. Because logistics processes are core operations for the LSPs, the LSPs are capable to perform these processes more efficiently and effectively than manufacturing companies ever could. One of the most important reasons to improve the logistics performance is the motivation of the logistics personnel. When the logistics personnel are working for LSP, they feel their work more valuable compared to situation in which the logistics activities are performed by the manufacturer, for whom the logistics rarely is a core business.
LSP does not necessarily need to be an external company but it can also be a business unit or department of the manufacturing company. This seems to be a good practice to achieve logistical excellence, because internal LSP understands the logistics operations of the manufacturer exhaustively. Especially, it seems to be extremely important that manufacturing company or its logistics department defines logistics goals, operational models and measures. After this definition work it is possible to evaluate which logistics operations is feasible to keep as a part of the company's core operations and which operations is more feasible to outsource.

2.Improved cost management. In the manufacturing companies it seems to be typical that remarkable part of logistics costs can be embedded on the production costs. As these costs are not measured separately, the manufacturing companies do not have clear knowledge on logistics costs. This embedding of logistics costs on production costs is especially typical for inner-company logistics, e.g. when production staff transfers material from warehouse to the assembly line. However, inventory and transport costs are quite well separated from manufacturing costs.

Major part of the logistics processes are performed by people. Because the costs of personnel usually generate the major part of the total logistics costs in Finland, the focus should be on improving the efficiency of the personnel work. Logistics costs seem to be more fixed costs than variable costs in the studied manufacturing companies. The LSP could make possible to manage logistics costs as variable costs, because the costs could be charged based on real logistics work performed. For example, the LSP could utilize same service personnel for different customers depended on their demand.

3.Improved cost efficiency by economies of scale. The most beneficial situation in outsourcing logistics processes for LSP seems to be in the case where the manufacturer has many subcontractors. In this case, the LSP has the possibility to achieve costs savings through economies of scale. For example, the LSP can use full truck loads when transporting material from place to place. In addition, it seems to be beneficial to outsource logistics processes for LSP when the distances between the manufacturer and its subcontractors are long and the volume of supplied material by single subcontractors is not very high. In this case, the LSP can for example use one truck to visit all the subcontractors and deliver the material to the manufacturer at the end of delivery round. In the case where the manufacturer has only few major subcontractors, it seems to be difficult to justify the usage of the LSP.

4.Improved flexibility and responsiveness. If demand is uncertain the LSP can improve the supply chain responsiveness. The LSP can provide fast delivery from its warehouse when material is needed. Furthermore, the LSP can deliver in small batches, which stabilizes incoming material flow for the manufacturer. Because the subcontractors´ production batches are typically bigger than the delivery batch demanded by the manufacturer, the LSP can synchronize material flows by stocking the subcontractor´s production batch. The LSP usually has more efficient warehouse and inventory management capabilities than the subcontractors or the manufacturers, which makes this kind of arrangement financially beneficial for all parties.
The LSP can improve flexibility in the situation when the manufacturer wants to replace some subcontractor or add a new subcontractor. On the other hand the manufacturer should not commit too tightly to the LSP, because the manufacturer should also be able to flexibly change the LSP if needed.

5.Improved productivity. Manufacturing companies can enhance productivity if their production personnel can concentrate on production tasks. Nowadays it seems that production personnel often perform also logistics tasks in the Finnish manufacturing industry. By using the LSP it is possible to separate logistics tasks from manufacturing task.
The manufacturing companies see the assembly set service provided by LSPs valuable. Different subcontractors deliver material to the LSP, which assemble material to sets and deliver these sets to the production cell of the manufacturer´s production line on right time. This makes for the manufacturer possible to decrease buffer stocks near the production line and improves production efficiency. Furthermore, if the subcontractors´ material is delivered to the manufacturer through the LSP, disruptions caused by deliveries will be decreased at the manufacturer´s production plant compared to the situation where every subcontractor delivers material to the manufacturer´s production plant. This kind of centralized delivery also improves efficiency of delivery service work, because material volumes can be remarkably higher than in decentralized delivery model.

6.More efficient logistics infrastructure. Manufacturing companies want to utilize space on their production plant as efficiently as possible. Space for stocks is typically pursued to minimize, because the stock keeping is not a core competence for the manufacturing companies. The

infrastructure of the manufacturing company is typically developed from the production point of view. Thus, infrastructure does not serve logistics tasks as efficiently as it could. Compared to that, infrastructure of the LSP warehouses are designed explicitly to support logistics tasks.
The warehouse capacity at the LSP´s warehouse is highly efficiently used, because it can be allocated simultaneously for many customers. Furthermore, the LSPs can make investments the newest logistics technology including information and communication technology (ICT), because LSPs´ material and information volumes of can be much higher than single manufacturing companies have.

The manufacturing companies can save on information system and system integration costs through utilizing LSP services. For example if the LSP operates with the inbound logistics, it might be enough for the manufacturing company to integrate its own information systems only to the LSP´s system. The subcontractors and the LSP can make the necessary system integrations between each other. In reality in this particular case, the needed amount of integration between parties does not decrease, but in fact it increases by one. On the other hand, the LSP might be more capable on building the integrations with the subcontractors than the manufacturer, because the LSP can have ready integration interfaces and major experience from the area of systems integration. The LSP can even offer ICT systems as a service for the manufacturing companies.

7.Secured availability. If material availability is crucial for the manufacturer, the LSP can operate as a safety buffer between the manufacturer and its subcontractors. Furthermore, it may be difficult to get information from subcontractors what is the state of the production and delivery process. For example the manufacturer could check from the LSPs´ system if subcontractor is reserved transport capacity from the LSP. The subcontractors do not necessarily have any information about the state of their process on information systems or information is in form, which makes it really difficult to collect and interpret. Thus it is major work load for the manufacturer to gather all this information from every subcontractor. If the subcontractor material is stocked at LSPs' warehouse, the manufacturer can check the inventory levels easily through one system. Furthermore, the information about the inventory levels is probably better in line with the real stock levels, if the inventory is managed by the LSP instead of the subcontractor. Reason for that is that inventory holding is a core business for the LSPs.

8.Aligned and transparent information flow. For the manufacturers the information flows can be highly fragmented because of many different subcontractors. Through information services provided by LSP it is possible for the manufacturing companies to gain clear and well structured information flow. For example, the LSP can collect data about stock levels of multiple subcontractors and show stock level information transparently for the manufacturer through one system as mentioned above. From reporting point of view the LSP can provide consolidation, timing, analysis and alignment services of reports for the manufacturer, which makes the manufacturer´s administrative process more efficient.

9.Outsourcing of inventory risk (holding and obsolescence costs). In the studied cases the manufacturers or the subcontractors owns the materials. These manufacturing companies typically pursue to decrease the material stock levels. To achieve this goal it could be possible to transfer the stock ownership for the LSP. In the case, the LSP owns the inventory the LSP could also have responsibility for ordering material from the subcontractors or even manage the subcontractor relationships. On the other hand, the subcontractors typically manufacture client associated material what for this kind of service model might not be very attractive for the LSPs. For customer-tailored material the LSP would have good knowledge of the manufacturer´s markets to be able to optimize the warehouse stock levels.

LOGISTICS SERVICE PROVIDER ROLE MODEL

Based on the discovered logistics outsourcing arguments presented in the former chapter, the LSP role model was developed. The model consists of six different LSP roles. The LSP roles can be nominated as follows: *improver of operational logistics efficiency, operational decision maker, value-adder, production maker, supply chain manager and developer, and enabler of business* *growth.* The strategic importance of the LSP increases in this model when moving from the role of *improver of operational logistics efficiency* towards the role of *enabler of business growth*. In the following, six different roles of the LSP are introduced.

1.Improver of operational logistics efficiency. In this traditional LSP role, the clients expect the LSP to be able to deliver cost savings in logistics costs. In this role, the typical outsourced functions are warehousing and transportation. Costs savings are typically pursued from functional point of view, instead of total costs point of view. The LSP performs logistics activities quite like the manufacturing company did before outsourcing but with higher efficiency.

2.Operational decision maker. In this role, the LSP participates on decision making in the supply chain. The decisions are based on the information available through the manufacturer´s or the subcontractor´s information system. For example the LSP can decide on ordering material from the subcontractor and delivering material to the manufacturer´s assembly line based on the information about the stock levels and inventory steering parameters set by the manufacturer.

3.Value-adder. In this role the LSP makes it possible to change the operational model between the manufacturer and the subcontractor on someway. In practice, the LSP makes the change possible and as such adds value to the supply chain. For example, the LSP can assemble sets from different subcontractors´ material and deliver these sets on right time to the manufacturer's assembly line. In this case the LSP provides value for the manufacturer by enhancing productivity and by reducing space required for buffer stocks in the production plant. In addition to material management, the LSP can provide value-added services on information flows. For example the LSP can unify all the subcontractor reports for the manufacturer to one standardized form, or the LSP can provide for the manufacturer the visibility for availability of material from subcontractors. In the *value adder role* the main logistics development responsibility lies on the manufacturer and/or subcontractors. However, the LSP can participate in some development and implementation tasks.

4.Production maker. In this role the LSP takes responsibility for some manufacturing or assembling tasks in the supply chain. In more sophisticated models the LSP could even produce part assemblies or modules for the manufacturer. In this case the LSP would operate like a contract manufacturer. In the *production maker* role the LSP could have also responsibilities for production steering. The assembly set work mentioned in the role of *value-adder* is not classified to belong to the *production maker* role, because this work does not include manufacturing tasks.

5.Supply chain manager and developer. In this role the LSP has partial responsibility of tactical or strategic management of supply chain or supply network. The LSP develops new operational models, which enhance the performance of the supply chain. Furthermore, the LSP sets up performance goals fro these new models, and measures and reports the performance of the supply chain. In this role the LSP could also source new subcontractors and make the agreements and contracts with them. This role differs from the earlier role of value adder in a way that supply chain is mainly managed an innovations are originated by the LSP instead of the manufacturer or the subcontractor. To be able to be in this role the LSP has to have a deep understanding of the industry environment in which they are working. In practise this kind of role is possible only in long-term business relationships.

6.Enabler of business growth. The LSP has strategic supply chain or supply network management role. In this role, the LSP can for example influence on sales volumes of the supply chain by making strategic decisions. For example the LSP can decide to increase the strategic buffer stock levels in the supply chain and thus allow the supply chain to improve responsiveness to demand. In this case the risk of the strategic stocks is allocated for the LSP, but on the other hand, the LSP attains possibility to increase revenues by increasing the sales of the supply chain. To be able to work in this role, the LSP has to have deep knowledge about the business environment and markets.

FINDINGS FROM STUDY PHASE 2

In this chapter, the results from testing the functionality of the developed LSP role model and the current state of the LSP roles in the studied supply chain are presented. The test was performed by studying client cases of four different LSPs.

Even though the studied four LSPs were remarkable players on overall LSP markets in Finland, the number of practical client cases was not very high when studying the utilization of the LSP in the manufacturer-subcontractor relationships. The studied LSPs typically operated much more within the consumer product logistics and the manufacturers´ outbound logistics cases than within the manufacturer-subcontractor relationships. Table 1 compiles the found roles of the studied LSPs operating in the supply chain between the manufacturer and the subcontractor. Because the LSP can work on multiple roles within the single client case, the most demanding role with this client is presented in the numbers of the table. In the model, the *Improver of operational logistics efficiency* can be said to be the least demanding role, while the most demanding role is the *Enabler of business growth*. For example if the LSP operated in the role of *value adder with some client*, the LSP typically also worked in the role of *improver of operational logistics efficiency* and *operational decision maker* for the same client.

Roles:	LSP 1	LSP 2	LSP 3	LSP 4
1.Improver of operational logistics efficiency	2	2	4	3
2.Operational decision maker	2	3	2	4
3.Value-adder		5		2
4.Production maker		2		
5.Supply chain manager and developer		2		
6.Enabler of business growth		1		
Total quantity of client cases:	**4**	**15**	**6**	**9**

Table 1: The roles of the LSPs, which operate between the manufacturer and subcontractor.

According to Table 1, the studied LSPs mainly performed operational logistics activities between the manufacturer and the subcontractor. This means that they are placed at the first two roles in the LSP role model. In these client cases, the main objective of logistics outsourcing was to improve logistics efficiency, which can be said very traditional objective when outsourcing logistics operations.

The LSP 2 had the largest number of client relationships in the studied manufacturer-subcontractor supply chain and it also operated on widest range of different roles. The business strategy of this studied LSP is to add value for their customers and to participate in tactical and strategic supply chain management, which can be seen from the study results. The LSP 2 operated with some clients in *value-adder, production maker, and supply chain manager and developer* roles. In the *value-adder* role the LSP for example delivered material sets on right time to the manufacturer's assembly line. In the role of *production maker* the LSP had responsibilities to make simple pre-assembly work on behalf of its clients. In the role of *production maker and supply chain manager and developer* the LSP for example designed the assembly set process and set boxes for its client. The LSP 2 even enabled *Business growth* for its one client by financing the supply chain material before products were delivered to end customers.

The developed LSP role model worked quite well when the model was utilized in analyzing the current state of the LSP roles. Only confusion with the model was related to the LSP client cases in which the LSPs have multiple different roles.

CONCLUSIONS

This research focused on studying role of LSP in the Finnish machinery industry supply chain between the manufacturer and the subcontractor. In the first phase of the study, the arguments for the logistics and supply chain management outsourcing were studied. Based on the logistics development needs gathered from five manufacturer-subcontractor cases, nine arguments for outsourcing was nominated: *logistics is a core competence of the LSP, improved cost management, improved cost efficiency by economies of scale, improved flexibility and responsiveness, improved productivity, more efficient logistics infrastructure, secured availability, aligned and transparent information flow, and outsourcing of inventory risk.* Based on the results of the first study phase, the LSP role model was developed. The model included six different roles for the LSP: *improver of operational logistics efficiency, operational decision maker, value-adder, production maker, supply chain manager and developer, and enabler of business growth*.

In the second study phase, the developed LSP role model was tested with four different LSPs. The model worked in practice quite well. However, it should be pay attention to that the boundary between the LSP roles is not very precise and the roles can overlap in practical business cases. The studied LSPs mainly operated on operational tasks to decrease logistics costs of the supply chain. This means that they can be placed at *improver of operational logistics efficiency and operational decision maker* roles in the LSP role model. One studied LSP made an exception to this general line by operating with some clients as the *production maker* and the *supply chain manager and developer*, or even as the enabler of *business growth*.

This study revealed that the studied manufacturing companies are interested in increasing the outsourcing of logistics and supply chain management activities for the LSPs. However, the manufacturing companies seemed to have opinion that LSPs do not necessarily have skills or tools to be able to provide demanding supply chain management services. On the other hand, the studied manufacturing companies are necessarily not ready to large scale logistics outsourcing operations, because their operation models, processes, resources and organisation should demand for comprehensive re-arrangement and re-engineering work in the case of large scale outsourcing. Thus it can be said that the willing and the preparedness of the manufacturing companies do not necessarily match.

The limitation of this study was the small number of the cases researched that limits the generalization of the study. The second major limitation concerns on the fact that the study was performed only in the Finnish environment regarding machinery industry. In follow-up studies, the LSP role model could be tested in different industries and with larger number of LSPs. Furthermore, it would be interesting to study LSP roles in the company network environment. In this case, the research focus would be on cases in which the LSP operates in manufacturer and subcontractor networks instead of manufacturer-subcontractor supply chains.

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AN EXPLORATION OF THE SUPPLY CHAIN DESIGN AND ORGANISATION OF THE UK CARAVAN MANUFACTURING INDUSTRY

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ABSTRACT
The study focuses on the supply chain of the UK caravan manufacturing sector. The principal output from this exploratory research is to determine the key challenges currently facing the industry during the economic downturn to provide a foundation for developing research questions for a future more in depth study of the sector. The research is case study based, undertaken via site visits with data collected through observations, analysis of sales and production figures, interviews and semi structured questionnaires. The principal academic question addressed is whether in pursuing a supply chain management strategy are, production, marketing and inter-firm relationship orientations independent of each other or are they inter-related and consequently need to be balanced off against each other? The research concludes that in the case of this sector an understanding of the trade off issues which exist between each of the three orientations is important in developing appropriate supply chain strategies. The research is also innovative in that very few previous academic studies have been undertaken in this sector, while the study has generic significance, as the caravan manufacturing industry has many similarities to other business sectors.

INTRODUCTION
The caravan industry encompasses caravan manufacturing and services, caravan sales, and caravan parks generating annual total revenue for the UK at £5 billion and employment for 100,000 people (NCC, 2009). The paper presents findings from a multi-case based exploratory study of a major component of this sector, the UK touring caravan manufacturing industry and its constituent supply chains. Predominantly in response to the recent economic downturn, the sector is undergoing substantial rationalisation of product ranges, overhaul of business models and is fundamentally questioning its supply chain strategies. The principal output from the exploratory research is to determine the key challenges currently facing the industry to provide a foundation for a future more in depth study.

The research is innovative in that very few previous academic studies have been undertaken in this sector. A further significance is that the actors within the industry’s supply chain consider the manufacturing and design to be “market orientated”. The study explores the challenges in undertaking this strategy when many have been “caught short by the ferocity of the manufacturing downturn” (Minford, 2009) particularly in the second half of 2008. The study has generic significance as the caravan manufacturing industry has many similarities to other business sectors such as automotive, van, truck, recreational vehicles (RVs) and even white goods manufacturing.

The paper provides an historical overview of the evolution of the UK touring caravan manufacturing sector. Next, the multi-case study based methodological approach is explained. The literature review examines the tensions which can emerge in supply chains between various “orientations” of strategy; in this case the dilemma of following a production, market and inter-firm relationship based orientation strategies. Findings are reported within the context of these “orientations”. Finally, the principal challenges for the industry are developed and conclusions are reached. It is argued that the recent economic turbulence has fundamentally shaken the business model of the sector. What is required is to re-build sales and confidence. Managing the supply chain to ensure a balance amongst the three orientations is reached is difficult yet desirable to achieve.

INDUSTRY PROFILE
The caravan industry has been termed a ‘cottage industry’ by many authors, a term which emerged during the pre Industrial Revolution to refer to industries where “experts …manufactured hand tooled, highly customized goods” (Chandy et al, 1998). Nevertheless, although the sector is small compared to the automotive industry for instance, it is still significant and is indicative of

many sectors of the UK economy. The UK touring caravan manufacturing industry accounts for at least £1.6 billion of turnover annually with average pre-tax margin is 7.9% (Plimsoll, 2009). There are currently an estimated 1,000,000 caravan owners within the UK, 4.74 million (2007) UK touring caravan holidays are taken annually and more than £1.75 billion (2007) is spent within the UK on caravan holidays (NCC, 2009). Indeed, the UK has become the largest market for caravans in Europe and over 90% of the domestic market is supplied by indigenous manufacturers from the South West and North of England (Timms, BERR 2007). To more fully appreciate the background to the development of the sector an historical overview linked to the Haperberg and Rieple (2001) industry life cycle model (Figure 1) is presented. It is divided into four time phases spanning over half a century.

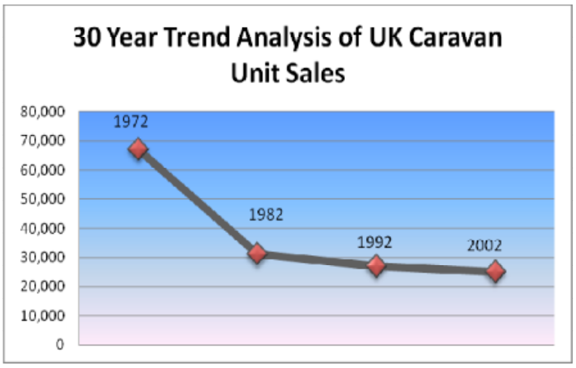
	Introduction 1947 -1959	**Growth 1960s-1979**	**Maturity 1980s-2007**	**Decline (?) 2007- present**
BUYERS	Rich, curious	Widening	Mass market	Diverse
PRODUCTS	Poor quality standard product	Reasonable quality, customised product	Improved quality, customised product	Variable quality, standard and niche markets development
COMPETITORS	Few	Many new entrants	Unstable, fragmented	Condensing Supply Issues
MARGINS	High (?)	High	Variable	Low
PROFITS	Low	Highest	Pressurised	Weak

Figure1: The industry life cycle model for the UK caravanning manufacturing sector based on Haperberg and Rieple's (2001) generic industry life cycle model

- The "***introductory phase***"***:*** from the 1940s until the late 1950s the UK caravan manufacturing industry began to emerge. The touring caravan was portrayed as "the plaything of a privileged minority". Production of caravans rose from 3,031 units in 1947 to 10,258 in 1950 and 43,118 units by 1960 (NCC, 2009). Sam Alper (1924-2002) was known as "the Henry Ford" of caravanning bringing mass production to the caravan industry post World War II. This was possible due to the increasing availability of cars, improving road networks and considerable social change due to increasing levels of disposable income (Frost, 2002).
- The "***growth***" or second phase saw rising production levels during the 1960s with a rise in the number of manufacturers and production levels reaching an all time peak of 67,000 units in 1972. A new caravan developed by Alper, The Sprite, at a starting price of £199 was indicative of this period and in high demand from the average working class family (BBC4).
- This growth phase came to an end after the industry hit turbulent times in 1974. Factors such as fuel shortages, high inflation, soaring costs of raw materials and increased competition from foreign package holidays, led to major restructuring within the industry and the fall of manufacturers during the 1980s. In the ***"maturity"*** stage the industry tried to appeal more to the mass market, but sales and margins were more pressurised and profit margins variable. Indicative of this was the demise of Caravans International (CI) in 1986. CI had been the largest caravan manufacturer on the London Stock exchange in 1976. Further consolidation of manufacturers took place during the 1990s leaving a more stable network structure until 2007. In summary, sales fell from a peak in 1972 of 67,000 units to a projected volume of around one third of this in the ensuing thirty years (Figure 2a). However, during this current decade volumes were more buoyant and grew from the low of around 20,000 to 30,000 units a year (Figure 2b) by 2007 before the next, potentially highly significant, decline phase began.
- The fourth phase since 2007 has been characterised by exceptionally challenging economic conditions. This has led to a significant fall in new caravan sales. There is a fear that this will

possibly lead to the long term "***decline"*** phase of the industry. Two manufacturers collapsed during this period and further uncertainty exists over another in spring 2009. Production dropped sharply falling by 48.6% for the three month period to February 2009, causing the moving annual total (m-a-t) of production to fall from 31,854 tourers to 23,280 (Glass's 2009b).

The market structure of OEMs in the sector in 2007 is illustrated in Figure 3. It shows a projected market share position of the manufacturers developed by the authors from figures in a major industry report (Plimsoll, 2009) combined with data gathered during the primary research phase of this study. The market is dominated by a couple of major manufacturers whose market share is likely to have increased today following the collapse of the two smaller players.



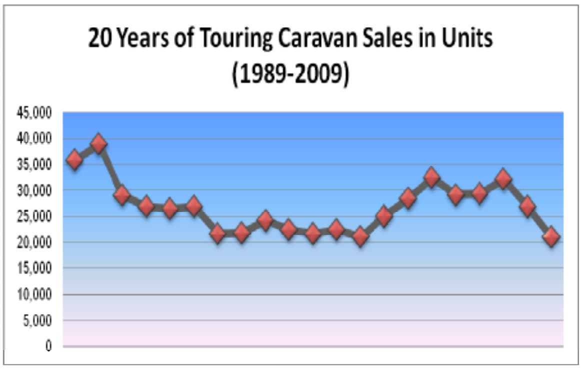


Figure 2a and Figure 2b: Trends Analysis of the UK Touring Caravan Industry sales based on units sold (Figures developed from NCC, 2009 data)

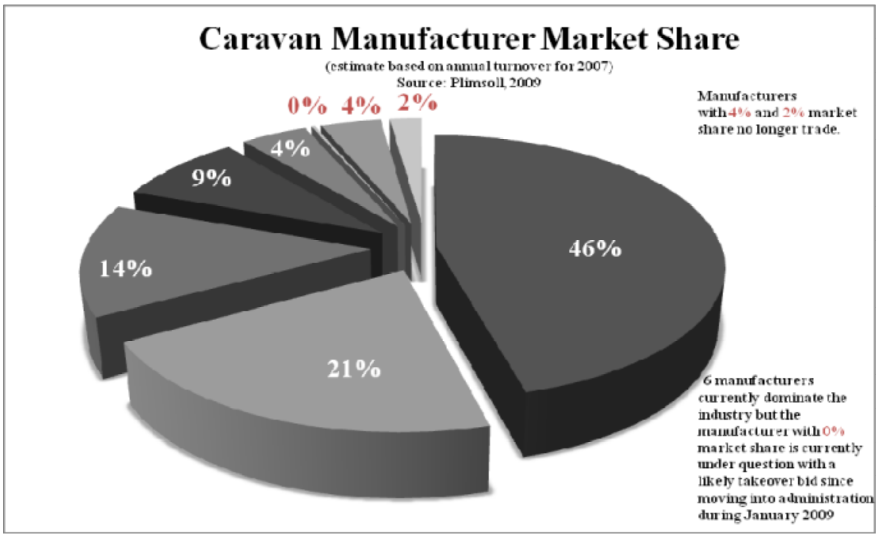


Figure 3: Estimated Caravan Manufacturing Market Share (Developed by the authors from Plimsoll, 2009)

The downturn in sales has coincided with problems being faced both by the dealer network and by the upstream supply base. In 2007 an outside investor grouped fifteen retailers together (later rationalised to eight branches) reshaping the structure of the dealer network. During 2008 the upstream sector experienced the loss of several smaller suppliers including one key supplier holding a monopolistic position. In response to the declining sales levels 85% of dealer networks have reported higher level discounting to keep sales at an acceptable level. These developments provide testimony to the pressures felt at all supply chain levels. Figure 4 provides an overview summary of the current structure of the UK caravan industry. The six manufacturers which survive today in the sector receive supplies and parts from up to 200 suppliers. Downstream there are approximately 500 dealer networks but not all of these retail new caravans.

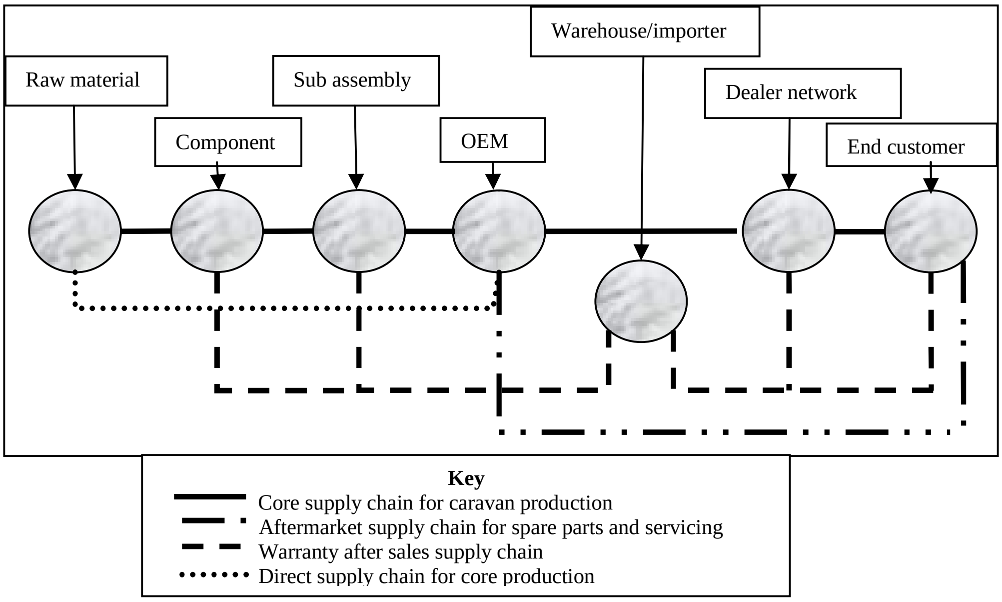


Figure 4: The Caravan Industry Supply Chain (Authors' own model)

LITERATURE REVIEW

Christopher (1992) suggests that "supply chains compete, not companies". The question that emerges from this statement is how should the supply chain, such as the ones exhibited in the UK caravan sector, be managed and configured to be effective, efficient and flexible to provide superior value for end customers. In addressing this, the concept of supply chain management (SCM) has developed and is now regarded by many academics as a discipline in its own right (Storey et al, 2005). However, SCM is invariably not an easy idea to translate into practice. In reality to optimise value organisations have to wrestle with the sometimes conflicting objectives of three different orientations:

- **Production orientation**: determining the most effective manufacturing strategy for the supply chain organisations to pursue
- **Market orientation**: putting the customer first and the ability to translate this into product customisation at a reasonable cost, and
- **Inter-firm Relationship orientation**: the desire to pursue collaborative inter-firm relationships with supply chain partners (espoused by the SCM paradigm)

Kotler (1988) conceptualises the changing orientation of marketing noting that there has been a move from production orientation to consumer orientation. Gonroos (1989) goes further in developing this arguing that consumer orientation is surpassed by having a relationship orientation. Intriguingly, Lehtinen (1996) asks about the degree of independence each of the orientations have with each other. The literature review sets out a brief explanation of each of these orientations concluding with research questions which frames this study into the UK caravan manufacturing sector.

Production Orientation

One of the core questions facing supply chain actors which has implications for the whole supply chain, is the issue of determining the most appropriate manufacturing strategy or production orientation (Kotler, 1988). More recently the importance of process optimisation rather than a narrower view of optimising production at the point of manufacture have developed across the wider supply chain. In this context to appreciate the issues surrounding supply chain manufacturing strategy more clearly Hoekstra & Romme's (1992) classification of the positioning of the decoupling point within the supply chain is useful to reflect upon. They state that where the customer is not prepared to wait for supply of a product the optimum stocking point is at the retailer, so the customer can purchase the item from stock. This is known as the make to stock (MTS) strategy. On the other hand where the customer accepts a lead time between order and goods received an opportunity is presented for a make to order strategy to be adopted (MTO). As long as the production and delivery lead time (P) is less than the customers' lead time threshold (D), the decoupling or stocking point can be positioned further upstream. Examples include assemble to order (ATO) or even design to order (DTO) (Lampel and Mintzberg, 1996). Essentially the degree of production orientation, in the pursuit of production efficiencies to provide affordable products and services that will attract consumers (Kotler, 2000) can be an important consideration in developing the most appropriate supply chain strategy.

Market Orientation

As well as production orientation the development of a market orientated approach to business has been recognised as a strategically important component of supply chain management strategies. Jaworski and Kohli (1993) suggest that developing external market knowledge and responding to it is an essential element of organisational success. Matanda and Mavondo (2001) describe market orientation as a set of behaviours devoted to acquiring and utilising market information whilst in the pursuit of achieving ultimate customer satisfaction. They further identify Narver and Slater's (1990) three behavioural components as customer orientation, competitor orientation and interfunctional coordination and consequently propose that market orientation leads to the development of supply chain management activities in order to enhance business performance. Therefore supply chain managers who adopt a market orientation approach by putting the customer first and translate this into action are expected to improve profitability and market share (Fuller et al, 1993).

Inter-firm Relationship Orientation

Beyond inter-functional coordination, relationship marketing (B2C and B2B) emerged in the mid 1980s (Rosenberg and Czepiel, 1984). In contemporary supply chains the emphasis on developing the relationship between buyers and suppliers has been seen as being increasingly important (Lambert et al, 2004). The inter-firm relationship is categorised by Gadde and Hakansson (2001) based on the level of involvement; this then further determines the economic consequence for the end customer; value should be added in the supply chain inter-firm relationship.

An important consideration in the development of inter-firm relationships is the notion of the degree of power one firm has over another and the degree of trust within the inter-firm relationship. Gadde and Hakansson (2001) believe power and dependence are important concepts to inter-firm analysis. Indeed, Cox (2001) theorises on his study of the Japanese that "power is at the heart" of all B2B relationships. Abuse of power can also lead to a loss of trust. In contrast, Kramer and Tyler (1995) cite Lorenzo's (1988) belief that trust ensures there is no abuse of bargaining power once an agreement has been made. Their study of Japanese businesses recognises the difficulties that supplier relationships face when trying to build trust, even though it is considered the primary foundation to decision making.

Summary

Levitt (1960) stated: "it is not surprising that, having created a successful company by making a superior product, management continues to be orientated toward the product rather than the people who consume it". Since then, the importance of developing a market orientation and beyond this an inter-firm relationship orientation has been advocated to compete with or compliment a production orientation. However, developing the right supply chain (Fisher, 1997) with the right balance of the three orientations in a more complex and turbulent environment is recognised as an arduous task, which may be even harder for a 'cottage industry' (Chandy et al, 1998) such as UK caravan manufacturing. Many organisations within the sector are long established (30 years plus) and while this could be considered a success it could also prove to be barrier in the sector's capabilities to react and face up to the difficulties currently presented which are both economically and socially challenging. This dilemma can be framed by resolving the tension between being the product, market and/or inter-firm relationship orientations.

METHOD

This is an exploratory study conducted using a predominantly qualitative methodology. Silverman (2000) advocates this approach as better able to provide a "deeper understanding of social phenomena" using a "zoom lens" to focus. The study focuses on the UK caravan manufacturing sector which is selected because it provides a useful industry to examine the orientation issues to be researched, yet has parallels with other similar industries. It also has been an under-researched sector, although there is good access for the research study to be pursued. The research is case study based. The principal techniques for data collection are observations, analysis of sales and production figures, interviews and semi structured questionnaires all conducted via site visits. Twelve organisations, all of whom are market leaders in their supply chain echelon including raw material suppliers through each of the supply chain tiers up to and including the dealer networks are surveyed. Participants included company chairmen, owners, senior directors and area sales managers across the industry. The companies are carefully selected as market leaders within their supply chain echelons of the industry, thus ensuring a significant proportion of turnover is represented within this study. To further improve the reliability of the data gathered secondary data is collected using data and information taken from industry reports compiled by recognised affiliated bodies in the caravan industry.

FINDINGS

Production Orientation

Essentially the study shows there are three categories of production strategy adopted by the main manufacturers. Firstly, caravans may be assembled to order; the customer orders a caravan at the dealer network and this triggers the assembly process. The lead time is approximately 7 weeks (Figure 6). Ideally in this instance the OEM assemblers would prefer the sub assembly and component suppliers to be able to respond within this time frame so that the stocking point could be pushed further upstream. In reality only a few of the suppliers can comply with this. Consequently the OEM assemblers' orders are usually based on forecasted rather than actual demand. The second category of production is triggered by the dealer network – a MTS strategy. This is clearly based on forecast demand with estimates placed initially a year in advance and refined quarterly. This category includes "dealer specials" as well as the core product ranges. The third category is the demonstrator and show vans which again are supplied on MTS basis and delivered to the network at the outset of each season.

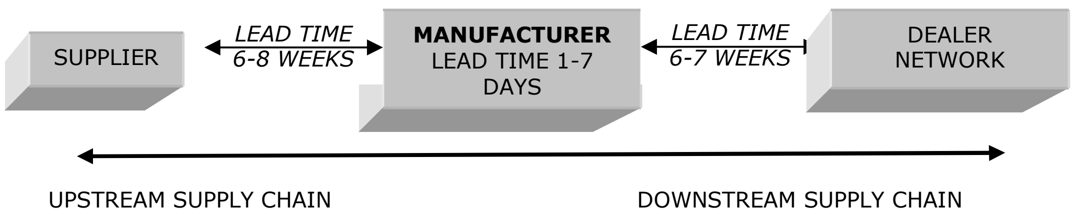


Figure 6: Lead Time Analysis of Touring Caravan Production

Market Orientation

All those interviewed feel that the industry is market orientated. For example, over the last decade the range of alternative product variations has multiplied, further adding complexity within the supply and after market. The tradition has developed that at the beginning of each new trading year (September until August) new versions of all the ranges are introduced to the market. To what extent these innovations are truly market led or fuelled just by the need to incorporate the latest evolution of the component suppliers' products is a mute point. By presenting a new specification for every model every year a large issue of handling model obsolescence is presented to the industry. Dealers have to mark down out of date stock during the "quiet season" at the end of each summer which is a large hidden cost for the industry. This further restricts the opportunity for the OEM assemblers to provide stock for the dealer network as understandably dealers are reluctant to commit themselves to the risk of high mark down costs. In a move away from this example of market orientation, the recent economic downturn has led to a fresh rationalisation of product ranges. For the two leading OEM assemblers this still leaves 11 ranges with 86 model variations by the end of 2008.

Inter-Firm Relationship Orientation

As has been discussed, the sector could be described as a 'cottage industry'. To support this it is evident from the study that many businesses are still family owned and have passed through many generations. There is a strong perception that this has resulted in a wealth of experience and knowledge being retained within the sector. This level of family ownership has a direct bearing on inter-firm relationships which are invariably characterised by the players surveyed as being very loyal, long lasting and "close-knit". Respondents stated that in many ways this level of partnering is driven by friendship and social understanding as well as commercial needs.

However, the industry could be perceived as being relatively insular and hence too traditional to respond to the degree of market driven change necessary to respond appropriately to the economic downturn. Two developments have begun to challenge the current relationship orientation further. Firstly, in 2007, a new consortium acquired a significant proportion of the dealer network in an attempt to "modernise" the industry by "applying auto industry principles" (Parker, 2007) but this has proved difficult to achieve. To protect their sales performance, the main OEMs have made changes to their distribution of product ranges bringing much less exclusivity to dealer networks. Secondly, considerable economic turbulence has afflicted the UK caravan market as well as many other industry sectors over the last twelve months. A dramatic fall in sales has shaken many long established inter-firm relationships impacting both dealer networks and the upstream supply chain actors, and this has been compounded by the fact that many of the suppliers only operated in the caravan industry. This has resulted in a surplus of stock in the supply chain. In turn confidence has lowered resulting in increasing concern over the accuracy of forecasts. Alternative international supplier numbers have also increased. These developments have created extra tensions within the inter-firm relationships.

Industry challenges

There are different challenges facing the players at each echelon within the supply chain. OEMs are now more open about who has licenses to retail their brands and as a consequence dealers, who used to rely on their exclusive regional right to supply a product, must now compete through aspects such as exceptional service or introducing "specials" to the product ranges to survive. The component and sub assembly suppliers need to become much more responsive and capable of adapting to the OEM production strategy. There were many other factors that were uncovered in the study, which have a bearing on the supply chain. These included the access to finance, the management of risk, the significance of both the second hand and aftermarket sectors, and the on-going need to respond to environmental concerns. In identifying the appropriate way forward for the sector many of the challenges it faces are symbolic of the dilemmas currently being faced by many other manufacturing industries globally.

CONCLUSIONS

Although this is only exploratory research, the study does allow for some tentative suggestions on how the sector may address the challenges it currently faces. The challenges can be categorised as follows;

- In developing the appropriate supply chain strategies, OEMs need to resolve the issue of the need for constant innovation together with the cost of excessive obsolescence;
- OEMs need to decide on the best balance between MTO, ATO and MTS levels;
- To support the OEM production strategy there needs to be a development of the capabilities of providers to ensure continuity of the upstream supply base. These include raw material, component and sub assembly suppliers.
- The findings highlight the need to build confidence back into the industry amongst all supply chain players. Trust is an outcome – what is required is recognition again of the advantages that can be derived from developing a more collaborative supply chain strategy and mutually sharing the benefits.

One manufacturer/owner recently described the current trading climate as "the most challenging time ever known" (Anon, 2009). When social change is also coupled with an economic downturn this presents enormous challenges to the management of the supply chain and questions the role of the three orientations identified. In pursuing a supply chain management strategy it is important to consider that production, marketing and inter-firm relationship orientations all need to be balanced. These three paradigms do not appear from this study to be independent as questioned by Lehtinen (1996). Although leading members of the UK caravan manufacturing sector have stated in this research that they are market orientated, in facing up to the current challenges they are actually tackling the underpinning basis of each of these three paradigms to try to deliver workable solutions to secure the future of the industry.

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COMPONENTS, SUBASSEMBLIES AND OEMS: THE ROLE OF TIER ONE SUPPLIERS IN RECONFIGURED SUPPLY CHAINS

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ABSTRACT
It is posited that corporate focus on core competency results in strategic relationships along the supply chain. This research considers the case of OEM specialisation in product design and branding and investigates the impact on a tier one supplier. A participative research approach was adopted and focuses on a case study company that supplies a number of OEMs across a range of industries. We find evidence to support changing supply chain strategy and configuration in response to core competency development. Firms develop supply chain relationships in order to capitalise on suppliers' processes, technology and capabilities. Both complexity of product/service and knowledge-management systems are identified as key dimensions of supplier relationship management. The core competency hypothesis motivating this research yields much food for thought, in particular the need to better understand sources of competitive advantage arising from inter-organisational networks and governance of such networks.

Keywords
Tier one supplier, OEM, Supplier development and management, Competitive advantage.

INTRODUCTION
Over recent decades global companies have increasingly focused on core competencies as they seek global competitive advantage in specialist areas. This focus has increased the need to outsource and form partnerships with other companies in order to provide a product or service that satisfies the final customer's needs. This paper reports on findings from the early stages of a research project that seeks to investigate the impact of increasing specialisation of OEMs (Original Equipment Manufacturers) on the role of tier one suppliers.

THEORETICAL PERSPECTIVE
Supply Chain Management adopts a holistic view of not only the organisation but of the entire process of product/service inception, production and delivery. This has become a popular approach over the last couple of decades as opportunities to reduce costs and add-value are increasingly found not only within the confines of one organisation, but within and between organisations along the chain. This resembles a paradigm shift, not in the sense of our understanding of management principles, but in our application of these principles in a seamless fashion across organisational boundaries.

There is widespread agreement that supply chain integration impacts positively on corporate and supply chain performance (Frohlich and Westbrook, 2001; Vickery et al., 2003; Childerhouse and Towill, 2003). Indeed a survey of some 33 academic papers in this area by der Vaart and von Donk (2008) find a positive relationship between integration and performance. This is hardly surprising since the relationship between activities is a fundamental principle of organisational establishment. However, we find that in recent decades firms have sought to achieve such alignment not through vertical integration but through some form of relationship management along the supply chain. The Resource-Based View of the firm (RBV) (Barney, 1991; Wernerfelt, B., 1984) offers a theoretical rationale to support such decision-making – i.e. that the firm focuses on core competencies (Prahalad and Hamel, 1990). This approach relies on inter-firm networks since 're-organised' or 'deconstructed' firms focus on a key competency and area(s) of operation (e.g. manufacturing, design, research & development, branding) and rely on other specialist firms to perform the other key supply chain operations. Typically firms categorise suppliers on a continuum from 'commodity' to 'strategic', with various levels of interaction and types of partnership. Lambert *et al*. (1996) classified three types of partnerships: Type I: organizations recognize each other as partners and coordinate activities and planning on a limited basis. Type II: companies integrate activities involving multiple divisions and functions. Type III: companies share a significant level of integration with each viewing the other as an extension of itself. More recent work by Day *et al*. (2008) included a wide ranging survey of 819 respondents across Asia, Europe and North America, and found widespread agreement about the role of strategic supplier relationship management, but less understanding around the leadership competencies and operational processes required to achieve the expected benefits of this approach.

The motivation to pursue an integrated supply chain strategy goes beyond cost reduction and seeks to create competitive advantage and thus firms' use of supply chain management often evolves from an operational to a strategic level. Dervitsiotis (2008) provides an interesting synthesis of key supply chain management trends. His review emphasises the changing configuration of both organisations and supply chains as 'outsourcing' has moved from outsourcing non-core activities to creating networks of linked core competencies across organisations and geographies. Thus, supply chain management has increasingly focused on how firms utilise suppliers' processes, technology and capability to their advantage – i.e. the firm's success is a function of its suppliers' capabilities (Christopher, 1992, Tan, 2001). This is evident in evolving OEM strategy, increasingly these firms focus on design and branding and outsource other activities. Indeed, the term OEM – Original Equipment Manufacturer – is something of a misnomer since most OEMs don't manufacturer anything.

The aim of this research was to consider such strategy and relationship management from the perspective of a multinational organisation that changed from component manufacturing to a tier one supplier offering 'supply chain coordination' services to OEMs.

METHODOLOGY

A case study methodology was adopted to investigate the impact of OEM specialisation on tier one supplier strategy. The case company is a multi-billion dollar precision engineering multinational organization that supplies OEMs across a range of industries. Case company data was collected over two phases: (i) a case study selection phase entailed discussion with company executives and review of company documentation, and (ii) a research workshop involving 49 senior managers from the company's global community including supply chain and other supporting functions such as operations, finance and programme management. Table 1 profiles the workshop participants. A participative action research approach was adopted. Workshop participants represented from all company sites and five product lines and were organised into five cross-functional teams. The workshop was designed to address the following areas: (i) strategic orientation and perception of supply chain relationship management, (ii) the potential of this approach for the company, and (iii) organisational changes required to implement this approach.

Roles	Number
Strategic Supply Chain Manager	14
IT Roles - Various	6
Product line Operations Manager	2
Supplier Development Manager	10
Buyer Planners	10
Site Operation Manager	1
VP of supply chain Management	1
Site General Manager	2
Contracts Management	2
Product Line financial controller	1

Table 1: Workshop participants

FINDINGS

The case company was purposely selected based on researchers' background knowledge of the firm. A review of company strategy and interaction with the Company Executive Operating Committee confirmed that over the last ten years this company has shifted from a 'manufacturing company' to a 'global supply chain company'. There has been a shift from 80% "make" to 80% "buy" as this tier one supplier positioned itself as a strategic supplier to OEMs. The findings from the workshop provide an interesting insight into the perceptions and challenges at an organisational level.

Strategic Orientation & Perception of Supply Chain Relationship Management
At a strategic level we find that a number of factors influenced the strategic shift from manufacturer to supply chain coordinator, in particular the following emerged as strong drivers of strategic change: (i) demand from OEMs for subassemblies rather than components; (ii) the need to complement internal traditional engineering based competencies with those from suppliers in order to design and build subassemblies; and (iii) the need to create a global supply network to leverage low cost advantages in emerging economies. The workshop discussions point to widespread awareness of changing demands from customers and corporate strategic response to this. In particular it was evident that the strategy pursued by OEMs to increasingly outsource the fabrication of subassemblies prompted the case company to respond by repositioning itself in the supply chain as supplier of subassemblies rather than constituent components.

Discussion on supply chain relationship management revealed strong customer relationships where "*long-term partnerships with the customers had evolved to close collaboration on product design where we use our core competencies and technologies to create innovative solutions in their products*". On the other hand relationships with suppliers were less developed, but a changing emphasis on supplier development follows the company strategy to position themselves as a key tier one supplier to selected OEMs. There was evidence that the case company endeavoured to leverage its traditional component manufacturing core competency (i.e. leading edge specialist precision engineering) to evolve into a new supply chain competency that encompasses design and subassembly. The latter is based on engineering and relationship management capabilities that are not specific to particular OEMs – i.e. delivery to OEMs across target industries was fundamental to this strategy. Similarly it became evident that suppliers may also be competitors, therefore supplier development and management processes where highlighted as key to the success of this new strategy.

Workshop groups considered different supplier relationships based on the type of product/service sought – "*it can be broken into custom, complex or standard product*". They typically categorised suppliers from commodity to strategic. The case company supplied markets that require access to parts for a specified number years after production of the subassembly ceases, thus access to a supply of components over a number of decades is often required. Given this context the respondents' perception of commodity suppliers versus strategic suppliers centred on the nature of the component rather than the expected duration of the relationships. The relationship was considered 'commodity orientated' if the component could be easily specified and pricing fixed according to delivery schedules, whereas if it could not be easily defined and scheduled this indicated the need for a more strategic relationship. Furthermore such strategic relationships involved a number of functions from both organisations. Thus, level of ambiguity and cross-functional involvement influenced the categorisation of relationships as commodity orientated or strategic.

These findings point to the emergence of a new business model for the case company. This is in response to their positioning as a tier one supplier, the core competencies of which are supply chain and design-based. They also support typical supplier classification typologies found in the literature but emphasise the nature of exchange rather than expected duration of the relationship.

Potential

There was widespread understanding of the changing competitive environment and changing role of the company: "*We recognise that this is going to be a core competency …. It is going to require different skill sets Engineering, Planning, Development, Quality control [are] key support functions to develop it. [This] can be a major mind set change to long-term thinking. [We need to development the] business process that needs to underpin this, including different supplier selection processes e.g. partnership, growth potential, quality etc*." There was also some discussion about the inherent risk of becoming "*more dependent on our supplier-base*", however most discussion centred on the need for organisational change necessary to support supplier relationship management.

Organisational change

Cross-functional teams and information flow were the key challenges identified: "*We're faced with difficulty getting the customer's point of view through our functions and out to suppliers*". There was some discussion of the need to create inter-organisational knowledge systems rather personal relationships: "*There are typically interactions across multiple functions between us and the supplier. These personal relationships are important, yet should be independent of the people. These relationships need to be consciously managed*." Thus there was some concern that these relationships would rely on tacit information and this prompted an interest in procedures to codify information and create knowledge-based systems. These systems were seen to be of particular importance given the global nature of the company and the diversity of industries served. In this regard consideration was given to various levels of relationship and knowledge management – the refrain 'one-size does not fit all' was well rehearsed during the workshop!

In summary two key dimensions emerged from the workshop discussions: (i) relationship category based on the complexity of the product/service and (ii) systems to support relationship development and operation. These are illustrated in figure 1 below.

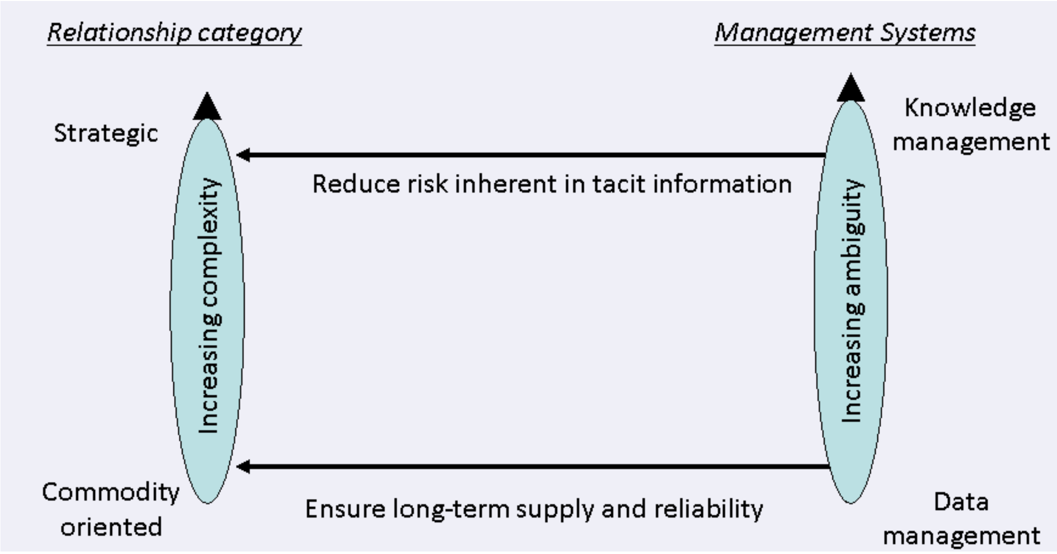

Figure 1: SRM – categories and systems

DISCUSSION AND CONCLUSIONS

This case provides an interesting insight into the drivers and impact of changing supply chain configuration at tier one supplier level. The approach taken reflects supplier relationship typologies found in the literature; however the strategic interest in developing a competency in this area is of particular interest.

The case study company involvement in knowledge-based networks was largely a function of their need to specialise in a particular area which in turn increased their need to co-operate with other firms specialised in complementary functions. It was evident that as firms position themselves to take advantage of changing supply chain configurations, more complex and diverse networks emerge in comparison to the hub-and-spoke type networks traditionally associated with sub-contracting and leader-firm networks based on market power. The case study firm was found to serve a number of OEMs and build supply pipelines with firms that were also engaged in other networks. The core competency hypothesis motivating this research yields much food for thought, in particular the need to better understand the competitive advantage that tier one suppliers can leverage from a core competency across networks and industries.

Prahalad and Hamel’s (1990) seminal contribution to our understanding of core competency distinguished such competencies as those that: (i) provide access to a wide variety of markets, (ii) makes a significant contribution to the perceived customer benefits of the end product, and (iii) should be difficult to imitate. The second and third criteria have received much attention; however the findings from this study highlight the importance of the economies of scope that can be achieved from access to a variety of markets. This reflects Dervitsiotis’ (2008) observation that the formation of large global networks of firms may span several traditional industries and are typically based around two basic types of ‘keystone hubs’ - proprietary technology or network orchestrator. Extending core competencies across industries is of particular interest given the dominance of many product categories by a few firms. Of course this dominance is a logical outcome of core competency focus over the last two decades or more. These firms now wish to achieve synergistic performance through leveraging their core competency across not only product categories but also across industries/applications – the evidence from the case study company supports this thinking. As Michael E. Porter (1987) argued some time ago “Corporate strategy is what makes the corporate whole add up to more than the sum of its business unit parts”. The difference today is that the focus on ‘specialisms’ along the supply chain provides the opportunity to achieve synergy not only internally but also across organisations in the network. Hence the challenge for scholars and practitioners alike is to consider the impact of this thinking on not only organisational configuration but also on supply chain configuration. In addition to drawing our attention to the need to further investigate sources of competitive advantage arising from inter-organisational networks these observations also prompt us to consider governance of such networks.

While there is increasing interest in creating stronger linkages between 'design' and 'delivery' supply chains (Simichi-Levi *et al*, 2008; Mangan, *et al*., 2008), it appears likely that OEMs will endeavour to maintain control over the design process and restrict tier one supplier visibility to sub-assembly level. In turn it is likely that tier one suppliers will endeavour to develop technological hubs that serve design and delivery requirements across not only OEMs in the same industry but across industries (e.g. electronics, medical device, aerospace clusters; food, pharmaceutical, heath service clusters). In this way tier one suppliers extend their ex-ante limits to investment as economies of scope offer greater return on investment. Furthermore, this strategy counter-balances the OEM market power based on design and market share.

These observations are prompted by a review of literature and exploratory case study work and merely serve to stimulate debate and further research on competitive advantage and supply chain configuration.

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SECTION 12 – Reverse Logistics

AN INTEGRATED MODEL FOR PRODUCT RETURNS IN REVERSE LOGISTIC NETWORKS

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ABSTRACT
This paper studies the problem for manufacturers to decide the collection methods for collecting the used products, at the end of the product life, from the customers. The manufacturers have several options of collecting returned products that include picking up the products from the customers, letting customers to drop off the products to a drop-off facility, and letting the customers to mail return the products. This study examines potential implementation of all the abovementioned collection methods by a manufacturer required to collect its products at the end of the product life under government's environmental regulations. Specifically this study aims to develop a location-allocation model for the manufacturer's reverse logistics network to maximize the profit. A mixed integer non-linear programming model integrating the three collection methods is proposed to achieve the objectives.

Keywords: *reverse logistics, product recovery network design, collection methods*

INTRODUCTION
The extended producer responsibility states that manufacturers are responsible for free taking back and recovery of their end-of-life products and must bear all or significant part of the collection and treatment costs (Mansour and Zarei, 2008). At the same time, the amount of collected returned products should at least satisfy the required minimum collection rate. It is also noted that collection of used products potentially accounts for a significant part of the total costs of any closed-loop supply chain (Dekker et al, 2004)). Collection effectiveness depends on the consumers' willingness to return used products at the time of disposal (Wojanowski et al., 2007). It has been identified that two important factors which influence customers' willingness to return their products are accessibility and incentives. Min and Ko (2008) pointed out that customers' convenience when returning their products should be maximized as it will eventually encourage more future returns. There are three collection methods that are normally used by manufacturers namely mail delivery return, pick up collection and customer drop off. Installing a drop-off facility near residential or commercial areas encourage customers to return their products (easy access). This collection method requires the manufacturer to bear the cost of building or renting as well as operating the drop-off facilities in certain selected area. Nonetheless, the more important decision is to decide how many drop-off facilities are needed and their locations. In practice, the facilities need to be located within close proximity to the customers. Some manufacturers use intermediaries such as retailers acting as collection centres to collect returned products from the customers. Previous studies usually group customers based on geographical zones and each zone is served by one particular drop-off facility (Wojanowski et al, 2007; Aras and Aksen, 2008; Aras et al, 2008).

In the mean time, incentives play a significant role in influencing customers' willingness to return their products. According to Aras et al (2008), some manufacturers have been able to influence the quantity of returns by using buy back campaigns and offering financial incentives to product holders. Apart from an increment in terms of product return quantities, the amount of incentives offered by the manufacturers influences the quality level of the returned products (Aras and Aksen, 2008). Similar to Wojanowski et al (2008), these two studies examine how the amount of incentives offered to the customers affects manufacturers' profit and collection strategies. There are several differences between the abovementioned papers and ours. In our paper, we examine a situation where a manufacturer have a choice of adopting the three collection methods simultaneously while in Wojanowski et al. (2008), Aras et al. (2008) and Aras and Aksen (2008) the models were only focusing on one particular collection method at a time. We also consider the element of government regulation (minimum collection rates) that manufacturers are facing. Our study is motivated by the need for analytical approaches that foster an in-depth understanding on this simultaneous implementation of the collection methods. The aim of this study is to develop a facility location-allocation model that determines the optimal number and locations of collection centres as well as incentives offered to customers, so as to maximize the profit.

PROBLEM DEFINITION

This study examines a manufacturer-typed product recovery network design. This type of collection network is practiced by many companies (Savaskan and van Wassenhove, 2006). Specific attention is given to the collection stage of product returns. At this stage, customers have several options of returning used products either via a drop-off facility, a mail delivery return or a pick up collection method provided by the manufacturer. It is up to the manufacturer to influence customers' preference and assign them to certain collection method using the incentive offers. As long as it is technically possible and economically viable, we therefore assume that customers' decision to return their unwanted products as well as their preference over a particular collection method is heavily influenced by the amount of incentives offered. It is also assumed that customers have no other option to return their products. The network structure is depicted in the following diagram.

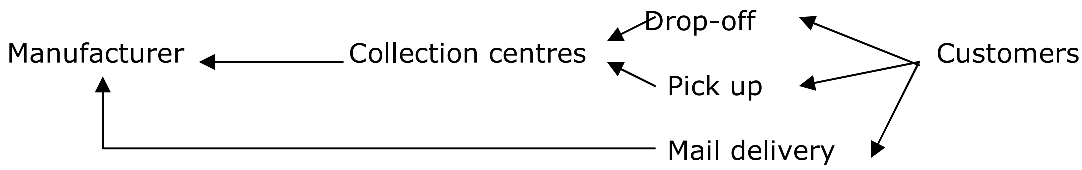
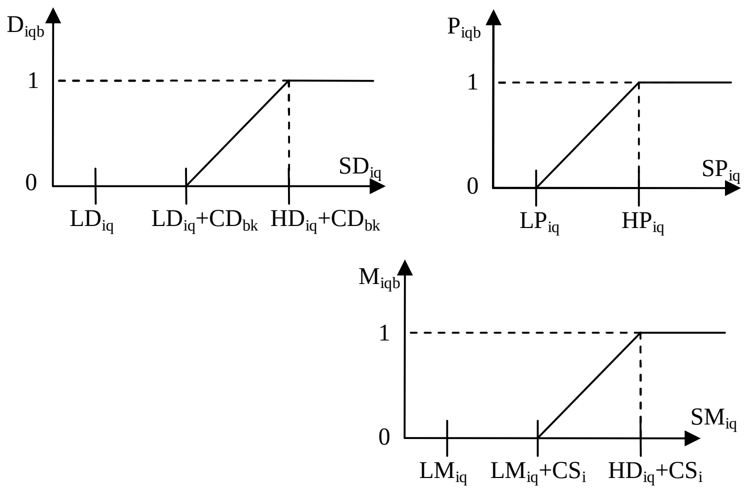


Fig 1: The collection methods in product recovery network design

In this study, the manufacturer is assumed to implement a centralized collection policy within a single period timeframe consisting of both direct (mail delivery return) and indirect (drop-off and pick up methods) collection channels. For this study, the manufacturer is assumed to use its forward distribution networks to collect returned products. In particular, the manufacturer may select and appoint certain retailers as collection centres/drop-off points. Similar to what was done in previous studies, to reduce complexity, customers are grouped into certain zones instead of being considered as individuals. In terms of the return flow, if drop-off option is chosen for a customer zone, customers in the zone will have to travel to a collection centre to drop-off their products and only one collection centre can be chosen for the customers in each zone. Hence, the function of each collection centre will not be overlapping. If a customer zone is assigned for pick up collection method, returned products will be picked up and then transported to the selected collection centre.

Meanwhile, the costs of operating a collection centre and implementing the pick up method consist of fixed operating costs and variable costs. The operating costs may include setup/rental cost and handling cost. We assume that operating costs for every collection centres are the same and all facilities are homogenous. The operating cost for the pick-up operation may comprise of vehicles rental, maintenance and drivers' wages. The vehicles used are also assumed to be homogenous. The variable cost of a pickup trip is defined by the cost per unit of distance and the distance of travelled from the collection centre to the customer zone and back. The amount of incentives offered is assumed to affect customers' decision to return their products. Our study uses an acquisition price per unit of returned product as an incentive based on the quality condition. Apart from that, the values of the incentives (acquisition prices) vary between the collection methods in order to compensate customers' effort and their travelling costs to return their products. It is also assumed that all collected products are recoverable and hence still have remaining values to be recaptured. In terms of customers' willingness to return their products, if the incentive offered is less than what the customers expect, then probability of customer return is zero. On the other hand, if the amount of incentive offered is equal or higher than the maximum amount of incentive that the customer expect for a particular product, then all customers will return their products. The amount of return will not change further if the amount of incentives increases above the maximum incentives that customers expect. This situation can be illustrated by Figure 2 (following *Aras and Aksen, 2008*). Figure 2(a) shows the proportion of product *i* of quality *q* returned as a function of incentive offered for the drop-off collection method. The minimum incentive value is denoted by "LD_{iq}" while maximum incentive is represented by "HD_{iq}". The cost of travelling to return the used product from customer zone *b* to collection (drop-off) centre *k* is depicted by "CD_{bk}". Figure 2(b) shows similar function for the pickup collection method. The minimum incentive is LP_{iq} while maximum incentive is represented by HP_{iq}. The minimum incentive value for mail return delivery in Figure 2(c) is denoted by "LM_{iq}" while maximum incentive is represented by "HM_{iq}". The mailing cost to return used products is depicted by "CS_i".



(a) for drop-off method (b) for the pickup method (c) for mail return method

Fig. 2: Proportions of product returned as a function of incentive offered

It can also be assumed that $HM_{iq} > HD_{iq} > HP_{iq}$ considering the conveniences for customers to return their products using different methods. Similar assumption may be made for the minimum amount of incentives offered for each type of the collection methods. In the mean time, the requirement by government regulations can be reflected in the form of minimum recovery rates. In this study, a manufacturer is assumed to be producing multiple products that can be returned by customers using either one of the collection methods. Products such as ink cartridges, rechargeable batteries, disposable camera, mobile phones and books fit the bill.

MODEL FORMULATION

We develop an integrated generic model for the manufacturer to decide locations of collection (drop-off) centres in its reverse logistics network, the collection method for each customer zone and the incentives offered for returning products. The objective of the model is to maximize the total profit which is the value of the collected products minus the collection costs. We assume that customers have no other return options except the aforementioned collection methods. The estimated amount of products of each type and each quality class available to return in each zone is assumed known. The model formulation of the drop-off collection method is based on the work of Aras and Aksen (2008) and extensions have been made to incorporate other collection methods.

Parameters

n = Number of product types
n_b = Number of customer zones
n_q = Number of product quality classes
n_k = Number of potential collection centres
TA_i = Total amount of returned product type i
T_{iqb}= Total amount of used product type i of quality q in customer's zone b
CD_{bk} = Travelling cost per unit distance for drop off from customer zone b to collection centre k
D_{bk} = Distance between potential collection centre k and customer zone b
cv = Fixed cost of operating a vehicle
CV = Pick up vehicle's travel cost per unit distance
C_k = Fixed cost of operating a drop-off facility k
CM_i = Cost of receiving and handling a unit of product i returned via mail
CS_i = Customers' shipping/post cost to return a unit of product i via mail
KV = Maximum load (capacity) of a vehicle
KD_k = Maximum capacity of a collection centre k
HP_{iq} = Maximum incentive of product i of quality q (pick up method)
HD_{iq} = Maximum incentive of product i of quality q (drop-off method)
HM_{iq} = Maximum incentive of product i of quality q (mail delivery method)
LP_{iq} = Minimum incentive of product i of quality q (pick up method)
LD_{iq} = Minimum incentive of product i of quality q (drop-off method)
LM_{iq} = Minimum incentive of product i of quality q (mail delivery method)
R_{iq} = Expected value per unit of product i in quality class q
XR_i = Required minimum collection rate for product i
W = A large number

Decision variables
SP_{iq} = Incentive offered for product i of quality class q (pick up method)
SD_{iq} = Incentive offered for product i of quality class q (drop-off method)
SM_{iq} = Incentive offered for product i of quality class q (mail delivery method)
P_{iqb} = Proportion of product i of quality class q collected from customer zone b
D_{iqb} = Proportion of product i of class q dropped off by customers in zone b
M_{iqb} = Proportion of product i of quality class q returned from customer zone b
V_{bk} = Number of vehicles needed to collect and transport returned products from customer zone b to collection centre k
Y_k = 1, if a drop-off facility (collection centre) is setup at site k, 0, otherwise
XD_{bk} = 1, if product owners in zone b is assigned to drop-off their products at collection centre k, 0, otherwise
XP_{bk} = 1, if product owners in zone b is assigned for pick up collection to collection centre k, 0, otherwise
XM_{ib} = 1, if product owners of product i in zone b is assigned for mail delivery method, 0, otherwise
α_{iqb} = 1, If product owners in zone b do not drop off their products, 0, otherwise
δ_{iqb} = 1, If all product owners in zone b drop off their products, 0, otherwise
β_{iqb} = 1, If product owners in zone b do not return their products (pick up), 0, otherwise
ρ_{iqb} = 1, If all product owners in zone b return their products (pick up), 0, otherwise

χ_{iqb} = 1, If product owners in zone *b* do not return their products (mail return delivery), 0, otherwise

μ_{iqb} = 1, If all product owners in zone *b* return their products (mail return delivery, 0, otherwise

The model:

Max $Z_1 + Z_2 + Z_3$

Where Z_1, Z_2 and Z_3 are profits from the pickup (not counting the operating costs of collection/drop-off centres), drop-off (counting all the operating cost of the collection/drop-off centres) and mail return methods respectively.

$$Z_1 = \sum_{i=1}^{n}\sum_{q=1}^{n_q}\sum_{b=1}^{n_b}\sum_{k=1}^{n_k} P_{iqb}T_{iqb}(R_{iq} - SP_{iq}) - \sum_{b=1}^{n_b}\sum_{k=1}^{n_k}[cv + 2CVD_{bk}]V_{bk} ,$$

$$Z_2 = \sum_{i=1}^{n}\sum_{q=1}^{n_q}\sum_{b=1}^{n_b} D_{iqb}T_{iqb}(R_{iq} - SD_{iq}) - \sum_{k=1}^{n_k} C_k Y_k , \quad Z_3 = \sum_{i=1}^{n}\sum_{q=1}^{n_q}\sum_{b=1}^{n_b} M_{iqb}T_{iqb}(R_{iq} - SM_{iq} - CM_i)$$

Subject to:

A collection centre, *k*, can receive collected products from more than one customer's zones, *b*, but each zone is assigned to only one collection method, and if it is assigned to pickup or drop-off method, it can only be assigned to one collection/drop-off centre:

$$\sum_{k=1}^{n_k} XP_{bk} + \sum_{k=1}^{n_k} XD_{bk} + XM_b = 1 , \quad b=1,\dots,n_b \tag{1}$$

Returned products of all types and qualities collected via the pick up and drop-off methods can only be delivered to a collection centre that is set up:

$$XP_{bk} + XD_{bk} \le Y_k , \quad b=1,\dots,n_b , \quad k=1,\dots,n_k \tag{2}$$

The incentive values represent customers' willingness to return their products. In terms of the drop-off method, the relationships between the incentives and the proportion of products returned are as follows:

$$SD_{iq} \le (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) + LD_{iq} + W(1 - \alpha_{iqb}) , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{3}$$

$$SD_{iq} \ge (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) + LD_{iq} - W\alpha_{iqb} , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{4}$$

$$SD_{iq} \le (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) + HD_{iq} + W\delta_{iqb} , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{5}$$

$$SD_{iq} \ge (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) + HD_{iq} - W(1 - \delta_{iqb}) , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{6}$$

$$D_{iqb} \le 1 - \alpha_{iqb} , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{7}$$

$$D_{iqb} \ge \delta_{iqb} , \quad i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{8}$$

$$D_{iqb} \le [SD_{iq} - (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) - LD_{iq}]/[HD_{iq} - LD_{iq}] + W(\alpha_{iqb} + \delta_{iqb}) ,$$
$$i=1,\dots,n , \ q=1,\dots,n_q , \ b=1,\dots,n_b \tag{9}$$

$$D_{iqb} \ge [SD_{iq} - (\sum_{k=1}^{n_k} CD_{bk} XD_{bk}) - LD_{iq}]/[HD_{iq} - LD_{iq}] - W(\alpha_{iqb} + \delta_{iqb}) ,$$

$i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(10)

As for the pick up collection method, the relationships are as follows:

$SP_{iq} \leq LP_{iq} + W(1-\beta_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(11)

$SP_{iq} \geq LP_{iq} - W\beta_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(12)

$SP_{iq} \leq HP_{iq} + W\rho_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(13)

$SP_{iq} \geq HP_{iq} - W(1-\rho_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(14)

$P_{iqb} \leq 1-\beta_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(15)

$P_{iqb} \geq \rho_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(16)

$P_{iqb} \leq [SP_{iq} - LP_{iq}]/[HP_{iq} - LP_{iq}] + W(\beta_{iqb} + \rho_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(17)

$P_{iqb} \geq [SP_{iq} - LP_{iq}]/[HP_{iq} - LP_{iq}] - W(\beta_{iqb} + \rho_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(18)

The relationships between the incentives and the proportion of products returned from zone *b* via mail are illustrated in the following equations:

$SM_{iq} \leq (CS_i XM_{ib}) + LM_{iq} + W(1-\chi_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(19)

$SM_{iq} \geq (CS_i XM_{ib}) + LM_{iq} - W\chi_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(20)

$SM_{iq} \leq (CS_i XM_{ib}) + HM_{iq} + W\mu_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(21)

$SM_{iq} \geq (CS_i XM_{ib}) + HM_{iq} - W(1-\mu_{iqb})$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(22)

$M_{iqb} \leq 1-\chi_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(23)

$M_{iqb} \geq \mu_{iqb}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(24)

$M_{iqb} \leq [SM_{iq} - (CS_i XM_{ib}) - LM_{iq}]/[HM_{iq} - LM_{iq}] + W(\chi_{iqb} + \mu_{iqb})$,
$i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(25)

$M_{iqb} \geq [SM_{iq} - (CS_i XM_{ib}) - LM_{iq}]/[HM_{iq} - LM_{iq}] - W(\chi_{iqb} + \mu_{iqb})$,
$i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$
(26)

Note that constraints (9-10), (17-18) and (25-26) are active only when
$\alpha_{iqb} = \delta_{iqb} = 0, \beta_{iqb} = \rho_{iqb} = 0, \chi_{iqb} = \mu_{iqb} = 0.$

No product can be returned using a collection method if the method is not chosen:

$D_{iqb} \le \sum_{k=1}^{n_k} XD_{bk}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$

(27)

$P_{iqb} \le \sum_{k=1}^{n_k} XP_{bk}$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$

(28)

$M_{iqb} \le XM_b$, $i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$

(29)

The amount of returned products delivered to a particular collection centre via the pick up and drop-off methods should not exceeds the capacity of the centre:

$\sum_{i=1}^{n}\sum_{q=1}^{n_q}\sum_{b=1}^{n_b}(D_{iqb}XD_{bk}T_{iqb} + P_{iqb}XP_{bk}T_{iqb}) \le KD_k$, $k=1,\ldots,n_k$

(30)

The constraint below determines the number of vehicle required to collect all returned products from customer zone b to collection centre k via the pick up method.:

$(\sum_{i=1}^{n}\sum_{q=1}^{n_q} P_{iqb}XP_{bk}T_{iqb})/KV = V_{bk}$, $b=1,\ldots,n_b$, $k=1,\ldots,n_k$

(31)

The total amount of collected product i via all collection methods from all customer zones should satisfy the required minimum collection rates:

$\sum_{q=1}^{n_q}\sum_{b=1}^{n_b}\sum_{k=1}^{n_k}[(P_{iqb} + D_{iqb} + M_{iqb})T_{iqb}]/TA_i \ge XR_i$, $i=1,\ldots,n$

(32)

The number of vehicles should be in integer values and non-negative:

$V_{bk} \ge 0$ and integer, $b=1,\ldots,n_b$, $k=1,\ldots,n_k$

(33)

The continuous variables are all required to be non-negative:

$P_{iqb}, D_{iqb}, M_{iqb}, SP_{iq}, SD_{iq}, SM_{iq} \ge 0$ **and** $P_{iqb}, D_{iqb}, M_{iqb} \le 1$

$i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$

(34)

The binary constraints:

$Y_k, XP_{bk}, XD_{bk}, XM_{ib}, \alpha_{iqb}, \delta_{iqb}, \beta_{iqb}, \rho_{iqb}, \chi_{iqb}, \mu_{iqb} \in \{0,1\}$,

$i=1,\ldots,n$, $q=1,\ldots,n_q$, $b=1,\ldots,n_b$ $k=1,\ldots,n_k$

(35)

CONCLUSION

The pressure to achieve higher recovery rates for used products forces manufacturers to explore more possible avenues to improve collection rate. It is increasingly important for manufacturers to utilize available collection methods in order to improve collection rate as it affects manufacturers' product recovery performance. In this study we developed a facility location-allocation model for manufacturers to consider different product collection methods simultaneously. The model incorporates different collection methods of mail return, pick up and drop off into an integrated model. The model also includes requirement by government regulations in the form of minimum collection rates. The relationships between incentives and proportions of returns for each collection methods are also included in the model. The model can potentially give better results than models only consider one collection method. Nonetheless, the model is nonlinear and involve integer variables and hence is hard to solve. We are currently working on the solution of the model with some test data.

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CAPACITATED LOCATION-ROUTING AND BALANCED ALLOCATION IN REVERSE LOGISTICS NETWORK

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ABSTRACT
Reverse Logistics (RL) is a timely and relevant topic for both academics and practitioners. Some of the major issues in reverse logistics are determining the location of Temporal Collection Points (TCP) and Centralized Return Centers (CRC), allocating recoverable products to CRCs and manufacturing processes if required and finally finding optimal routing patterns between all stages from customers to processing center where RL processes will be carried out. We contribute to the literature by integrating all the three decisions pertaining to Location, Allocation and Routing using a mathematical model, commonly referred to as CRAB (Capacitated Routing and Allocation with Balancing constraint) with the assumption that the vehicles and centralized return centers have limited capacity as well as probabilistic approach has been adopted to select suitable RL process for particular product. Thus, the purpose of this CRAB problem is to allocate each CRC to TCPs in a balanced manner and obtain optimal vehicle routes from processing center to CRCs, CRCs to TCPs, as well as from TCP's to customers with the overall objective of minimizing total cost. To solve this CRAB problem, a decomposition methodology has been adopted and its performance is tested with data sets retrieved from standard sources. The results from this model would help practitioners to develop efficient reverse logistics networks.

Keywords: Reverse Logistics, Location-Routing, Clustering, Balanced Allocation, remanufacturing

INTRODUCTION
Reverse Logistics (RL) is the process of planning, implementing, and controlling the efficient and cost-effective flow of post-use materials in the form of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. Companies are interested in reverse logistics for a variety of reasons from managing the returns process to dealing with environmental issues relating to disposal of waste. Collaboration among members of a supply chain is essential to manage an efficient RL process (Zuluaga,2005). Flows from returned products have been increasing lately due to factors such as environmental consciousness of customers, enforcement of product take-back laws and the economic value gained by re-using products (De Koster et al., 2001). Thus, handling return flows has become an important decision in logistics management. The Literature review reveals that considerable amount of research has been carried out on the location-allocation problem in RL settings. However, few studies have attempted the joint consideration of the Location-Routing Problem (LRP) as well as the Balanced Allocation Problem (BAP) in RL applications. An integrated location-routing approach may help logistics managers develop more efficient logistics networks (Min,1996). From the literature review, it has also emerged that very few attempts have been made on BAP in a forward logistics network and that many firms do not consider the RL network

inherently, but are forced to respond to government regulations. Since the collection cost is highest among the RL costs and the existence of less standardized RL collection network, necessitates the design of the successful collection network for returned products, in order to maximize the use of resources (Rogers and Tibben-Lembke,2000). In such a situation, while assigning some of their limited resources for RL application, they will give more importance for effective utilization and balanced allocations. Unbalanced allocation of resources in RL network, may result in underutilization or over-utilization of resources which ultimately cause higher operational costs and increased workload disparities among workers (Chan and Kumar,2009).The objective of our research problem is to determine the location of temporal collection points for returned products and the location/allocation of centralized return centers in such a way that total reverse logistics costs (e.g., inventory carrying and transportation costs, RL processing costs) are minimized. We do this by also taking into account that the capacity of temporal collection points and centralized return centers are fully utilized, and by looking at the convenience of customers who return products.

PROBLEM DESCRIPTION

The location and expected return number of units by a set of I customers and the total number of TCPs are given. Each customer is to be assigned to a TCP that will temporarily hold the customer's expected returns. The product returns are specified in units of a single representative commodity. The location of processing center and its fixed cost is known .Also given is a set K of the CRCs and the fixed costs at each CRC.If q_i is the total return units from a customer, each customer with $q_i > 0$ must be allocated in balanced manner to a CRC via a TCP located near the customer, so as to completely satisfy q_i. Each TCP will have a vehicle with certain capacity Q_j in its location, which will be used to make an optimal tour to all assigned customers for the collection of returned products. Then, separate vehicles from CRCs will travel to each assigned TCPs and after collection will again return to the corresponding CRCs. From each CRC, the vehicles will transfer the collected products to processing center for final processing. The vehicles and the centralized return centers have limited capacity. The purpose of this CRAB (Capacitated location-Routing and Allocation with Balancing constraint) problem is, then, to find locations of TCPs and CRCs and to choose the TCPs that must be allocated to each CRC in balanced manner, that is with balanced workload among each other or minimum work load disparity among each other as well as to find the routing pattern with the shortest distance from processing center to CRCs, CRCs to the TCPs as well as from each TCPs to their assigned customers, given the objective of minimizing total cost which comprises of location and distribution costs as well as costs for selected RL processes for each product.

To explain the CRAB model, let us consider an automobile manufacturer that reduces its manufacturing cost by reusing or recycling or remanufacturing parts from its End of Live Vehicles (ELV) received from customers. That is, the manufacturer may establish its own processing center where different RL processes will be carried out based on received ELV quality and centralized return centers with sufficient capacity for storing the collected ELV's from customers. The vehicles available in each TCP are based on the central location for a group of customers.

The vehicles will make an optimal route of traveling to their allocated customers and returning to TCP. Then, the vehicles from each centralized return centers will travel to collect ELV's from temporal collection points, taking into account both capacity and balancing constraints. Finally, they return to the corresponding centralized return centers which store the collected ELV's. From each CRC, collected ELV's will be transferred to the processing center where that may be inspected for final processing.

Assumptions

The assumptions made in the integrated CRAB model are as follows:

(1) The possibility of direct shipment from customers to a CRC is ruled out due to insufficient volume;

(2) Each TCP has sufficient capacity to hold single type returned products and holding cost is negligible;

(3) The transportation costs between customers and their assigned TCPs are to be borne by customer given short distances between each other;

(4) The location/allocation plan covers a planning horizon within which no substantial changes are incurred in customer demands and in the transportation infrastructure;

(5) The number of units allocated to each CRC via TCPs is assumed to be equal or having not more than 10% degree of imbalance among each other; and

(6) The number of CRCs is approximately equal to the integer part of half the total number of TCPs as per (Min et.al,2006).

(7) The selection of RL processes for each product has been done by generating random numbers for each product and comparing with assumed probabilities of each RL processes.

Model Parameters

i -Index for customers; $i \in I$

j -Index for TCPs; $j \in J$

k -Index for CRCs; $k \in K$

p -Index for RL Processing Center;

r -Total number of customers;

t -Total number of TCPs;

s -Total number of CRCs;

I -Set of customers {1,……..r};

J -Set of TCPs {1,……..t};

K -Set of CRCs {1,……..s};

x_i, y_i -Geometric position of the customer i;

x_k, y_k -Geometric position of the CRC k;

x_j , y_j -Geometric position of the TCP j;

x_p, y_p -Geometric position of the RL Processing Center p;

n_j -Number of customers assigned to the TCP j;

q_i -Demand of the customer i;

Q_j -Capacity of a vehicle that travels through the TCP j;

FC_k -Fixed cost for establishing a CRC k;

FC_p -Fixed cost for establishing a RL processing center p;

u_j -Total Number of units carried through a TCP j;

Q_k -Capacity of a centralized return center k;

VC_k -Variable Cost/unit throughput at CRC k,

$D_{ii'}$ -Distance between customer i and customer i';

u_i -Sequence order number of customer I;

$u_{i'}$ -Sequence order number of customer i';

P_{rec} –Range of probability for selection of recycling process;

P_{rem} –Range of probability for selection of remanufacturing process;

P_{dump} –Range of probability for selection of dump or landfill process;

C_{rec} –Cost for recycling process;

C_{rem} –Cost for remanufacturing process;

C_{dump} –Cost for dump or landfill process;

R_i -Generated random number for each product for RL process selection;

Decision Variables

V_{kj} -Number of units allocated to CRC k by TCP j;

Y_{ij} =1, If the customer i is assigned to TCP j,

= 0, otherwise;

X_{kj} = 1, If the TCP *j* is allocated to CRC *k*,

= 0, otherwise;

$Z_{ii'}$ = 1, Vehicle travels from customer location *i to customer* location *i'*,

= 0, otherwise;

N_k = 1, If the CRC *k* is open,

= 0, otherwise;

C_{rem} = 300, If R_i falls between P_{rem} = 0.6-0.8,

= 0, otherwise;

C_{rec} = 200, If R_i falls between P_{rec} = 0.6-0.8,

= 0, otherwise;

C_{dump} = 100, If R_i falls between P_{dump} = 0.2-0.4,

= 0, otherwise;

Objective Criterion

The objective criterion of the CRAB model is considered as minimization of Total Cost (TC) incurred from customer to processing centre which is expressed as follows:

$$\text{Minimize } TC = \sum_{i\varepsilon I}\sum_{j\in J}((x_i - \bar{x}_j)^2 + (y_i - \bar{y}_j)^2) Y_{ij} + \sum_{k\varepsilon K}\sum_{j\in J}((x_k - \bar{x}_j)^2 + (y_k - \bar{y}_j)^2) X_{kj} + FC_p$$
$$+ \sum_{k\varepsilon K}((x_k - x_p)^2 + (y_k - y_p)^2) + \sum_{k=1}^{s}\sum_{j=1}^{t} VC_k V_{kj} + \sum_{k=1}^{s} FC_k \; N_k + C_{rem} + C_{rec} + C_{dump} + \sum_{i=1}^{r}\sum_{\substack{i'=1 \\ i\neq i'}}^{r} D_{ii'} Z_{ii'} \quad (1)$$

Constraints

$$\sum_{j\varepsilon J} Y_{ij} = 1, \forall i\varepsilon I \text{ (Allocation constraint)} \quad (2)$$

$$\sum_{i\varepsilon I} Y_{ij} = n_j, \forall j\varepsilon J \text{ (Allocation constraint)} \quad (3)$$

$$\sum_{i\varepsilon I} x_i Y_{ij} \le n_j \bar{x}_j, \forall j\varepsilon J \text{ (TCP Location constraint)} \quad (4)$$

$$\sum_{i\varepsilon I} y_i Y_{ij} \le n_j \bar{y}_j, \forall j\varepsilon J \text{ (TCP Location constraint)} \quad (5)$$

$$\sum_{i\varepsilon I} q_i Y_{ij} \le Q_j \text{ (TCP Capacity constraint)} \quad (6)$$

$$(\bar{x}_j, \bar{y}_j)\varepsilon t, n_j \varepsilon r, Y_{ij} \varepsilon \{0,1\}, \forall i\varepsilon I, \forall j\varepsilon J \text{ (Bound Constraint)} \quad (7)$$

$$\sum_{j=1}^{m} X_{kj} = 1, \forall k\varepsilon K \text{ (Allocation constraint)} \quad (9)$$

$$\sum_{j=1}^{m} V_{kj} X_{kj} \ge \sum_{j=1}^{m} u_j, \forall k\varepsilon K \text{ (Return Unit constraint)} \quad (10)$$

$$\sum_{j=1}^{m} V_{kj} X_{kj} \le Q_k, \forall k\varepsilon K \text{ (CRC Capacity constraint)} \quad (11)$$

$$\sum_{j=1}^{m} V_{1j} = \sum_{j=1}^{m} V_{2j} = \ldots\ldots = \sum_{j=1}^{m} V_{sj} \text{ (Balancing constraint)} \quad (12)$$

$$\text{DOI} = \{[\text{Max. of } (\sum_{j=1}^{t} V_{1j}, \sum_{j=1}^{t} V_{2j} \ldots\ldots \sum_{j=1}^{t} V_{sj}) - \text{Min. of } (\sum_{j=1}^{t} V_{1j}, \sum_{j=1}^{t} V_{2j} \ldots\ldots \sum_{j=1}^{t} V_{sj})] /$$

$$[\text{Average of all } (\sum_{j=1}^{t} V_{1j}, \sum_{j=1}^{t} V_{2j} \ldots\ldots \sum_{j=1}^{t} V_{sj})]\} \leq 10\% \quad (13)$$

$$\sum_{i=1}^{r} Z_{ii'} = 1, i' = 1,2 \ldots\ldots r; i' \neq i \text{ (Forward Vehicle tour constraint)} \quad (14)$$

$$\sum_{i=1}^{r} Z_{ii'} = 1, i = 1,2 \ldots\ldots r; i' \neq i \text{ (Reverse Vehicle tour constraint)} \quad (15)$$

$$u_i - u_{i'} + rZ_{ii'} \leq r - 1; i, i' = 2,3, \ldots\ldots\ldots r; i' \neq i \text{ (Subtour constraint)} \quad (16)$$

$$u_{i'} \geq 0, u_i \geq 0, \text{ (Non-negativity constraint)} \quad (17)$$

Constraint (2) imposes a condition that each customer is allocated to exactly one temporal collection point. Constraint (3) provides the number of customers in each cluster. Constraints (4), (5) suggest the position of temporal collection points. Constraint (6) imposes a condition that capacity at each temporal collection point is restricted. Constraint (7) defines the decision variables, and the upper limits on the number of individuals per group. Constraint (9) states the condition that each centralized return center should be allocated to only one temporal collection point. Constraint (10) states the condition that total volume at centralized return center *k* should exceed total demand requirements of temporal collection points allocated to centralized return center *k*. Constraint (11) insures that the total volume of units allocated to the centralized return center *k* never exceeds its capacity. Constraint (12) insures that there is "Balanced allocation' among centralized return centers. Constraint (13) insures that the Degree Of Imbalance among centralized return centers should not exceed 10%. Constraint (14) ensures that each vehicle arrives once at each customer location. Constraint (15) ensures that the vehicle leaves each customer location once. Constraint (16) is to avoid the presence of sub-tour. Constraint (17) defines non-negativity state of u_i and $u_{i'}$.

METHODOLOGY

The objective criterion is decomposed into the following sub problems:

(i) Capacitated Centered Clustering Problem (CCCP) [Sub problem 1]
(ii) Location-Balanced Allocation Problem (LBAP) [Sub problem 2]
(iii) Traveling Salesman Problem (TSP) [Sub problem 3]

Each sub problem is solved in sequential manner, to get the final solution. LINGO Version 8.0 optimization solver has been used to obtain the solution to the problem.

RESULTS AND DISCUSSION

The performance of the integrated model has been tested by solving various sizes of problems taken from standard sources (Gaskell67- 29X 5, Gaskell67- 32 X 5, Gaskell67- 36 X 5) (Barreto,2003) using LINGO optimization solver (Version 8.0). Table.1 shows the results of the problems.

Table.1. Results for test instances

Test Instances	CRC coordinates		TCP served & its position coordinates			TCP Vehicle Route sequence
	x_k	y_k	No	$\bar{x}_j$	$\bar{y}_j$	
29X5 (Gaskell 67)	175	377	1	120.91	346.99	TCP1-7-13-16 -15-10-11-12-8-14-9-17-TCP1
	175	377	2	181	359.99	TCP2-19–22-20-TCP2
	175	377	3	199.6	398.99	TCP3-25-27–28-26-29-TCP3
	190	373	4	214.29	374.57	TCP4-1-24-6-3-4-2-5-TCP5
	190	373	5	154.67	343.67	TCP5-18-23-21-TCP5
	Total Cost = 146594.51					
32X5 (Gaskell 67)	264	405	3	270.49	426.49	TCP3-29-30-TCP3
	264	405	4	312.12	394.75	TCP4-18-19-25-24-23-22-20-14-TCP4
	264	405	5	273.49	397.49	TCP5-16-28-26-27-TCP5
	273	422	1	319.54	442.45	TCP1-2-3-4-6-7-8-9-10-32-12-TCP1
	273	422	2	298.86	424.57	TCP2-1-15-17-14-31-11-13-TCP2
	Total Cost =327752.04					
36X5 (Gaskell 67)	42	45	2	24.99	29.99	TCP2- 1-2-3-9-8-7-TCP2
	42	45	3	59.99	64.99	TCP3-23-24-30-36-35-29 –TCP3
	42	45	4	61.43	42.86	TCP4-21-27-32-33-34-28-22- TCP4
	34	42	1	29.99	59.99	TCP1-4-10-16-11-17-18-12-6-5-TCP1
	34	42	5	51.25	26.25	TCP5-13-14-15-20-26-31-25-19-TCP5
	Total Cost =23001.29					

CONCLUSION

This study examines the importance of combination of various issues integrated into model for an efficient RL network, and its impact towards the objective function of cost minimization. It also highlights the importance of other issues such as balanced utilization of resources, processes to be selected beyond using cost as the only criterion. The issues considered in modeling were found to be effective and practitioners should give due weight age to these aspects while developing an efficient RL network. Our proposed model and solution methodology point to a number of avenues for future work:

(1) This work can be extended by taking into account inventory related costs;
(2) Stochastic demand, dynamic pricing and incentive price paid to the collecting agents may also be considered;
(3) Future research may include multi-product, multi-objective aspects into the current model;

(4) The co-ordination of two markets such as supply side(returns) and returns disposition may also be taken into account in future studies.

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RISK MANAGEMENT IN THE REVERSE SUPPLY CHAIN NETWORK

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ABSTRACT
As supply chains become more complex, the uncertainties and risks affecting the other links in the chain increase. The key issues in both forward and reverse supply chain are the formation of an effective supply network to ensure customer satisfaction and sustain capability. This requires the coordination of information, materials, and funds across multiple functional areas both within and among companies. To achieve this, companies must identify, evaluate, rank, and manage its supply chain risks. As supply chains become more complex, the uncertainties and risks affecting the other links in the chain increase. The paper focuses on the creation of a new risk management tool to help industries improve their material flow efficiency within their reverse supply chain. The purpose of the proposed risk management tool is to assist organizations in better preparing themselves in case certain risks occur. The framework developed helps monitor the reverse supply chain, specifically identifying, quantifying and managing potential risks.

The conceptual framework is then implemented using case examples from the high tech industry sector. In order to accurately quantify potential risks, a sensitivity analysis is performed on various possible risk quantification methods, in order to determine which formulation had the most accurate risk impact score. The tool is designed to be easily implemented at minimal cost and serves as a valuable tool for personnel faced with important and costly decisions regarding risk occurrence in the reverse supply chain network. This is an effective method for developing alternatives quickly and efficiently in the least amount of time without previous risk management experience.

INTRODUCTION
Customer satisfaction and sustainability hold a high priority in the eyes of organizations today. For most companies, as product sales increase, so do product returns, which in turn has companies' eager to maintain their customer satisfaction ratings. The forward and reverse supply chains have unique characteristics that vary among different organizations. Once lightly regarded, the flow of product returns is becoming a significant concern for many manufacturers. The total value of products returned by consumers in the U.S. is estimated at $100 billion annually (Blackburn et al. 2004). When products are returned by the customers, the manufacturer must decide how to most profitably dispose of the product: reuse as-is, refurbish, salvage, or recycle. There are many risks involved is the process of returned materials. Risk management in the reverse supply chain is relatively unexplored and underdeveloped. A major component in any effort to increase the efficiency and effectiveness of the flow of products back to the manufacturer must be the concurrent development of risk management system to control risk in the reverse supply chain.

The reverse supply chain refers to the series of activities necessary to remove new or used products from a customer for the purpose of recycling, remanufacturing, and re-using the product (Kocabasoglu et al. 2007). This chain is traditionally characterized by a backward flow of materials and entails five sequential steps (Blackburn et al. 2004): *Product Acquisition* - obtaining the used product from the user; *Reverse Logistics* - transporting the precuts to a facility for inspecting, sorting and disposition; *Inspection and Disposition* - assessing the condition of the return and making the most profitable decision for reuse; *Remanufacturing* - returning the product to original specifications, also known as refurbishing; *Marketing and Distribution* - creating secondary markets for the recovered products.

The risk management tool developed is to be used by management and other employees in the Reverse Logistics Group of a global company with the following characteristics: High-tech industry sector, Domestic returns (U.S. and Canada), Returned products sent to one location. Management for this group and all of the receiving facilities involved in the reverse supply chain is located mainly in California. The Reverse Logistics group is responsible for all products being returned to the company in the United State and Canada. Various teleconferences are held daily to keep the team up to date with the latest information regarding returned materials.

Currently the Reverse Logistics group does not acquire any sort of tool to help evaluate, assess, or manage risks in the process of returned material. After careful analysis of the people, locations, and processes affecting the returns stream, the implementation of the risk management tool seemed necessary.

METHODOLOGY

The proposed risk tool consists of six main components: Map the reverse network, Identification of risks, Map impact of risks, Assess and quantify risk, Assess and quantify loss, Manage risk. The framework to identify, assess, quantify, and manage risk in the reverse supply chain is provided in Figure 1.

The first step to the efficient implementation of this framework is to map the reverse the supply chain network of the organization. A diagrammatical representation of the supply network helps the user understand the process and is beneficial in mapping the flow of all returned materials from one or several locations. Mapping this reverse supply network involves the understanding of key roles and responsibility in the various steps of the network. There are three primary steps in creating an effective and accurate reverse supply network diagram: 1) Identify departments, 2) Identify locations and processes, 3) Map returned material process flow.

After establishing the network and processes of the reverse supply chain, the next step in the process of managing risk is to identify potential risks and the location of each risk. Risks are events that when triggered, cause problems. Hence, risk identification can start with the source of problems, or with the problem itself. The type of risks, location and definition may vary in different organizations. Therefore it is important for each organization to identify the significant risks and locate each risk in order to understand the impact a risk can have on the reverse network as a whole. This process encompasses three primary steps: 1) Identify types of risk, 2) Define each risk, and 3) Identify potential loss.

The largest impact a risk can have is the potential chain reaction of other risks that may follow. This occurs in supply networks for the reason that there are multiple links and processes connecting different locations in the network.

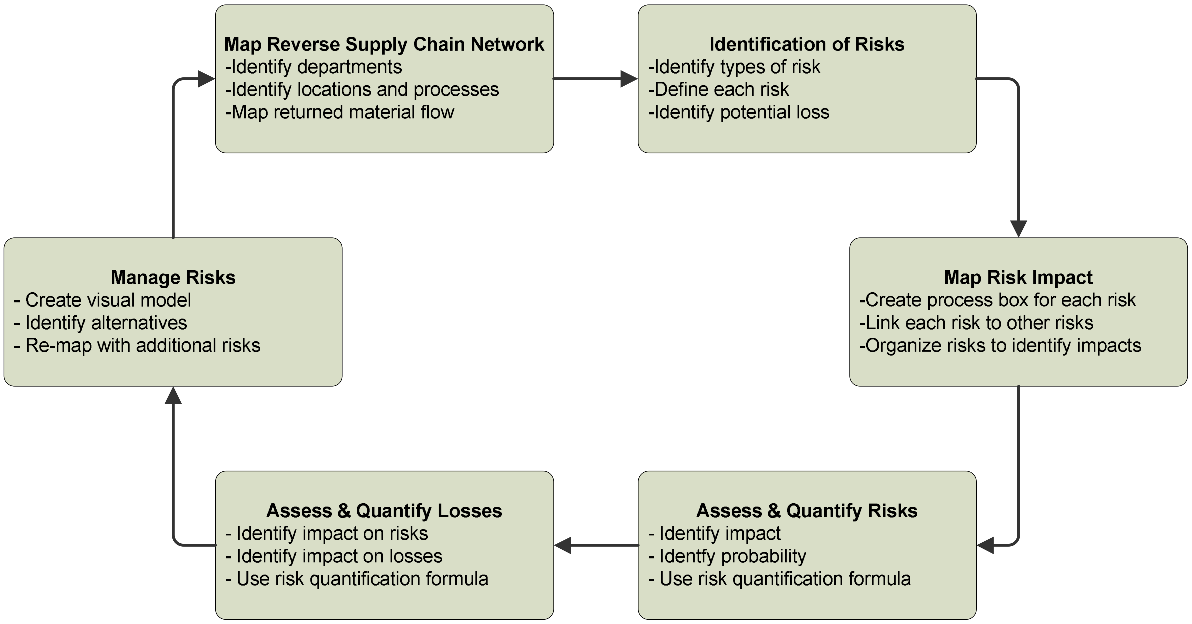


Figure 1: Risk Management Framework

Before assessing risks, the user should create a network diagram of all the risks in the organization, in order to link the affects of each risk. Creating a risk impact diagram of all the risks in the organization allows management to visualize the potential chain reaction of risks. In addition, the risk impact diagram illustrates how an individual risk or event is capable of affecting several other risks. Risks can also be grouped together if they are all in the same location or have similar affects.

Once risks have been identified and located, they must then be assessed as to their potential severity of loss and to the probability of occurrence. The fundamental difficulty in risk assessment is determining the rate of occurrence since statistical information is not available on all kinds of past incidents. Furthermore, evaluating the severity of the risk impact is often quite difficult for immaterial assets. Assuming statistics are not available, best educated opinions are the primary source of information.

A scoring system is proposed in this model to measure impact and probability of risk. Using levels of *High, Medium,* and *Low*, with corresponding scores of 3, 2, and 1, each risk will be given an impact score and a probability score.

Using the given impact score of risk $r(I_r)$, probability score of risk $r(P_r)$, and total risk score (R_r), the following formula is used for risk quantification of individual risk n: $R_r = I_r * P_r$.

Once the individual score of each risk is determined, the next step is to analyze what the company has to lose if a certain risk occurs. Other risks the company may suffer from due to a particular risk occurring needs to be analyzed. The true impact of an individual risk may be determined by incorporating the impact of losses and impact of risks affected in our previous risk quantification formula.

Once risks and losses are analyzed, the corresponding loss must be incorporated to achieve the true impact of each risk. Using levels of *High, Medium,* and *Low*, with corresponding scores of 3, 2 and 1, each loss will be given an impact score.

The total impact of each risk can not be determined unless all other risks affected are incorporated. Using the risk impact diagram, the chain reaction of risks and losses for each specific risk needs to be identified. In order to accurately quantify each risk, a sensitivity analysis was performed on four different possible calculation methods to determine which formulation had the most accurate risk impact score. After thorough analysis, each risk was quantified by multiplying all the correlating risks (I_r) by all the correlating losses (I_l) by the probability of the risk being measured (P_x) in order to achieve the total risk (R_x).

Equation 1: $$R_x = \forall I_r * \forall I_l * P_x$$

In order to validate the formulation, a sensitivity analysis was performed using a different equation quantifying the total risk. The following formula was used in order to analyze the risks and compare the results to equation 1.

Equation 2: $$R_x = \left[\sum_{i=m}^{m} I_{ri} + \sum_{j=n}^{n} I_{lj} \right] * P_x$$

In equation 2, the risk score of risk *x* (R_x) is quantified by adding the sum of the impacts of correlating risks (I_r) and the sum of the impacts of correlating losses (I_l). The number of risks and losses is infinite as represented by *m* and *n*. This value is then multiplied by the probability of risk *x* (P_x) in order to get the total risk score.

In order to validate the scoring system of 3-2-1, a comparative analysis was done using the scoring system of 9-3-1. The purpose of using scores 9-3-1 was to create a significant difference between the *High, Medium*, and *Low* values. Both scoring systems are used in order to compare the significance of the risk in the reverse supply chain.

The general equations developed allow the user to include the variety of risks and losses specific to the reverse network of the company. Once the risks are quantified, comparing the scores of each risk will determine the high impact risks that may concern the company, as well as the low impact risks with minimal consequences resulting from the risk occurrence.

Once the risks are identified and quantified, the process of managing risk begins. In order to manage risks, assessment information is analyzed and alternative interventions are proposed. Depending upon the risk position, scenarios of alternative network structures and relationship strategies can be developed to realign risk, exposure to it, likely losses and location of those losses. The network is managed simply by creating a visual model of all risks, losses, impacts, and drivers. When new risks are established, they can be placed in the model with the chosen redesign of the network and relationships within it. This strategy of managing old risks and new risks is implemented and gives rise to a remapping of the network.

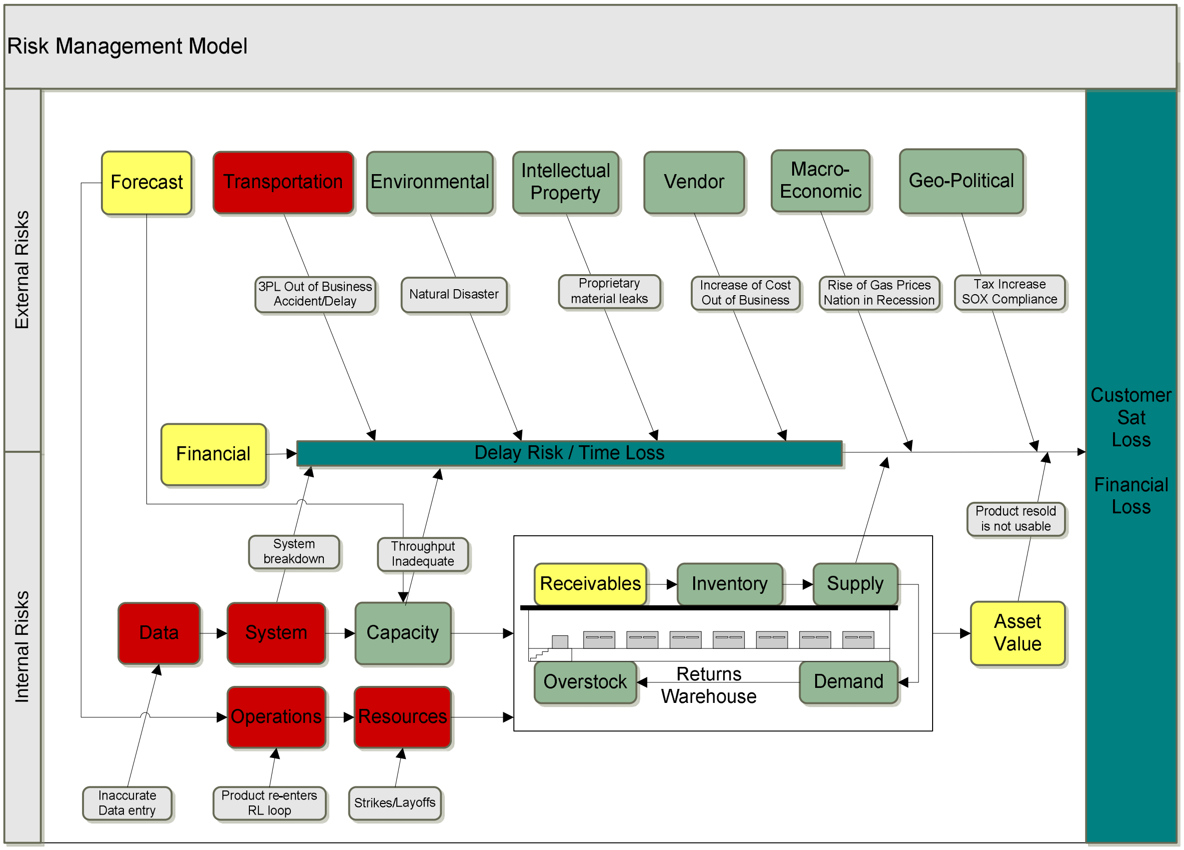
IMPLEMENTATION

The risk management tool developed for the Reverse Logistics group is intended to be reviewed on a daily basis to check risks that may have occurred. The tool will assist in identifying where each risk takes place as well as the cause and effect of each risk.

The first step is to map the reverse supply chain network in order to help the user understand the process flow of all returned materials. A layout of the reverse supply chain for Company ABC is developed. The layout is divided into three segments, each segment representing a department that is involved in the flow of returned materials. This layout will allow management to see who owns what in each department. Within each department are several locations involved in the flow of returned materials. It is important to understand the process at each location to identify who owns what at each location.

The second step involves identifying the risks in the reverse supply chain. The following external risks were identified: environmental, forecast, geo-political, intellectual property, macro-economic, transportation, and vendor. The following internal risks were identified: asset value, capacity, data, demand, financial, inventory, operations, overstock, receivables, resource, system, and supply. After identifying all of the risks, it is important to identify the different losses a company might experience due to the impact of risks. The following losses were identified: customer satisfaction, financial, and time/delay.

The third step involves mapping the impact of risks which requires linking each risk to other risks it may affect. Organizing the risks in hierarchy order and/or by type of risk helps visualize the impact the risk has on the entire network. A layout of risks impacting one another, specifically in the reverse supply chain of Company ABC was developed. As seen in Figure 2, the risks above the center line are external risks, and the risks below the center line are internal risk. The purpose of having Delay Risk in the center is the fact that both internal and external risks may cause delays in the return flow of materials. In addition, the purpose of grouping Receivables, Inventory, Supply, Demand, and Overstock together is for the reason that all five risks take place within the warehouse, and more often than not will somehow affect one other, creating a chain reaction.



Risk Score 1-30 **Risk Score 31-60** **Risk Score 61 +** **Loss**

Figure 2: Risk Management Model

The fourth step is assessing the risks identified earlier. Using the 3-2-1 scoring system with levels of *High, Medium,* and *Low*, each risk was assessed and given an impact score and a probability score. After assessing each risk, the risk was quantified using Equation 1.

The fifth step takes into account the effect of each risk, including the loss and the chain reaction of other risks taking place due to the initial risk. Using the 3-2-1 scoring system with levels of *High, Medium,* and *Low*, each loss was assessed and given an impact score based. After assessing all of the risks, the impact of each risk, and the loss generated by each risk, the true impact of each risk *x* was quantified using Equation 2.

Using the Risk Impact diagram created earlier the affect of each risk was identified and incorporated in the risk quantification equation. The score of each risk is directly correlated with the effect of each risk. The scores of the risks can be compared, the higher the score, the greater the effect the risk has on the entire network. By using the risk tool, we were able to quantify each risk in the reverse supply chain.

In order to compare results, a sensitivity analysis was done comparing Equation 1 and Equation 2. In addition, both formulations were analyzed using two different scoring systems, 3-2-1 and 9-3-1. Therefore, four separate analysis were conducted. It is reasonable to say that the significance of each risk differs applying each equation. When analyzing the risks, Equation 2 showed to be more effective, creating significant differences between the risks. However, by comparing the results of both scoring systems in the implementation, there was not a significant difference in the ranking of the scores. Therefore scoring system of 3-2-1 was continued to be used.

The final step is to create a visual model to help management view all risks, losses, and impacts in the reverse network. Each risk correlates with a color based on the score it received.

CONCLUSION

The framework proposed will assist the user such that they have the ability to identify, quantify, and manage risks in the reverse supply chain, without previous risk management experience. By analyzing several formulation methods, the concluding method of multiplying the risks affected by the losses affected will identify the significance of each risk.

The proposed risk management tool uses existing principles of risk management in supply chain; however, it is unique because the characteristics of the new tool are solely developed for the reverse supply chain. The tool allows the user to quantify and locate all risks in the reverse network at the time of risk occurrence. These features allow the user to achieve the overlying goal of managing risks and developing alternatives quickly and efficiently in the least amount of time. Since the tool may be used for different organizations, many different factors effect the identification and quantification of risks that lie in the reverse network of the organization. Therefore, the effectiveness of this tool will vary among different companies.

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REVERSE LOGISTICS PERFORMANCE IN THE THAI AUTOMOTIVE INDUSTRY

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ABSTRACT

Purpose of the paper
This paper attempts to explore the factors that influence the reverse logistics performance. Supply chain integration is proposed as the key influencing construct of the reverse logistics performance model.

Design/ Approach / Methodology
A questionnaire survey was conducted. First-tier suppliers of the major car manufacturing firms in Thailand were targeted. The total of 234 sets of data was gathered. Structural equation modelling was utilised to analyse the data empirically.

Findings
External and internal integration as well as supply chain orientation were found to significantly influence reverse logistics performance. Information system support and resource commitment can influence reverse logistics performance indirectly. Supply chain orientation, information system support, and resource commitment lead a firm to initiate and develop external and internal supply chain integration.

Research limitations/implications
Scope of reverse logistics in this study focused only on product returns caused by certain reasons such as defective product and faulty order processing. Other reasons for returning products were excluded. Also, this research was done in a single industry context so the generalizability of the findings to other industries may be questionable. Researches in other context may be done to expand the external validity of the model.

Practical implications
To improve performance of reverse logistics process, a firm must focus on both external integration and internal integration simultaneously. External integration should be done on both supplier and customer sides to guarantee that the reverse logistics operation will run smoothly throughout the supply chain.

Originality/value of paper
This study is probably one of the first attempts to investigate the effect of supply chain integration on reverse logistics performance. A structural relationship among key constructs was developed based on the arcs of integration concept proposed by Frohlich and Westbrook (2001) in the context of reverse logistics.

Keywords: Reverse logistics, Performance measurement, Supply chain collaboration, Internal & external integration

PAPER TYPE: RESEARCH PAPER

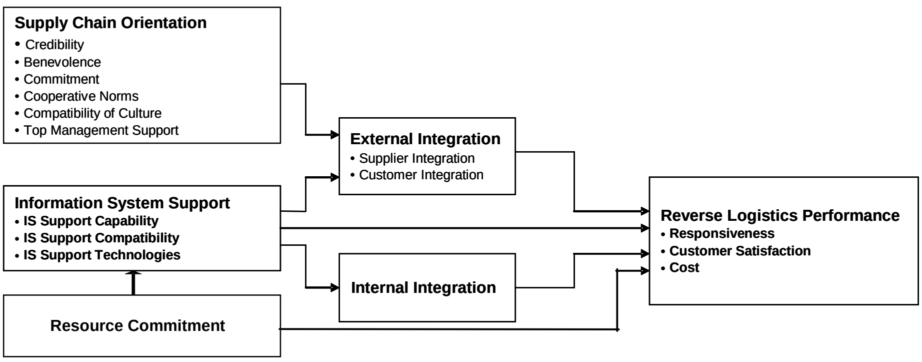
INTRODUCTION

Although reverse logistics has been a neglected part of supply chain management, it could facilitate some important contributions for business. A well managed reverse logistics practice may result in savings in inventory carrying, transportation, and waste disposal costs as well as improving customer service (Daugherty et al. 2001). The reverse logistics field has received somewhat more attention in recent years but the number of related studies is still very limited to a small set of constructs. The constructs that are frequently mentioned as influencing factors of reverse logistics performance are about industry, firm size, assignment of responsibility (Autry et al. 2001), resource commitment, information system support, relationship commitment (Daugherty et al. 2002), timing and resource, resource commitment, and innovation (Richey et al. 2005). It can be seen that the study of factors influencing the performance of reverse logistics is still at an early stage and with non-conclusive results. There is a need to explore more factors that are related to reverse logistics performance as well as to investigate some of the previously studied factors that still have non-conclusive statistical relationships with reverse logistics performance. Supply chain integration is considered an important construct in the logistics and supply chain area, but, surprisingly, it has been overlooked in the study of reverse logistics performance. Thus, this research attempts to develop a better understanding of reverse logistics process by investigating the relationship between supply chain integration and reverse logistics performance as well as other related factors.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Reverse logistics processes normally involve interactions and cooperation among several parties in the supply chain (Autry et al. 2001). The boundary of reverse logistics has expanded beyond a single firm to cover the whole reverse-logistics channel. Thus, several supply chain members should be involved (Dowlatshahi 2000). Pohlen and Farris (1992) suggested that greater coordination and better communication between supply chain members are needed to improve the flexibility of reverse logistics systems. Their study illustrated that supply chain integration, consisting of external integration and internal integration also had a potential to affect the performance of the reverse logistics program by improving cooperation and information sharing between supply chain members. As mentioned in the previous researches, information system support and resource commitment are another key factors that could provide some impacts on reverse logistics performance. Thus, both factors together with external integration, internal integration, and supply chain orientation were added into the research framework. The conceptual framework presented in Figure 1 illustrates the relationships among all key constructs.

FIGURE 1: CONCEPTUAL MODEL OF REVERSE LOGISTICS PERFORMANCE



Several authors mentioned that supply chain integration especially external integration among supply chain members allows synchronization of the core competencies to jointly improve service capabilities with lower total supply chain cost by reducing operational waste and redundancies (Gimenez and Ventura 2005; Rodrigues et al. 2004; Stank et al.

2001a). Successful integration should therefore result in efficient logistics operations and significant performance improvement (Boyer et al. 2003). Since reverse logistics is a part of the logistics process, it can be expected that such integration also enables efficient reverse logistic operations which would lead to cost reductions, increasing production efficiency and higher productivity (Gustin et al. 1995) as well as reductions in inventory, shorter lead times, customer service enhancements, and improved forecasting and scheduling (Muller 1991). Such improvement partly comes from the effective and efficient reverse logistics operations. Thus, it can be proposed that

H1: External integration i.e. a) supplier integration and b) customer integration are positively related to reverse logistics performance.

Besides that, internal integration among functional areas within the firm such as purchasing, production, scheduling, distribution, and sales is also associated with better inventory management and higher level of logistics performance (Gimenez and Ventura 2005; Stank et al. 2001b). In the reverse logistics context, better internal information sharing and communication lead to the reduction of inventories due to better forecasting and planning of reverse flows. Integration between reverse logistics process and production can reduce the stock level while avoiding spare part stock-outs, which is a main problem of long lead-time for repair services. High level of responsiveness and short cycle time leads to better customer satisfaction and better reverse logistics performance. From the reasons above, it is proposed that:

H2: Internal integration is positively related to reverse logistics performance.

Moreover, to successfully integrate within and across organisations, the factors facilitating and promoting effective communication and information exchange could not be overlooked. Information exchange has been recognized as a key logistics capability that enables improved firm performance (Bharadwaj 2000; Bowersox et al. 1999; Kearns and Lederer 2003). Information system provides an opportunity for companies to lower costs dramatically across the supply chain and to enhance their quality of services (Edward et al. 2001; Stank and Lackey 1997). In addition, high quality information system can lead to more efficiency and effectiveness of the supply chain by minimizing cycle time, identifying optimal inventory levels, reducing warehouse space, and increasing inventory turnover (Narasimhan and Kim 2001). Integrated information systems would not only enhance logistics performance, but also eventually enhance the company's competitiveness and position it for future growth (Goldhar and Lei 1991; Kathuria et al. 1999). Information system allows customers to experience shorter lead time to get return authorization or credit approval as well as continuously available returns information. This will boost up customer satisfaction with the service of a firm. Thus, the relationship between information system support and reverse logistics performance can be proposed as following.

H3: Information system support is positively related to reverse logistics performance.

Information system support not only influence logistics and reverse logistics performance but also acts as a part of the infrastructure supporting the integration of the extended enterprise. Information system support is the most important ingredient for supply chain integration that significantly improves the extent of internal and external information sharing (Daugherty et al. 1996; Edward et al. 2001). Moreover, it also supports the strategic linkages and increases coordination among supply chain partners (Sanders and Premus 2005;). The literature also suggested that the utilization of effective information technologies which give information capabilities and information compatibilities among supply chain members is expected to enhance the level of supply chain integration (Narasimhan and Kim 2001; Sander and Premus 2005). Thus, it can be proposed that:

H4: Information system support is positively related to external integration i.e. a) supplier integration; and b) customer integration.

H5: Information system support is positively related to internal integration.

Apart from information support system, reverse logistics, as with most business operations, requires a wide range of resources ranging from personnel to technology-related resources. Resources are necessary for a reverse logistics program (Richey et al. 2005). Reverse logistics program would not be successful without sufficient resources to the implementation of the program (Tibben-Lembke 2002). Lack of commitment in several types of resources may cause a poor reverse logistics performance (Daugherty et al. 2001; Richey et al. 2004; Tibben-Lembke 2002). Thus, a commitment in resources is required in order to overcome the early challenges and to implement a successful reverse logistics program which would lead to high reverse logistics performance (Richey et al. 2004). Moreover, the relationship between resource commitment and information system support should also be considered. To get information system support in place, a firm must invest in the procurement and implementation of such system. Thus, a firm that lacks resource commitment would not be able to implement an information system nor having an access to it. Therefore, two related hypotheses can be proposed as:

H6: Resource commitment is positively related to reverse logistics performance.

H7: Resource commitment is positively related to information system support.

Another important construct that should not be disregarded is supply chain orientation since it is closely related to the coordination and integration of business processes. A firm with supply chain orientation would focus on the activities beyond the regulations of the firm to attain the smooth flows of information and goods throughout the supply chain. Supply chain orientation would lead a firm to practice supply chain management, characterized as the integration of key business processes across the network of organizations from end user through original suppliers (Lambert 2004; Min and Mentzer 2004). The higher the level of supply chain orientation, the greater the level of integration of key business processes across the supply chain (Stank et al. 2005). Therefore, it is proposed that:

H8: Supply chain orientation is positively related to external integration i.e. a) supplier integration; and b) customer integration.

RESEARCH METHODOLOGY

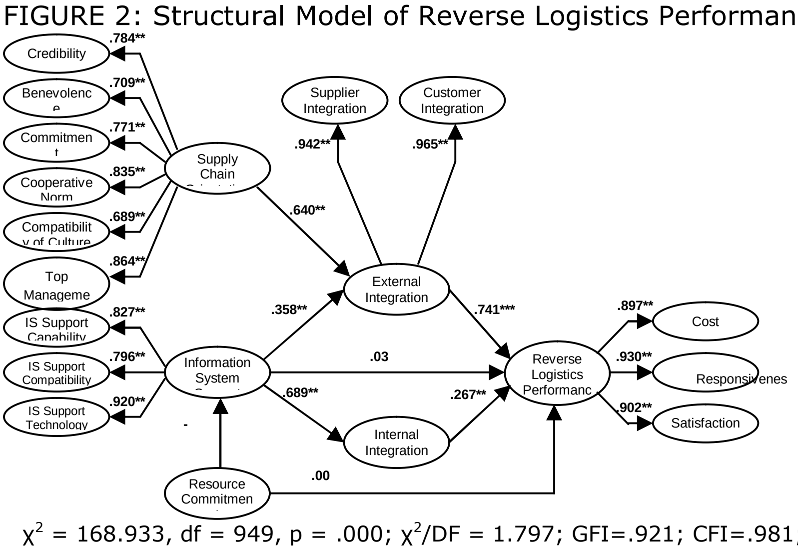
A survey was conducted to obtain empirical data. The Thai automotive industry was selected as a context of this study because a large part of distribution operations of companies in the automotive industry focuses on handling returns (Richey et al. 2005). Their day-to-day operations include the reclamation of used parts/products as well as returns of damaged product, overstocks, incorrect shipments, etc. These companies retrieve the items for re-manufacturing and/or refurbishing in preparation for re-sale (Frohlich and Westbrook 2001; Lemke et al. 2002). Therefore, the supply chain integration, information sharing and reverse logistics system are expected to exist. Thus, Thai automotive industry is suitable for the current study. A group of first-tier supplier firms that supply auto-parts, or automotive components, directly to car assemblers was selected as a target population. Managers and authorized persons who are responsible for logistics and supply chain tasks were targeted as the key respondents of the survey. The sampling frame was composed by consolidating the name lists from four sources, which are The Federation of Thai Industries (FTI), Thailand Automotive Institute (TAI), Thai Auto-Parts Manufacturers Association (TAPMA), and Thai Automotive Industry Association (TAIA). The consolidation resulted in a name list of 508 first-tier supplier firms. This sampling frame was further used for data collection. A questionnaire comprising five major sections was developed and used as a major data collection tool. In the first part, twenty items were modified from Min and Mentzer (2004) to measure six dimensions of supply chain orientation i.e. credibility, benevolence, commitment, cooperative norm, compatibility, and management support. Second, thirteen items were adapted from Daugherty et al. (2002), Closs and Savfitskie (2003), Sander and Premus (2005) to measure three dimensions of information system support i.e. IS support capability, compatibility, and technology. Third, 29 items measuring internal and external integration in both supplier and customer integration were developed from Closs and Savitskie (2003), Rodrigues et al. (2004), Sander and Premus (2005), Stank et al. (2001b), Stank and Lackey (1997). Next, three items measuring resource commitment were modified from Richey et al. (2004;2005). Finally, three dimensions of reverse logistics performance i.e. cost performance, responsiveness, and customer satisfaction were developed based on the studies of Autry et al.(2001), Daugherty et al. (2002), Rodrigues et al. (2004), Sander and Premus (2005). Six Likert scale anchoring 1 (strongly disagree) to 6 (strongly agree) were assigned to all measurement items.

A pre-test was conducted to ensure the interpretability of the measurement items. A total of 48 responses were collected and used as pre-testing data. The data was analysed by utilizing item-to-total correlation, Cronbach's alpha coefficient as well as the exploratory factor analysis. Satisfactory level of item reliability was obtained. The alpha coefficients of all constructs vary from 0.713 to 0.926 which exceed the minimum threshold value of 0.7 as recommended by Nunnally (1978). The result of exploratory factor analysis was also satisfactory. Most of the measurement items were loaded in corresponding components that are consistent with what were proposed. However, two measurement items were deleted to purify the scale since the factor loading of one item was significantly loaded in a wrong component and another item had low item-to-total correlation. A confirmatory factor analysis (CFA) was performed in the next step to examine the validity of scales and the appropriateness of their uses in a structural equation model and to confirm that the indicators sort themselves into factors corresponding to how the researcher has linked the indicators to the latent variables. The results suggested that the construct validity exists for all the proposed constructs. No more modifications were done in this step.

DATA ANALYSIS AND FINDINGS

An in-person drop-off delivery survey was applied to collect the data as suggested by Cooper and Emory (1995). A total of 234 completed questionnaires were returned which yields a response rate of 46.06 per cent. After assessing the non-response bias, two structural equation models (SEM) using AMOS 16 were developed to test all hypotheses. The first structural model was constructed based on the proposed model and main hypotheses. The good fit of the data was illustrated ($\chi 2/DF = 1.797$, GFI=.921; CFI=.981; NFI=.958; RMSEA = .058) as shown in Figure 2.

FIGURE 2: Structural Model of Reverse Logistics Performance (MODEL 1)



$\chi^2 = 168.933$, df = 949, p = .000; $\chi^2/DF = 1.797$; GFI=.921; CFI=.981; NFI=.958; RMSEA = .058;*** p<.001

The parameter estimates showing the structural relationships among constructs in the model are summarised in Table 1.

TABLE 1: Parameter Estimates and Test of Significance (MODEL 1)

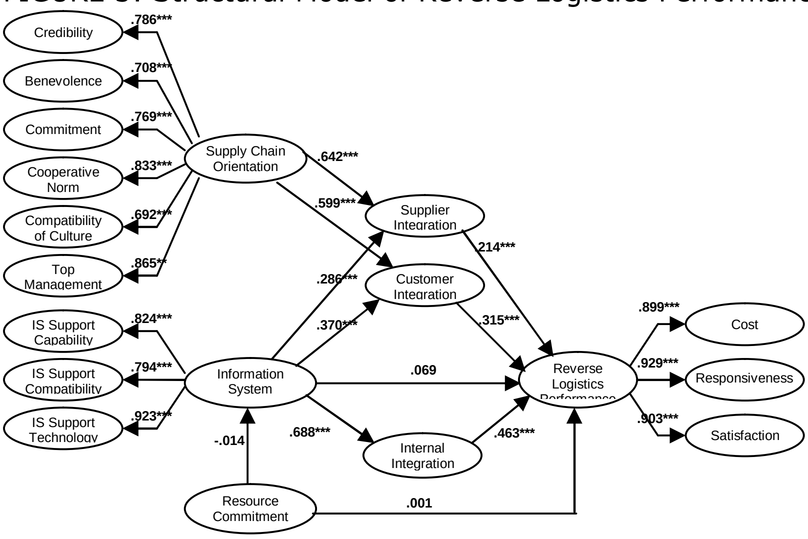
Hypothesis	Structural Relationships between		Regression Weight	Results
H1	External Integration →	Reverse Logistics Performance	.713 (.741)***	Supported
H2	Internal Integration →	Reverse Logistics Performance	.248 (.267)***	Supported
H3	Information Support System →	Reverse Logistics Performance	.029 (.032)	Not Supported
H4	Information Support System →	External Integration	.347 (.358)***	Supported
H5	Information Support System →	Internal Integration	.690 (.689)***	Supported
H6	Resource Commitment →	Reverse Logistics Performance	.006 (.006)	Not Supported
H7	Resource Commitment →	Information Support System	-.011 (-.012)	Not Supported
H8	Supply Chain Orientation →	External Integration	.694 (.640)***	Supported

Remarks: Figures shown in each cell indicate the unstandardised coefficients.
Figures in the brackets indicate the standardised coefficients.
*Parameters are significant at * p<.05; ** p<.01; *** p<.001.*

Although the result indicated that the model had a good fit, it can be seen that not all of the proposed relationships were significant. The relationships between information system support and reverse logistics performance, between resource commitment and reverse logistics performance, and between resource commitment and information system support were found to be not statistically significant. Thus, while H1, H2, H4, H5, and H8 were supported, H3, H6, and H7 were not supported by the data.

While the first structural model can test all the main hypotheses, sub-hypotheses copuld not be tested. Thus, the second structural equation model was developed and analyzed. The results of the model fitting indicated that the model 2 fitted relatively well ($\chi 2/DF$ = 1.89; GFI=.921; CFI=.979; NFI=.957; RMSEA = .062) even when the external integration construct was replaced by its two dimensions, i.e. supplier integration and customer integration. The details of the model 2 are presented in Figure 3.

FIGURE 3: Structural Model of Reverse Logistics Performance (MODEL 2)



$\chi 2$ = 171.87, df = 91, p = .000; $\chi 2$/DF = 1.89; GFI=.921; CFI=.979; NFI=.957; RMSEA = .062; *** $p<.001$

In order to summarize the relationships among constructs in this model, the parameter estimates and test of significance are shown in Table 2.

Based on the structural equation modelling analysis of the model 2, it was found that all the proposed sub-hypotheses were supported by the data. Consistent results were obtained for H3, H3, H5, H6, and H7.

TABLE 2: Parameter Estimates and Test of Significance (MODEL 2)

Hypotheses	Structural Relationships between			Regression Weight	Result
H1a	Supplier Integration	›	Reverse Logistics Performance	.195 (.214)***	Supported
H1b	Customer Integration	›	Reverse Logistics Performance	.293 (.315)***	Supported
H2	Internal Integration	›	Reverse Logistics Performance	.431 (.463)***	Supported
H3	Information System Support	›	Reverse Logistics Performance	.065 (.069)	Not Supported
H4a	Information Support System	›	Supplier Integration	.294 (.286)***	Supported
H4b	Information System Support	›	Customer Integration	.373 (.370)***	Supported
H5	Information System Support	›	Internal Integration	.692 (.688)***	Supported
H6	Resource Commitment	›	Reverse Logistics Performance	.001 (.001)	Not Supported
H7	Resource Commitment	›	Information System Support	-.013 (-.014)	Not Supported
H8a	Supply Chain Orientation	›	Supplier Integration	.735 (.642)***	Supported
H8b	Supply Chain Orientation	›	Customer Integration	.671 (.599)***	Supported

*Remarks: Figures shown in each cell indicate the unstandardised coefficients; Figures in the brackets indicate the standardised coefficients. ***Parameters are significant at p<.001.*

DISCUSSION AND CONCLUSIONS

The results from both models illustrated that supply chain orientation directly influenced the level of external integration of a firm while the level of external integration can also be influenced by information system support and resource commitment, supply chain orientation is mandatory for the initiation of external integration. Firms without supply chain orientation may not be able to create coordination of business processes and flows with those of other members of the supply chain since these activities require more than just a system to support the operations or a commitment in several kinds of resources. In addition, the results suggested an indirect effect of supply chain orientation on reverse logistic performance which was mediated by external integration. Supply chain orientation leads a firm to initiate external integration with its suppliers and customers which, in turn, enhances reverse logistics performance. The finding also suggested that information system support can significantly influence the level of external integration and internal integration. With more information sharing and cooperation among supply chain partners and among departments inside a firm, the performance of reverse logistics can then be improved. However, in order to generate such performance improvement, the investment in information system support capability, compatibility, and technologies must be done in the way that can enhance the extent of external integration and internal integration of a firm. Although the result suggested that there was no direct relationship between resource commitment and reverse logistics performance, it was found that resources committed to logistics operation would lead to higher level of external and internal integration. With such integrations, the performance of reverse logistics can be enhanced. Thus, resource commitment is also considered important and necessary for a successful implementation of reverse logistics program.

Consistent with the literature, the findings suggested that there was a significant positive relationship between external integration and reverse logistics performance and between internal integration and reverse logistics performance. Effective cooperation and coordination among supply chain partners and internal departments would ensure a responsive reverse logistics system. Without proper integration, it would be more difficult to effectively manage product returns. Both external integration and internal integration must be performed simultaneously in order to smooth out the reverse logistics process. A lack of either internal integration or external integration in a supply chain would create a bottle neck which affects a performance of reverse logistics process. For external integration, this study revealed that it is necessary that a firm pay attention to both supplier integration and customer integration since both supplier integration and customer integration are important to superior reverse logistics performance. Furthermore, the result of this study also suggested that internal integration is an important antecedent for external integration, which is consistent with the stages of supply chain integration proposed by Steven (1989).

THEORETICAL CONTRIBUTIONS

This study is probably one of the first attempts to investigate the effect of supply chain integration on reverse logistics performance. While the concept of supply chain integration is not new, it had never been studied in relation to reverse logistics performance before. Thus, this study is considered a successful attempt to fill this gap in the literature. This current study can be considered an application of the arcs of integration concept proposed by frohlich and westbrook (2001) in the context of reverse logistics. Frohlich and westbrook (2001) empirically investigated the relationship between the degree of supply chain integration and operational performance. The finding suggested that an outward-facing supply chain focus is associated with higher performance than strategies biased toward either suppliers or customers. The current study also considered external integration as supplier integration and customer integration independently, but in the specific context of reverse logistics performance rather than operational performance of a firm. The result was in the same direction as what was previously suggested. Both supplier integration and customer integration was found to directly influence reverse logistics performance. It can be interpreted that both supplier integration and customer integration are required to enhance the performance of reverse logistics process while having only supplier integration or customer integration would lead to inferior reverse logistics system.

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SECTION 13 – Distribution and Third/Fourth Party Logistics

LOGISTICS CITIES: A SPATIAL REQUIREMENT FRAMEWORK

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ABSTRACT
This paper focuses on issues surrounding the spatial requirements of a Logistics City, and the contributing investigation, in cooperation with various planning authorities in Melbourne, has been conducted on characteristics and attributes related to this concept. The spatial requirements identified here are segregated into four different layers as a framework which will contribute to the understanding of the behavioural patterns of spatial factors related to a Logistics City. This will enhance the ability of development authorities to support the planning and introduction of a holistic Logistics City and has the potential to improve the quality and effectiveness of these systems in a growing regional economy.

Keywords: Logistics City, Logistics Spatial Requirements, Logistics Cluster, Spatial Framework

INTRODUCTION

A Logistics City is a geographical concentration that is associated with a global trade gateway, contains multiple of logistics nuclei such as freight terminals, freight hubs or logistics villages and has embedded city constructs. Within the context of the logistics sector these geographical areas incorporate a critical amount of related infrastructure in addition to logistics services and supporting activities at international, regional and local functions. The Logistics City is seen as a strategy that addresses well-structured and relevant solutions to the longer term sustainability of a region in the global trading arena (Sengpiehl et al., 2008a; ILSCM, 2007).

Historically, logistics activities were concentrated around trade gateways such as international ports; but logistics activities are now tending to spread and agglomerate along existing trade corridors, especially higher value added logistics and associated activities. This development has occurred because of optimisation of transport function to markets and land scarcity within, and in close proximity to, trade gateways (Sengpiehl et al. 2008b; Van der Lugt and de Langen 2005; Abrahamsson et al. 2003). Therefore, fixing a geographical boundary for a Logistics City can be challenging. For most Logistics Cities, particularly where freight activities are widely dispersed, boundaries will necessarily include larger surrounding historical areas, in which appropriate logistics and supporting activities, such as education and knowledge centres, central business districts and residential zones, are embedded. Nevertheless, the logistics nuclei of a Logistics City can be geographical bounded, and this has a vital role for activities related to specific logistics planning zones and their related buffer areas. Whist clear boundaries should not be over-emphasised at the Logistics City level, benefits arise if the activities of stakeholders are aligned, thus the role of planning and governance in spatial planning becomes paramount (figure 1).

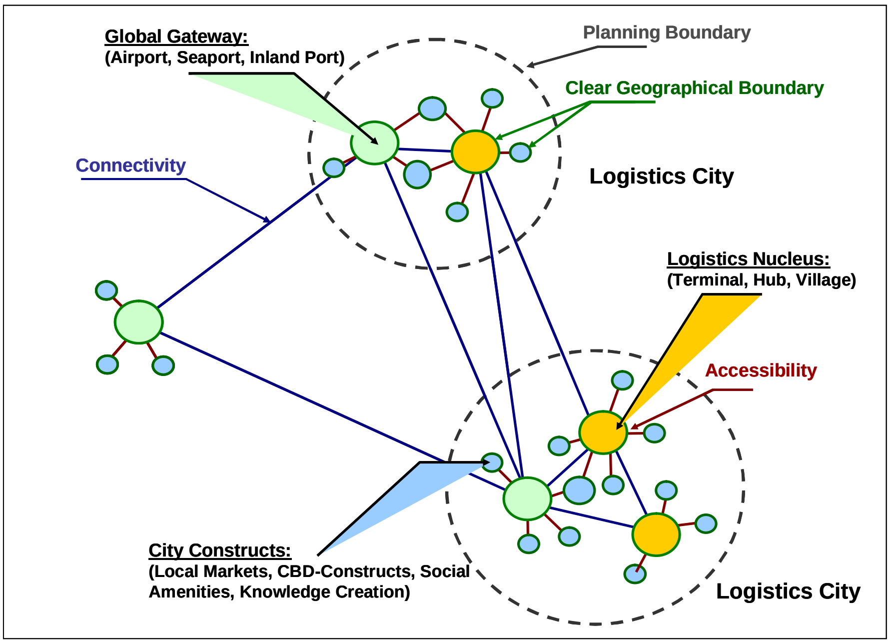

Figure 1: Physical and Planning Boundaries

The lack of a clear understanding for core spatial characteristics and attributes that link to the specific use of a Logistics City and its components creates challenges for authorities in the orderly planning and development of a Logistics City. Planning authorities need to conduct gap identification analysis at the spatial level in existing logistics concentrated areas to generate an indicative layout plan and identify possible future actions that need to be undertaken, such as attracting missing logistics activities or learning and knowledge hubs. Also, 'Greenfield sites' need to be assessed for possible logistics nuclei and therefore to identify existing locations within the planning boundaries of authorities that could favour logistics facilities or related city constructs based on spatial characteristics and attributes. Clearly, the growing importance of logistics and its attendant challenges request the development of an innovative spatial requirement framework (Parliament of Victoria 2008; Premier of Victoria Brumby, J. 2008; LeadWest 2008). The objective of this paper, therefore, is to report our spatial requirement framework, developed in cooperation with local and state planning authorities related to greater metropolitan area of Melbourne, and links spatial characteristics and attributes with the needs of a future Logistics City.

RESEARCH DESIGN

The notion of a Logistics City is an emerging concept, and is being developed in response to specific contexts, experiences and economic needs of practitioners. This constructed nature of the Logistics City, and its relation to spatial determinants, suggest that a constructivist theory of knowledge is appropriate as the epistemological position for the investigation. A constructivist perspective emphasises that the source of knowledge lies with the actors that are most intimately involved with the concept under review, and the methodology, further the method for data collection and analysis, chosen for the investigation must be consistent with this perspective (Fenner et al. 2005; Crotty, 1998). There are several methodologies consistent with the tenets of constructivist epistemology (Hussey and Hussey, 1997), and the controlled environment of planning and developing authorities and the attended change made 'Action Research', of all available choices the most applicable methodology.

Qualitative methods for data collection and analysis have been chosen as the most appropriate approaches for this investigation, and consequently 'Focus Group' data collection method combined with individual 'Interviews', both semi-structured and in later stages structured, were applied. This allowed us to collect data from the perceptions of relevant stakeholders that are involved in the environment of the possible future application. We have followed a general analytical procedure for dealing with qualitative data (Miles and Huberman, 1994) allowing us to become familiar with the data by developing data summaries and reconstructing the data using analytical matrices.

SPATIAL REQUIREMENT FRAMEWORK

Figure , this study identified four different layers relevant to the development of a Logistics City, and the description given below both justifies the importance we place on spatial attributes and assists in the gathering of appropriate data for spatial decision-making by planning authorities.

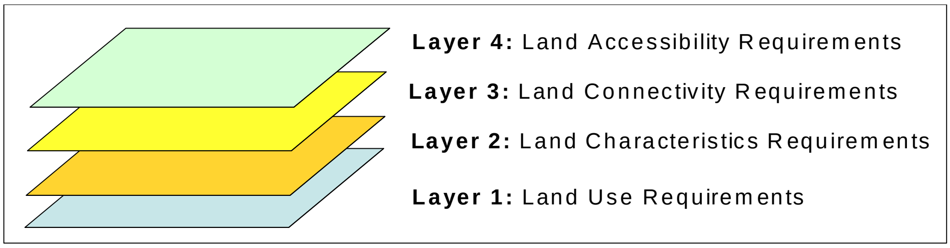

Figure 2: Layers of Spatial Requirement Framework for Logistics City

Land Use Requirements

The "Land Use Requirements" layer is related to the specific land use of the logistics nuclei of a Logistics City and does not take any city constructs into consideration. As the progression of logistics nuclei develop, the "Land Use Requirements" changes from ~30ha (freight terminal), ~80ha (freight hub) to ~130ha (logistics village). This layer is subdivided into four different categories that represent main land use activities which are key operational functions in compliance with services and infrastructure. These four categories can be applied to the gap identification at the spatial level for existing logistics-concentrated areas and generating an indicative layout plan, and can be deployed as checklists for possible Greenfield sites, enabling appropriate development of the identified land. The four categories are (i) Area for Freight Transhipment Activities, (ii) Area for Storage and Handling of Freight, (iii) Area for Professional Business Services, and (iv) Area for Technology Activities related to Logistics.

Concentration of freight related activities, beside transhipment activities, can be subsumed under the umbrella of freight storage and handling. A freight terminal does not have the single purpose of international freight consolidation or deconsolidation, and therefore does not necessarily require warehouses and empty container yards. In this respect, storage and freight handling areas only apply to higher progressions other than at the terminal level. Some higher value-adding logistics activities such as light assembly can be integrated in this category if executed in warehouses, but if these are located in other facilities that need a specific area, they fall into the "Area for Professional Business Activities'.

Professional businesses, though of secondary nature in a Logistics City, are intimately related to the value-adding functions performed by the core logistics services and should be located in close proximity. These activities include maintenance organisations, recruitment agencies, restaurants, hotels, cafes, consultancy companies, marketing organisations, as well as banking, finance and insurance-related industries. Most of these activities are related to the later progressions and do not need to be considered within the spatial planning at freight terminals or freight hubs level. However, technology activities that are linked to the logistics sector also need to be considered. These activities, like the professional business activities, have specific spatial conditions for efficient co-operation with the traditional logistics activities, and their activities are demanded by the traditional logistics activities as well as by professional business activities. These four categories of the "Land Use Requirement" layer are summarised in Table 1.

Land Characteristic Requirements
To achieve a comprehensive understanding of possible investment costs and required time, land characteristics for the development of the logistics nuclei must be considered. It is important to note that these "Land Characteristic Requirements" are mainly linked to the geographical bounded logistics nuclei but can be easily translated to any other site that is related to geographical bounded city constructs. This layer is subdivided into three sections: (i) Ownership and Land, (ii) Zoning, and (iii) Additional Land Conditions.

The first consideration is the ownership of the possible area and surrounds for further expansion, since planning should allow handling capacity of future mid and long term projections of freight volume and logistics facilities development. This will involve investigations of the current ownership of the expansion area and will clarify related costs and ease of land acquisition.

Knowledge of existing urban zoning will play an important role in any planned expansion since locating logistics activities will critically depend upon zoning regulation. If current regulations impede the establishment of logistics activities, a revision of the existing zoning might be required because any land adjoining the nucleus terminal or hub must allow for future expansion. In addition, land use controls around the precinct of the public access terminal or hub should provide for compatible use so that the capacity of the terminal or hub is not impaired. Land conditions of potential sites should also be checked to pinpoint environmental and geological constraints. Emission of particulate matter may be a consideration, and action may be needed to lower the constraints or to clean the process. Contamination issues should also be considered, since these might lead to high decontamination cost and reclamation time. Further the availability of infrastructure such as electricity, gas, water, broadband, sewage and drainage will allow savings in terms of set-up investment capital. Table 2 summarises the "Land Characteristics Requirement" layer.

Table 1 "Land Use Requirement"

Land Use Requirement		Freight Terminal	Freight Hub	Logistics Village
Area for Freight Transhipment Activities				
Platforms	**Platform for loading and unloading containers to and from trucks**	√	√	√
	Platform for loading and unloading containers to and from trains	√	√	√
	Platform for handling break-bulk cargo	√	√	√
Area for Storage and Handling of Freight and Buffer Zones				
Storage	**container yard for temporary storage**	√	√	√
	empty container yard for consolidation purposes	N/A	√	√
	break-bulk storage area	√	√	√
	bonded storage area	√	√	√
	dangerous goods storage area	√	√	√
	parking zones for trucks	N/A	√	√
	areas for warehousing	N/A	√	√
Handling	**area supporting customs administration, duty / tariff payment processing**	√	√	√
	area supporting quarantine and inspection	√	√	√
	buffer zones	√	√	√
	areas for freight pooling and consolidation / deconsolidation	N/A	√	√

Area for Professional Business Activities				
Offices	export / import agents	N/A	N/A	√
	recruitment agencies	N/A	N/A	√
	logistics consultancy	N/A	N/A	√
	logistics service provider	N/A	N/A	√
	logistics insurance	N/A	N/A	√
	simple commercial banking facilities	N/A	N/A	√
	post office facilities	N/A	N/A	√
Industrial	container maintenance, fumigation and cleanup	N/A	√	√
	areas for light assembling / customizing / quality control *(if not included in warehousing)*	N/A	N/A	√
Amenities	petrol station including washing facilities	N/A	√	√
	restaurants / cafes	N/A	√	√
	motel / hotel	N/A	N/A	√
	parking lots (other than for trucks)	√	√	√
	fresh-up amenities	√	√	√
Area for Technology Activities related to Logistics				
IT / Engineering	IT facilities	N/A	N/A	√
	engineering facilities	N/A	N/A	√
Library & Exhibition	information clearinghouse / library for logistics / business / IT and trade related publications	N/A	N/A	√
	exhibition facilities	N/A	N/A	√

Land Connectivity Requirements

In our model, two categories of connectivity have been introduced; Physical connectivity, (enabled through transport infrastructure), and Information connectivity, (enabled through Information and Communication Technology) (Toh et al., 2008). Whilst connectivity requirements are defined as the physical transport linkage between the logistics nuclei and trade gateways, IT-connectivity aims to link all stakeholders in a Logistics City. This, in terms of a physical freight transport network, the layer "Land Connectivity Consideration" is subdivided into three different sections: (i) Connectivity to Gateways, (ii) Intra-Connectivity, and (iii) IT Connectivity.

Table 2 "Land Characteristics Requirement"

Land Characteristic Requirements	
Ownership and Land Acquisition	
Current and Expansion Area	site ownership
	ease of land acquisition if not owned by the government *(time / compulsory acquisition)*
	land price

Zoning	
Current and Expansion Areas	**adequateness of current zoning**
	time and cost of necessary rezoning
Surrounding Areas	**interference with surrounding zoning and land usage**
Additional Land Conditions	
Current and Expansion Areas	**contamination of site**
	time and cost of decontamination
	soil conditions
	square and flat area
	technical licensing requirements and orders
	environmental compliance
	land encumbrances
	gas and water supply / investment cost if not already connected
	electricity supply / investment cost if not already connected
	drainage and sewerage / investment cost if not already connected
	IT infrastructure / investment cost if not already connected

Clearly, efficient movement of goods to and from different regional and international markets requires streamlined physical connectivity, linking to gateways and logistics nuclei via primary and secondary transport infrastructure. Gateways, through which goods move from one territory to another via transportation corridors, are commonly seaport, airports or inland gateways based on rail, road or inland waterway modes. What was the "hinterland" transport corridor for the gateway becomes the primary connectivity transport corridor for other logistics nuclei of a Logistics City, and whilst observations have shown that a Logistics City should provide multimodal transport assets, the final transport modes clearly depend on the geographical and natural factors.

Physical connectivity relates to an enabling component referred to as a freight network, which contains multiples of logistics nuclei as well as associated gateways in a flexible geographical boundary connected by transport infrastructure. The network approach goes beyond what is seen as "typical" single infrastructure planning and it is readily recognised that these systems are significant in themselves and therefore planning for an integrated freight network is a far more complex undertaking. However in terms of the Logistics Cities and its spatial requirements the network approach must be in place to allow an efficient and sustainable freight handling and other logistics supporting activities.

Transport infrastructural excellence on its own does not ensure efficient connectivity. Whilst physical transport infrastructure is clearly a necessity, especially with the creation of a network approach, the physical transport flow has to be complemented by efficient information flow which can only be provided by an appropriately designed information and communication infrastructure. Together, these can lead to a more optimised utilisation of physical transport infrastructure, storage capacity and therefore an increase in productivity of the network. Here the notion of 'ICT infrastructure' is used as a general term to encompass all information technology assets, such as broadband and servers availability, as well as the necessary software that will enable efficient information exchange across the range of stakeholders. These three categories of the "Land Characteristics Requirement" layer are summarised in Table 3.

Table 3 “Land Characteristics Requirement”

Land Connectivity Requirements	
Connectivity to other Gateways	
Seaport	**Freeway and arterial highway connectivity to seaport**
	principal rail connectivity to seaport
	inland waterway connectivity to seaport
Airport	**Freeway and arterial highway connectivity to airport**
	principal rail connectivity to airport
Other Regional Inland Gateways	**Freeway and arterial highway connectivity to other regional or interstate inland gateways**
	principal rail connectivity to other regional or interstate inland gateways
	inland waterway connectivity to other regional or interstate inland gateways
Intra-Connectivity	
Primary and Secondary Intra-Connectivity	**Primary road network that allows efficient inter-connectivity between any of the progressions**
	secondary road network that allows efficient inter-connectivity between any of the progressions
	primary rail network that allows efficient inter-connectivity between any of the progressions
IT-Connectivity	
Physical and virtual IT Infrastructure	**physical IT-Infrastructure**
	virtual information platform

Land Accessibility Requirements

The fourth layer is linked to city constructs and their accessibility by the logistics activities of a Logistics City. This layer is subdivided into three different sections: (i) Accessibility to Markets, (ii) Accessibility to CBD-Constructs and Social Amenities, and (iii) Accessibilities to Knowledge Creation.

Equally important to the connectivity of Logistics Cities is the accessibility to local markets within and around Logistics Cities. Infrastructural systems that provide accessibility to these local markets must be ready to cope with a wide range of goods, since some markets will, for example, require rapid, smooth and hygienic transport. In this respect, one bottleneck will disrupt the entire supply chain quality, therefore the size and quality of the possible local markets must be considered when locating logistics activities, hence logistics nuclei of a Logistics City.

In order to maintain appropriate workforce levels and for attracting Head Office functions, a Logistics City must be socially attractive, having accessible and sophisticated public infrastructure. The need for social amenities and CBD-constructs increases strongly within each step of progression and reaches is peak at the level of the Logistics City. Facilities for urban sustainability such as health care, education and childcare are required as well as parks and sporting areas. These accessibility requirements and the Logistics City have a symbiotic relationship that can be seen as self-sustaining and impart a positive impact on the region. Further, Knowledge generation is an important enabler for a Logistics City for sustainable growth, but while essential knowledge can be acquired through on-the-job experience within the logistics area; there is a growing understanding that appropriate knowledge can be generated by industry research, universities or other research platforms. Specific topics of collaboration related to knowledge generation between the public and private sectors must be clearly addressed, since a logistics supply chain inherits multiple stakeholders and therefore the establishment of specific knowledge generation centres must take place within a Logistics City. The spatial requirements of a Logistics City and all its progressions related to the notion of accessibility are shown in Table 4.

Table 4 "Land Accessibility Requirement"

Land Accessibility Requirements		Freight Terminal	Freight Hub	Logistics Village	Logistics City
Accessibility to Local Markets					
Retail / Wholesale	highway accessibility to local retail/wholesale markets to enable appropriate quantity and trade of goods				
	local road accessibility to local retail/wholesale markets to enable appropriate quantity and trade of goods				
Manu-facturing	highway accessibility to local manufacturing markets to enable appropriate quantity and trade of goods				
	local road accessibility to local manufacturing markets to enable appropriate quantity and trade of goods				
Accessibility to CBD-Constructs					
Leisure	restaurants and hotels	√	√	√	√
	recreation and entertainment *(including places for assembly)*	N/A	N/A	N/A	√
	shopping centres	N/A	N/A	N/A	√
Commerce	government business support services	N/A	√	√	√
	merchant banking	N/A	N/A	N/A	√
	legal services	N/A	N/A	N/A	√
	marketing and public relations services	N/A	N/A	N/A	√
	merchant insurance	N/A	N/A	N/A	√
	Headquarters	N/A	N/A	N/A	√
Accessibility to Social Amenities					
Public Transport	public bus transport	√	√	√	√
	public tram transport	√	√	√	√
	public train transport	N/A	√	√	√
Childcare & Education	vocational training	√	√	√	√
	childcare and kindergarten	N/A	N/A	√	√
	primary and secondary education	N/A	N/A	√	√
	tertiary education	N/A	N/A	√	√
Industrial	residential area *(workforce related)*	N/A	N/A	√	√
	health *(hospital, clinic)*	N/A	N/A	N/A	√
	emergency services *(police, fire brigade)*	√	√	√	√
Accessibility to Knowledge Creation					
Research Platforms	university research	N/A	N/A	N/A	√
	research institutes	N/A	N/A	N/A	√
	other research platforms	N/A	N/A	N/A	√

CONCLUSIONS AND FURTHER RESEARCH

As indicated, all four layers of spatial requirement and their related properties can be used for gap identification in existing logistics concentrated areas where such an analysis can generate an indicative layout plan of the area under investigation. In addition, for Greenfield developments, the framework can be used as a design checklist at the macro level, allowing each of the layers to be investigated separately to generate sufficient data related to essential spatial requirements. While decision makers using this framework can set their own priorities in terms of their separate internal criteria, making decisions in terms of spatial data requires a holistic view of the development. Further research related to the spatial requirement framework is planned in order to test these spatial characteristics and attributes linked to an existing Logistics City as a single case, allowing amendments to the framework to strengthen its applicability.

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THE PROGRESSION TO LOGISTICS CITY AND ITS IMPLICATION OF ECONOMIES OF AGGLOMERATION

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ABSTRACT
Purpose of this paper – This paper identifies the essential activities at logistics facilities and describes the progression of these facilities to logistics city. The impact of the progression on economies of agglomeration is analysed, the practical implication is presented, and the need for government initiatives, intervention and coordination as a catalyst is explained.

Design/methodology/approach – Based on the sophistication of logistics facilities progression, the essential activities at various logistics facilities are collected and the impact on economies of agglomeration is analysed.

Findings – This paper finds that while agglomeration economies explain past development, agglomeration forces alone are insufficient and government intervention is required as a catalyst. This may be in the form of the development of a common user freight terminal with intermodal and customs capability, e.g. inland port to aggregate consolidation/deconsolidation activities.

Research implications and limitations – The identification of essential activities of logistics facilities can minimise or prevent inappropriate uses of these facilities to ensure effective and efficient logistics services planning and high utilisation of transport infrastructure. The impact analyse of economies of agglomeration points out the role a government should play in logistics facilities development.

Value of paper – The paper identifies essential activities for logistics facilities and therefore makes it possible for governing agencies to plan and protect the development of logistics facilities and ensure high utilisation and effective usage of such facilities. The gap identification of economies of agglomeration ensures tangible economic benefits can be achieved through appropriate government supported logistics facility developments.

INTRODUCTION

A number of cities around the world have established their international standing, competitiveness and attractiveness as freight hubs. In some examples, the ultimate progression of their logistics intensive component of their economy involved the concerted rise to logistics city status. Several of these exist and whilst they are not always refereed to as such, these logistics cities such as Dubai (Proffitt, 2006; MEED, 2006; Turner, 2006), Shanghai (Leach, 2006; Harmsen et al., 2006), Singapore and those in the USA and Europe (Tierney, 2004) are multi-faceted in terms of their characteristics e.g. infrastructure, business services, and urban amenity. Those inherit significant economic growth potential, as well as possess an ability to attract investments and projects from leading international and local logistics companies, thus securing further strength in their supply chain management and general logistics capability.

These logistics cities not only hold the core elements such as dedicated logistics infrastructure, but also integrate industrial parks and urban constructs and some are strategically associated with a free trade zone. These examples show leverage of the excellent international connectivity and superior freight handling efficiency of the associated airport or sea port that enables quick turnaround, value-added logistics, and local, regional as well as international distribution activities.

These logistics cities hold considerable potential towards regional economic growth (Meidute, 2005; Sengpiehl et al., 2008).

The development of various logistics facilities, which starts from freight terminal, follows by freight hub and logistics village, and with logistics city represents the more sophisticated combination, illustrates the progressive changes of services, infrastructure and beneficiaries of these facilities. There are distinguishing or differentiating aspects that allow a classification between each stage of the progression. The differentiation is in terms of infrastructure and business services that each stage can provide, and with each stage, there is increasing sophistication.

Industrial agglomeration has been considered a source of sustainable competitive advantage for a national or regional economy. Agglomeration economies derive benefits from the location of activities near a specific facility, provide powerful forces and explain the advantages of the clustering of services around a particular facility (Chatterjee, 2003). At the freight terminal level the agglomeration of activities related to freight transit and transhipment are directly linked to the nucleus terminal. The support to the industrialisation economies at the level of the freight hub as well as logistics village becomes important. At the level of logistics city, it sustains urbanization economies, deriving benefits from the agglomeration of population, namely common infrastructures (e.g. utilities or public transit), the availability and diversity of labour and market size.

However, we have found that while agglomeration economies explain past development, agglomeration forces alone are insufficient and government intervention is required as a catalyst for comprehensive logistics facilities development. This may be in the form of the development of a common user freight terminal with intermodal and customs capability, e.g. inland port to aggregate consolidation / deconsolidation activities. These common user freight terminals, together with well-built transport infrastructure, will initialise the progressive development towards logistics cities once the critical mass of development forms.

This paper identifies the essential activities of logistics facilities at each level of the progression and tries to examine the impact of the progression on economies of agglomeration, to present the practical implication, and to explain the need for government initiatives, intervention and coordination as a catalyst for logistics city development**.**

THE PROGRESSION OF LOGISTICS FACILITIES

The general perception is that while logistics is a necessary activity for any business, it has been traditionally regarded merely as a cost factor and therefore a non value-adding activity. It now appears that this view of seeing logistics as a non value-adding activity has changed in recent years. This changed perspective may have resulted from significant structural movements in the whole area of goods handling. As a consequence, there has been an increasing focus on logistics management and systems, and logistics has evolved to such an extent that it has become an essential factor for companies aiming to achieve a competitive advantage in the field (Rutner and Langley, 2000; Abrahamsson et al., 2003).

Further traditional logistics activities have been widened and now include sectors such as, customising, quality control, light assembly, supply chain design, etc. It is in this respect that logistics is now becoming explicitly understood as a value-adding activity that significantly reduces supply chain costs, increases the actual value of goods e.g. due to customising and contributes to measurable gains in competitive advantage in the marketplace.

The progression of the essential activities starts with less value adding ones that are related to the logistics industry. The lower value adding services have linkages to the connectivity and basic gateway activities such as terminal operation, transport and the simple storage activities. The principal notion of a logistics city, on the other side, is the presence of critical mass of higher logistics value-adding activities, which are commonly linked to the main gateway function.

The presence of supporting industry is an important element in the development of a logistics city. Various industry sectors as well as public services have direct linkages to the core logistics activities. Since these supporting services are essential to the logistics industry, they should be accessible and commonly located within or close to each of the progressions. The availability and accessibility of these services form a strong suite of supporting activities and create potential advantages for the logistics industry.

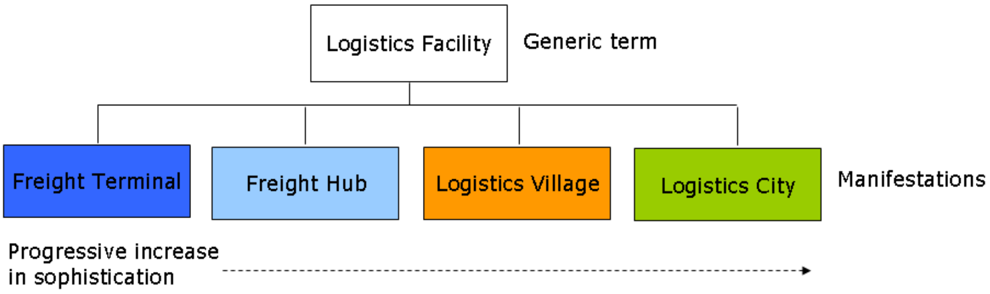

Figure 1: Progressions of logistics facilities

It is therefore desirable to classify the various instances of logistics facilities in terms of sophistication in planning for land use and access options, operations, advice on community and social issues and the potential impact of the development, as well as the essential activities related to these facilities. The principal stages of this progression and their relationship to the generic term "logistics facility" are illustrated in **Error! Reference source not found.**. It starts from the basic logistics facility of freight terminal, and then evolves to freight hub, logistics village and eventually to logistics city.

Freight Terminal

A freight terminal is a place equipped for the transhipment and storage of transport units, which is the nucleus for an agglomeration economy derived from localisation, where the benefits are derived from the attraction of a set of freight intensive activities near its precincts. The essential activities happen at a freight terminal basically deal with fundamental logistics operations, such as:

- Loading / unloading of container, general cargo and break bulk related to trucks, trains, airplanes and vessels;
- Freight receipting, freight sorting and freight tracking;
- Load building, e.g. LTL (less-than-truck-load) management, packing, pallet and container building;
- Last mile despatching;
- Container management, e.g. container storage, repairing and tracking;
- Hazardous materials and waste management

Freight Hub

A freight hub is a node used for the collection, sorting, transhipment and distribution of freight for a particular area, including at least a freight terminal. It transfers freight from one transport mode to another (McCalla et al., 2001). The functionality at the freight hub level is the provision of value adding services such as bulk cargo breaking, picking and packing, freight consolidation and deconsolidation. A freight hub therefore must provide the infrastructure that allows the consolidation and deconsolidation of freight such that the freight flows to and from associated distribution centres can be optimised.

A freight hub may augment a distribution network as an additional facility, but there may also be an opportunity for retailers or manufacturers to use this facility to bypass distribution centres through direct shipment to closely located retail outlets or manufacturing facilities. The freight hub provides a stage that allows companies to postpone inland shipping decisions until the arrival of goods. The contents of ocean containers can be sorted and aggregated to match any distribution pattern but within more immediate timeframes, thereby reducing forecasting errors.

Associated with the intermodal capability, especially with international transport routes, the following essential activities are required to support a freight hub:

- Freight consolidation and deconsolidation;
- Freight pooling;
- Warehousing and bonded warehousing.

Logistics Village

A logistics village is a geographical grouping of independent companies and bodies which are dealing with logistics, such as freight forwarders, shippers, transport operators, customs agencies, and with accompanying services, such as professional logistics related services, maintenance and human resources. The attraction of industrialisation economies, which is a type of agglomeration economies, generates benefits in terms of savings and cost reductions due to spatial concentration of industrial activities and convenient logistics support. They benefit from their joint utilisation of local industrial infrastructure and close proximity to respective suppliers and customers.

The logistics village therefore attracts a concentration of logistics related activities within a specific area, commonly planned for, built and managed for such a purpose. The core of the logistics village is the freight terminal. Although a logistics village can be serviced by a single mode of transport, association with an inter-modal freight hub with the added functionality of customs and hub activities (e.g. consolidation/de-consolidation) can offer direct access to global and regional markets. The development of logistics villages has many benefits to the management of freight flows generated by several unrelated users through sharing the same facilities and equipment around them. The essential activities happen at a logistics village aim to enhance the fundamental logistics services through:

- Export / import services;
- Customs agency services;
- Professional logistics services;
- Insurance and finance services;
- IT services.

Logistics City

A logistics city is a more compact and logistics intensive industrial development, within a logistics friendly precinct, served by strong and fast freight transport links, to reduce road dependency and provide a wide choice of logistics services, business services, civic amenities, and employment opportunities, focusing on appropriate urban design and freight transport applications, appropriate and opportunities for new land use mixes, a marketing and sales strategy for logistics city, amenities and planning approvals (Leach 2006; Harmsen et al. 2006). The logistics city is enabled by city constructs and provides benefits derived from the agglomeration of population, namely common infrastructures (e.g. utilities or public transit), the availability and diversity of workforce and market size.

The essential activities accessible from a logistics city expand significantly from that provided by the preceding logistics facilities, such as:

- Merchant banking, e.g. general corporate lending, asset-based and project finance of infrastructure, hedging instruments;
- Infrastructure and environmental planning and development;
- Peripheral activities, e.g. entertainment, hospitality, tourism and retail;
- Urban, town and residential planning and development.

THE IMPLICATION OF ECONOMIES OF AGGLOMERATION

The economies of agglomeration describe the benefits and advantages that companies can obtain when locating near each other. It relates to the idea of economies of scale and network effects. Hesse and Rodrigue (2004) argued that due to logistical integration, transport cannot be solely considered as a derived demand, but as an integrated demand where physical distribution and material management are interdependent. Logistics is a key organisational system for material flow and goods delivery. A well-designed logistics system can not only provide good logistics services, but also attract companies (logistics service users) to locate next to or in close proximity of such logistics facilities.

From the perspective of setting up new logistics facilities, logistics services are attracted by good transport infrastructure and vigorous market demand, and the availability of supporting services (Hong, 2007). The development of logistics facilities at freight terminal and freight hub level therefore can be established by individual companies, since they can select good locations for their logistics facilities. However, as the progression evolves to higher levels, simply relying on market force to form economies of agglomeration might not be sufficient due to the high cost of infrastructure planning and development. Therefore, government support or initiatives, such as setting up a common user freight terminal with intermodal and customs capability, e.g. inland port to aggregate consolidation and deconsolidation activities, will create the basic platform of logistics city and foster future development. The planning for land use and in determining compatible uses about the freight terminal precinct has to be justifiable and agglomeration economies (i.e. localisation, industrialisation and urbanisation economies) are underpinned by forces that result in the "clustering" of activities, ranging from manufacturing to retail, around a specific facility such as a transport terminal.

The development of a logistics city therefore forms an excellent platform for various industry developments to share the high efficient transportation infrastructure and low cost logistics services, where good transport conditions, sufficient workforce supply, and potential logistics services users attraction can accumulate. The analysis conducted by Oum and Park (2004) regarding the location of distribution centres of multinational enterprises across Northeast Asian countries confirms that market size, transport conditions, labour considerations and input costs are the location considerations. The areas where there was obvious concentration of existing industrial sites and freight activities were perceived to be good locations for the major part of logistics cities, since planning time and related investment cost can be minimised and agglomeration benefits already exist.

The logistics industry at logistics city level provides a mature foundation for economic development and fosters industrial agglomeration and attracts local, regional and international investment. Additionally the logistics city and its lower progressions need to take into account the associated freight transport network. The contained components of the associated network, as well as transport corridors, have many stakeholders with different objectives. These stakeholders, however, do have interdependency and share a competitive position as a region that needs to be coordinated and promoted by a unique governance model to achieve synergies and create benefits across the whole network. The services provided by a governance model aim for better utilisation of the logistics facilities and building competitive advantage through various private, public and governmental schemes and initiatives, such as:

- Government business collaboration;
- Enterprise / capability development and sustainability;
- Start-up enablement;
- Accreditation / recognition, policy development;
- Branding, marketing, and investment attraction;
- Large scale infrastructure planning and development.

The above mentioned activities go far beyond single or a group of companies can achieve. One may learn from the Singapore example, which has established a so called "Champion Agency" that is the bridge of all relevant private and public stakeholders in the area of transport and logistics. Its primary work is to promote, coordinate and develop the logistics industry in Singapore.

Identifying developmental needs of private industry, working with governmental departments and agencies to remove unnecessary impediments and aligning regulations as well as promotion are areas of responsibility for the Champion Agency (ERC Working Group, 2002).

The logistics city also underpins the land use planning. The purpose of this is to capture available knowledge about the elements that constitute a logistics city and also to define this in an unambiguous manner. The start point of this work was the freight terminal and how significant advances in land planning concepts may be developed around the terminal, to achieve the industrial agglomeration and sustainable growth with urban and environmental considerations.

The pursuit of an integrated logistics hub / village / city will require immense amount of coordination, effort and work from various sectors and government agencies. A “champion” agency to coordinate and push through difficult decisions is therefore necessary to ensure that implementation is not clouded and overwhelmed by the sheer amount of work, politics and sectors to be covered. This work has to look broadly at a diversity of interests and work cooperatively with government agencies and other stakeholders to achieve the best possible freight outcomes. The logistics city has to be developed on the basis of gaining the benefits from locating compatible activities in close proximity to key infrastructure where government intervention is necessary as a catalyst to economic agglomeration forces.

CONCLUSION

The concept of a logistics city, and achieving its status, is becoming recognised as a means for attaining sustainable economic growth, as evidenced by a number of examples around the world. Through identifying the essential activities of logistics facilities, this paper points out that government initiatives and intervention might be necessary to achieve economies of agglomeration. The identification of essential activities not only enables the governing agencies to plan and protect efficient and effective logistics development and achieve high utilisation of such facilities, but also recognises the gap to economies of agglomeration which eventually provides employment growth and economic development for a particular region. The gap may be filled, as a catalyst and an initiative, by a logistics facility in the form of the development of a common user freight terminal with intermodal and customs capability, e.g. inland port to aggregate consolidation and deconsolidation activities, together with the necessary transport infrastructure development. The government intervention in terms of planning and coordination is also required to ensure an integrated logistics city development.

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TRANSPORT RELIABILITY OF CONTAINERISED AGRICULTURAL GOODS FROM THAILAND TO CHINA: A SHIPPERS' PERSPECTIVE

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ABSTRACT

Ever since the early 1990s, the Chinese economy has grown at an annual average rate of 8 percent[1], representing the greatest sustained growth period in recent times. Several neighbouring countries, such as Thailand, have oriented their transport systems towards coping with the dynamism of trade in the Chinese import and export market. However, in the current international trade climate, significant adjustments in the trade patterns have focused attention on issues of reliability and the long-term sustainability of trade and transport. This is especially true in the agricultural sector, where transport patterns vary according to cost, time, seasonality, exchange rate, business relationships and market accessibility factors. These factors are considered to be the main determinants of decisions concerning transport corridor, modes, methods, and selection of transport carriers. The type and nature of the cargo itself, and the volumes of cargo shipped are also potentially very important.

In this paper, a case study of over 100 containers of agricultural goods from North of Thailand to Southeast of China was monitored through measures of cost and time, along with 34 survey responses of service and quality. The purpose of this study is to evaluate the factors affecting choice of routes and modes in between the selected corridor. A "Fast Track Transport Measurement" (FTTM) matrix was proposed in evaluation of the reliability of a given transport corridor. As a result, cost factors turned out to be the key transport decisions for trade between Thailand and China rather than service or quality of transport.

Key words: Transport Reliability, Agricultural Goods, Thailand, and China.

INTRODUCTION

As the global economic system has become more intricate and interconnected, China's participation in the World Trade Organisation has enabled its economy to grow at a rapid rate with considerable competition in every sector of the market. Transport development, regarded as one of the key components of China's explosive economic expansion, introduces mutual-initiatives programmes such as ASEAN-MT[2], which has strengthened and attracted direct investments and trade along with neighbouring countries. However, in order to cope with the pace, provision of logistical systems, infrastructural enhancement, along with macroeconomics stability and long-term development strategy, will be the key requirements in sustaining economic development (Banomyong, 2001). Regardless of efficiencies of transport supplies, a need for freight transport to be more agile and responsive to customers' demand is also relevant in the content of strategic supply-chain management.

Focusing on Southeast Asia, Thailand is regarded as one of the main regional logistics centres, in terms of its transport infrastructure, policies for improving trade transport service and adoption of multimodal transport methods. However, Thailand still suffers from high logistics costs derived from:

- Poor transport infrastructural standard in comparison to China (Main ports),
- Under-developed transport and logistics services,
- Lack of technology acceptance and utilisation,

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1 Source from ADB: http://www.adb.org/media/Articles/2007/12084-chinese-economics-growths [Accessed on 10 April 2009]

2 Association of Southeast Asian Nations-Multimodal Transport

- Inflexible transport service and route options,
- Poor reliability of transport service and,
- Slow and costly bureaucratic procedures for exports and imports

These key factors have become barriers to growth of the economy, as well as limitations in trade competitiveness against other neighbouring countries such as Malaysia and China. According to Meixell *et al,* (2008), a key decision in logistics management is the selection of the transportation mode and carrier to move the firm's inbound and outbound freight. Therefore, identification of factors affecting choice of route and mode are crucial in improvement of export and import performance. Notwithstanding the value of trade, performance of particular modes of transport represents as a key determinant of the effectiveness in logistical system as a whole. Recognition of the importance in route and mode evaluation, transport service quality plays a significant impact on decision-maker's perception on route reliability and mode selection.

The focus of this paper is to explore the rationality of the shippers' choice of routes and transport service provider in international freight transport between Thailand and China via Fast Track Transport Measurement (FTTM) matrix. Primary data were collected via e-mail from 34 companies with frequent export activity in between the two countries, along with cargo monitoring data of 100 containers from two selected companies. Firstly, a background study will be provided to gain a foundational understanding of transport issues followed by the research methodology. Finally, findings and conclusions will be provided in order to highlight shippers' perspectives on transport reliability performance of the corridors.

BACKGROUND

Ever since the introduction of ISO containers around 50 years ago, revolutionary changes in transport operation have uplifted the efficiency of global trade (Lowe 2006). In terms of the global export volume in agricultural products, an approximate increase of 370 percent in volume was observed from 1966 to 2006[3]. With such volume of trade climate, significant adjustments in the trade patterns have been observed, especially on issues of reliability and the long-term sustainability of trade and transport. As to trade relationship between Thailand and China, emerging bilateral trade agreements (ASEAN-FTA[4]), initiated by the government have stimulated, and will continue to stimulate trade by lowering trade barriers through tax agreements and unification of legal trade frameworks.

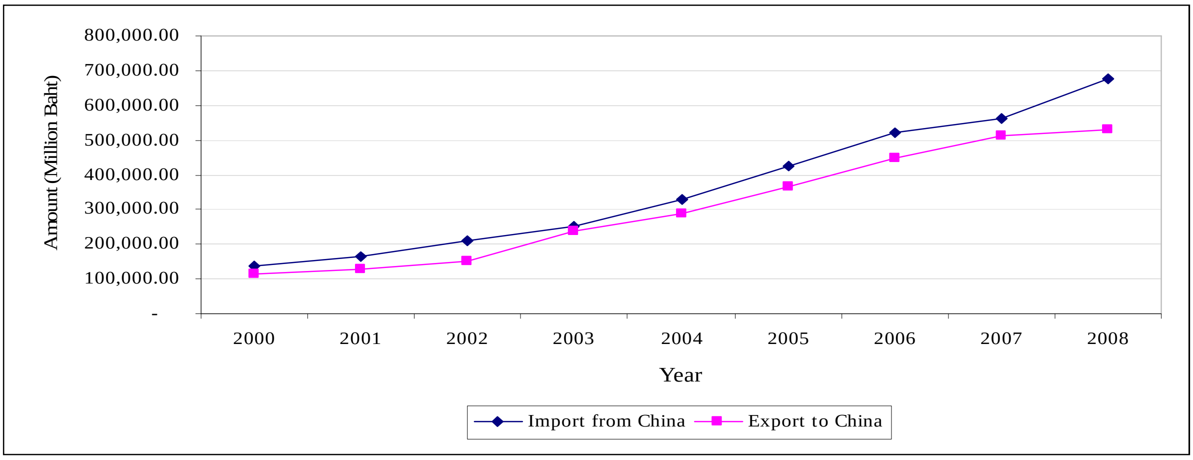
Regarding decisions on route and mode choice, McKinnon (1989) has identified several key indicators of factors affecting freight transport as well as the distinct characteristics of transport mode choice, which signify the direct impacts on the efficiency of a logistic channel. According to Hayuth (1987), transport competition involves continuous improvement of both "hard components" and "soft components" in a mutual exclusive manner in order to provide competitive services for shippers in facilitating international trade. Along with the advancement of transport systems, namely: unimodal, through transport, intermodal transport or multimodal transport, business relationships are constantly evolving in order to meet the shippers' requirements.

In research on transportation systems, reliability is defined as the consistency of the transit time, costs, service and quality that a carrier provides (Coyle *et al*, 2003; Hayuth, 1992; Rodrigues *et al,* 2008). These key determinants are considered the main components in governing the decision making process of shippers. Other unpredictable external factors which may directly affect transport operations are event such as terrorism, industrial action, disease epidemics, and severe weather conditions. Industrial and financial turbulence, corporate re-alignments and government interventions, in the forms of taxation changes or new regulations, can also be very important (Rodrigues *et al*, 2008).

[3] Adapted from WTO: http://www.wto.org/english/res_e/statis_e/its2007_e/its07_appendix_e.pdf [Accessed on 2 March 2009]
[4] ASEAN Free Trade Agreement

As one of the main logistic platforms of ASEAN region, Thailand is active in trade with China. With the current negotiating ASEAN-FTA for 2010, engagement of deeper trade relationships can be foreseen. According to Figure 1, a parallel increase of both import and export trade value between Thailand and China is shown; it can be deduced that trade relationships between these two countries will increase even more after the full implementation of the ASEAN-China FTA (Banomyong *et al*, 2006).

Figure 1: Trade Statistics between Thailand and China



Source: Adapted from Thai Ministry of Commerce (2009)

In this paper, a case study of containerised agricultural trade from North of Thailand to Southeast of China is chosen to illustrate corridor reliability from the shippers' perspective. Containerised agricultural cargo is used in this research due to ease of data accessibility and authors' interest. Implementation of a FTTM matrix will be used to underpin the rationale behind shippers' decisions on routes and modes selection in these corridors.

METHODOLOGY

According to McKinnon (1989), the route comparison is the prerequisite of the model selection. A Radar Chart is used to represent the visual model of FTTM. Firstly, the measurement scale was introduced. Based on the previous research, the measurement scales were revised by both academics and practitioners to ensure the internal and convergence validity. However, the measurement scales are not yet appropriate for the comparison or benchmarking. Therefore, uncertainty measurements on time and cost were introduced in association with service and quality dimensions. The tools were designed as a complementary technique to the cost- model (Banomyong and Beresford 2001).

Cost, time, service and quality are the four main factors under this study. Cost and time can be numerically collected from the industry. However, service and quality could not be captured in the same way. The measurement scales of the previous research were reviewed and tested in the pilot study. The development of the questionnaire was aimed to provide some insights into shippers' evaluation in utilisation of the two routes. Under the 'Quality' and 'Service' dimension, questionnaires were designed based on the existing research on decision making factors namely, customer "value" criteria (Johansson *et al*, 1993), factors affecting freight modal choice (McKinnon 1989) and factors affecting the decision-making process (Banomyong *et al*, 2005). Regarding to this research, service is defined as functional aspects and quality is defined as guidelines for services.

This paper adds the uncertainty dimension into transport modal choice decisions. Route uncertainty will be measured by percentages of delays and the differences between expected and actual cost. Then, measurement scale for service and quality are also included in the model. In order to benchmark service and quality level of the routes, statistical tests may be performed to confirm the significance of the results. The list of factors was then compiled and divided into two dimensions (quality and service). The frequently overlapped factors, in accordance to the compilation of previous research, was selected and reworded for the appropriateness of questionnaire. Accordingly, the unit of cost is the currency that is used in the payment. There is no need to discuss the unit of time thanks for its uniqueness. The 4 dimensions of the factors this study are showed in table 1 hereunder.

Table 1: The Dimensions of the Benchmarking Indexes

<table>
<tr><th>Cost</th><th>Time</th><th>Service</th><th>Quality</th></tr>
<tr><td>• Estimated Cost of Transport Service
• Actual Cost of Transport Service</td><td>• Estimated Time of Arrival
• Actual Time of Arrival
• Total Lead Time</td><td rowspan="2">• Transport Reliability
• Accessibility to Service
• Ease of Documentation
• Ease of Control and Monitoring
• Level of Cost Transparency</td><td rowspan="2">• Meeting Customer Requirements
• Transport Process Integrity
• Route Robustness
• Level of Geographical Coverage
• Fitness for use</td></tr>
<tr><td colspan="2">Derived from the company's record of numerical data of the two specific routes used.</td></tr>
</table>

With regard to the proposed dimensions, semi-structured interviews were carried out via telephone with shippers and operators from both Thailand and China to validate the questionnaire. The collection of data was divided into two steps. In order to capture the essence of cost and time dimensions, 100 containers of agricultural goods from North of Thailand to Southeast of China was monitored with permission from two agricultural exporting companies. Later on, data related to service and quality was collected through a questionnaire with 135 responding firms selected by the author. The respondent was selected based on his or her authority in transport decision-making in the firm. 34 questionnaires were returned with a response rate of 25.2%.

FINDINGS

Large portions of containerised agricultural cargoes were transported via road haulage from Lumphun (Northern Thailand) to Laem Chabang Port (privatised port near Bangkok) for international sea freight. Freight transport via Laem Chabang Port is commonly chosen due to preference of transport operators and flexibility of the given service in comparison to Bangkok Port (Public Port). Lumphun is one of the leading agricultural provinces in Northern Thailand and is well-known for exporting reprocessed agricultural goods to China. The general routeing from Lumphun to Laem Chabang is performed via road haulage with 2 days of start time. However, twenty-four hours of cargo waiting time (buffer time) are required before the actual departure of the ship. The amount of cargo goods and the strength of business relationship can significantly reduce cargo waiting time.

Ideally, the selection process of ports is governed by geographical coverage of the market demand justified by the ultimate-end-customer. For example, routeing via Ningbo would serve markets in ZheJang, AnHui, ShangHai, WuHan, HuBei and JiangXi; and routeing via QingDao would serve markets in ShanDong, Jinan, HeBei, ShanXi, Beijing and Dalian. However, due to the proximity of these two ports, several overlapping regioins in providing door-to-door service are found such as, LianYunGang, JiangSu, NanJing, ZhengZhou and Henan, which denotes the area as a port competition zone. According to the interview, few insights are derived in accordance to the two selected ports.

Routeing to Ningbo

Ningbo port is one of the main terminal ports in China with multipurpose logistics services. It has 191 berths including 39 deep-water berths capable of handling 10,000 plus GRT[5] vessels. Along with the number of berths, it has dedicated berths for ore vessels, crude oil terminals and 6^{th} generation container vessels (more than 8,000 TEU[6]: GDV 2009). However, according to the interview, levels of service rely heavily on level of relationship between custom officers and shippers which causes inconsistency of freight cost. Documentation requirements seem to be more

[5] Gross registered tonnage
[6] Twenty-foot equivalent unit

rigorous when comparing other seaports. Customs check can be quite meticulous and several shippers face difficulties in finding storage areas due to insufficient warehouses. Nevertheless, direct door-to-door services are available from Thailand to Ningbo routes, which provide wide coverage for southeast of China.

Routeing to Qingdao

Qingdao port lies on the Yellow Sea basin and on the western Pacific Rim along with other major ports. It is one of the top ten-world busiest port regions and second largest port in China with capacity to handle 265million tons[7] at once. It is recognised as one of the most important hub of international trade and sea-going transportation. Besides its large-scale container, crude oil and ire ore facilities, it also handles other various types of goods such as fertilizer, alumina, cement, sodium carbonate, rubber, wool pulp, cotton and extra-large shipments. However, several shippers face difficulties in retrieving goods from the port. Transit lead-time is usually higher than other ports because of its lack of port operational efficiency. In comparison to Ningbo port, cost of sea freight is usually less expensive but with lower cargo handling efficiency due to high frequency of damaged goods found in the process of transhipment. One of the most significant setbacks of the port is its cargo clearance capability. Several shippers faced port congestion due to seasonal instability such as storm, snow, fog, which limits its opportunities for maximum port utilisation.

ROUTE BENCHMARKING

Despite of the differences in between the two sea legs, commonalities of intermodal transfer point are found. Transporting goods from the place of origin to the first intermodal transfer point (Laem Chabang Port) are pre-dominantly performed by road haulage. No alternatives are found in providing similar services through other types of transport such as rail or inland waterway. The initial leg of the multimodal transport would require a total of 48 hours to reach the port destination. However, according to the port customs, an extra 24 hours buffer time is required for cargo handling and prevention of freight congestion. Therefore, an additional 24 hours idle time is expected after the arrival of the goods at the Laem Chabang Port. Nevertheless, from the shipper's perspective, the expected idle time contributes as a positive attribute in achieving on-time freight transport schedule with expectancy of minimal human error. As for the second transport leg, differences could be spotted. The required lead-time from Laem Chabang Port to both Ningbo and Qingdao varies according to distance. Ningbo is approximately 780 kilometres from Qingdao. A detailed outline of the transport lead-time is provided hereunder (Table 2).

Table 2: Transport Lead-time

Origin	Intermodal Transfer Point	Road Leg (Transfer)	Destination	MSS** Leg (Port Destination)	Total Transport Time
Lumphun (North of Thailand)	Laem Chabang Port (Bangkok)	3 Days*	Ningbo	7 Days	10 Days
			Qingdao	12 Days	15 Days

Note: * 2 days actual transport lead time from Lumphun to Laem Chabang port and 1 day buffer lead time for cargo handling. All freight goods are required to be delivered 24 hours before the actual departure time of the freight vessel.
** MSS: Medium Sea Shipping

Due to the divergent nature of the measuring unit, a common index is given to neutralise the units into comparable benchmarking units. Uncertainty of time is measured through the differences between the average expected time of arrival by the actual time of arrival. Uncertainty of cost is derived from the variance of cost through the difference between the expected cost and the actual cost. An adjusted index was given to both the time and cost functions to normalise the data set. Both service and quality measures are calculated by averaging the total responses of the five dedicated dimensions in each factor. According to the types of primary data which was collected through survey and company confidential data, mix methods was used to represent the decision-

[7] Source from Official Qingdao port website: http://www.qdport.com/ [Accessed on 28 April 2009]

making trend. Service and quality measures are measured through qualitative knowledge of the respondents (soft data). In contrast, cost and time factors are measured through a series of numerical data (hard data). In order to visualise the difference between the two routes, a FTTM matrix is provided hereunder (Figure 2).

Figure 2: The Fast Track Transport Matrix between Qingdao and Ningbo Route

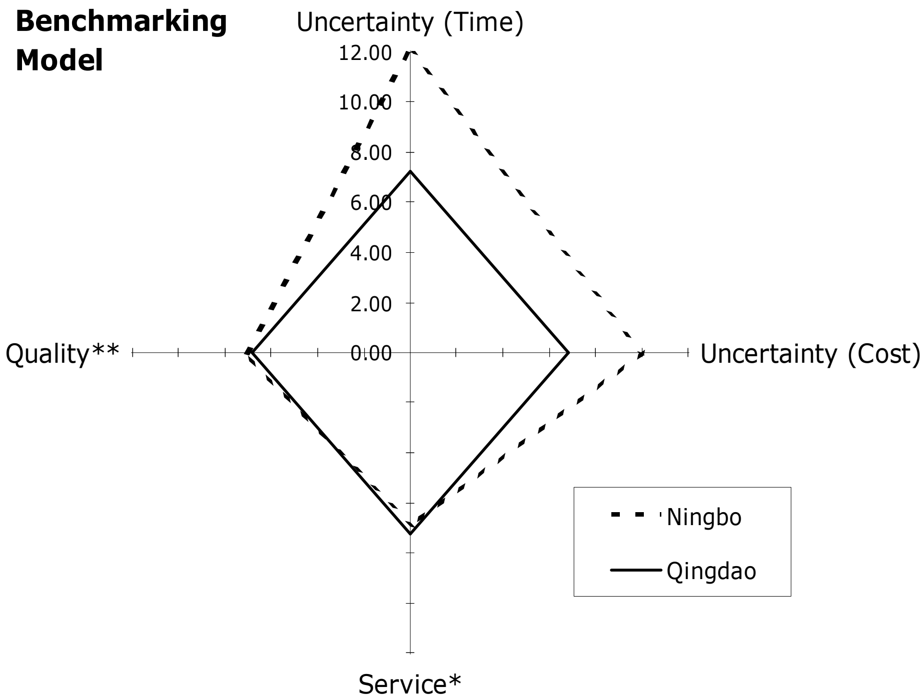


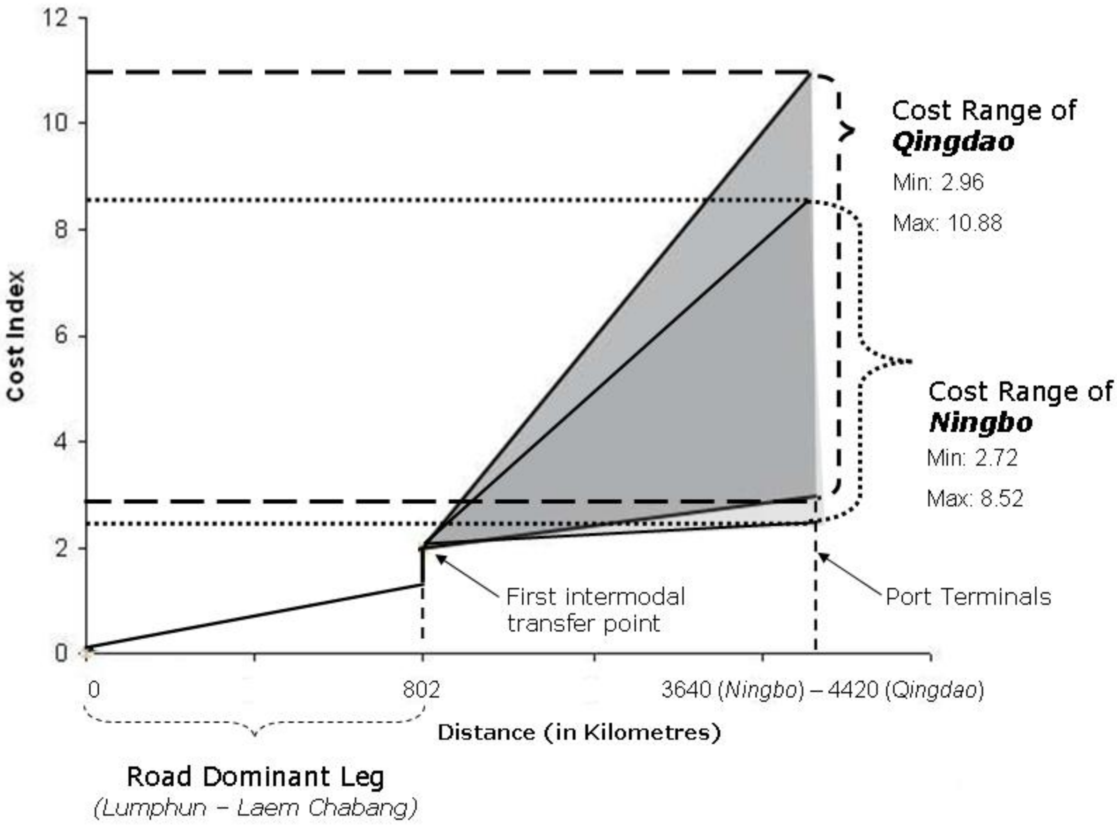
Table 3: Statistical Performance between the Two Ports

Dimension	Ningbo	Qingdao
Uncertainty (Time)	12	***7.24***
Uncertainty (Cost)	10	***6.81***
Service*	6.98	***7.24***
Quality**	***7.05***	6.81

Note: Italic-bold are the better performances
* The difference between two routes is statistically significant (p<0.05)
** The difference between two routes is statistically significant (p<0.10)

According to the FTTM matrix (Figure 2), the three factors namely, time uncertainty, cost uncertainty and service are better performed on the Qingdao route, but the benchmarking index for transport quality is slightly lower than on the Ningbo route (Table 3). This is because of the inconsistency of the seasonal instability which affects the corridor reliability. According to survey respondents, cost was one of the key decision-making factors in selecting the most optimal transport corridor. Therefore, a cost comparison between Qingdao and Ningbo route is provided hereunder (Figure 3).

Figure 3: Cost Comparison between Qingdao and Ningbo Route



With this overall iterative benchmarking process, this paper unfolds the rationale of shippers in selecting a transport corridor in the port competition zone. Despite the minor difference between service and quality of transport, uncertainty of time and cost remain as the main dominant decision factors. It was found that even though distance is closely interrelated with the uncertainty of time, shippers seem to place their dominant decision-making factor on reliability of cost. Therefore, a cost comparison would be ideal in comparing the transparency and reliability of the cost structure provided for the shippers. Nevertheless, with application of FTTM matrix, an explorative understanding could be reached.

CONCLUSION

This paper represents research which has investigated the reliability of transporting containerised agricultural goods from North of Thailand to East of China. Through the case study, different classification of uncertainties had been discussed via benchmarking indexes and surveys. The FTTM matrix acts as a fundamental and practical benchmarking template which shippers could use to develop a strategic transportation plan. Identifying the uncertainties and factors affecting transport decisions provides a great opportunity to prioritise plans for supply-chain re-engineering. According to the geographical characteristics of the two ports, several factors have intervened with the transport decision-making process in selecting of routes. Three key attributes have been identified in decision-making within of these three routes.

- Shipper's relationship with transport operators and custom officer
- Communication efficiency between parties (service and quality expectancy)
- Cost transparency

Regarding the time sensitivity of agricultural goods, prompt response to shipper's transport needs is essential in uplifting the quality of an international transport corridor. Some limitations that this research has encountered were gathering of confidential data for each 34 companies. Dedicated time and cost dimensions were collected from 2 out of 34 companies and adjusted to present a general picture of the two routes. However, this research endeavours to provide a better understanding of shipper's perspective of transport reliability between Thailand and China by means of utilising the FTTM matrix.

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THE CHALLENGE FOR DECISION MAKING IN INTERMODAL SUPPLY CHAINS

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ABSTRACT
The aim of this paper is to create new common knowledge for a decision support system for intermodal operations, especially from the operator point of view. This paper analyses the requirements for a decision support system coming from the intermodal operator and other stakeholders in the supply chain. Our target is to develop a decision support system based on the requirements. The developed system will contribute to the competitiveness and success of intermodal operators in European and global supply chains.

INTRODUCTION

Environmental issues are an increasing topic in academic and practitioner discussions. The CO2 emissions and increasing logistics costs have set new requirements on businesses. The European transport policy, as well as national transport policies, aims at increasing the market share of more environmentally friendly transport modes like rail, inland waterway and short sea shipping (EC White paper, 2001). Road transport still has the biggest share and is still a dominant mode of transport for intra-European freight transport. In the freight transport sector, intermodal transport is one potential solution for reducing pollution and making supply chains more competitive and sustainable.

There are a great many players involved in intermodal transport, and for this reason a fluent information flow and the transparency of the transport process, including the management support, are absolutely crucial. Our focus is on the intermodal operator's role in the transport chain. The intermodal operator is a company that is responsible for managing intermodal door-to-door shipments processes. The intermodal operator only manages the transport process; the physical movement from consignor to consignee by utilising intermodal transport loading units is bought from different stakeholders, like road hauliers, rail operators and terminal operators.

The managerial and operational decision making is challenging for the intermodal operator because of the lack of information about the overall process. Some stakeholders, like rail operators, provide track-and-trace solutions, but these individual solutions are not integrated into a common system. When you operate hundreds of deliveries at the same time, it is not possible to use individual solutions for follow-up and decision making.

METHODOLOGY

This research is part of the FP7 project called EURIDICE. EURIDICE is about the development of ICT solutions for transportation and intelligent cargo. Our pilot application is for an intermodal operator in Finland. The aim is to collect the requirements for the intermodal operator decision support system from the operators and stakeholders. The research is based on a single case study according to Yin methodology. The semi-structured interviews with the personnel at the intermodal operators and the stakeholders are the main means of collecting information. In the first phase of the data collection, the aim is to understand the present state of intermodal transportation. Inconveniences, bottlenecks, problems and future requirements are identified together with the experts in the stakeholders' organizations. The findings are turned into both business and technology requirements for the system to be developed. This paper focuses on the requirements phase of the project.

INTERMODAL TRANSPORT

Intermodal transport is defined as "the movement of goods in one and the same loading unit or vehicle which uses successively two or more modes of transport without handling of the goods themselves in changing modes" (UN, 2001). There are many rather general to more specific definitions for intermodal transport, but, according Bontekoning et al (2004), the UN definition could be used as a common definition. However, intermodal transport is not yet a common transport mode at the European level and many challenges should be solved before intermodal transport can increase its share of freight transport (Promit, 2007). Intermodal transport is seen by the European Commission as a key priority for a European freight transport policy (EC, 2001). The aim of the Commission's policy on Intermodal Freight Transport is to support the efficient door-to-door movement of goods using two or more modes of transport in an integrated transport chain (ibid). Each mode of transport has its own advantages, e.g. potential capacity, high levels of safety, flexibility, low energy consumption or low environmental impact (e.g. Floden 2007). Intermodal transport allows each mode to play its role in building transport chains that are more efficient, cost effective and sustainable overall. The intermodality enables the available transport capacity to be used more rationally and better use to be made of the railways, inland waterways and transport by sea, which individually cannot provide a door-to-door service (Vrenken et al. 2005). Combined transport is a segment of intermodal transport and is defined as "Intermodal transport where the major part of the journey is by rail, inland waterways or sea and any initial and/or final legs carried out by road as short as possible" (UN, 2001). Combined transport is often used as a synonym for intermodal transport.

The European transport policy, as well as national transport policies, aims at increasing the market share of more environmentally friendly transport modes (rail, inland waterway and short sea shipping integrated into intermodal transport alternatives). Road transport has still the biggest share and is still the dominant mode of transport for intra-European freight transport. One of the main reasons for this development is intermodal logistics' inability to adequately meet the customer requirements (e.g. Floden 2007). Road transport is often considered to be more flexible, cost effective, transparent, efficient and providing higher service quality than intermodal transport alternatives. Organisational, technical, financial, economical, infrastructural and logistical barriers hinder a wide breakthrough in intermodal logistics. The better integration of transport modes requires technical harmonisation and interoperability between systems.

The lack of information and transparency of the transport chain is one of the main reasons why intermodal transport is not used more in freight transport. There are two levels of information in the intermodal transport chain: 1) the transport loading unit level and 2) the transport process level. The transport loading unit level means the information and documents about the goods packed in the transport loading unit. The information could consider both physical and electronic documents, which is everyday life for all kinds of transportation. This has its own challenges, but new technologies could support the information management of the transport loading unit level. The second level is more challenging.

INTERMODAL VALUE CHAIN INTEREST GROUPS

The consignor and the consignee are important interest groups as customers of intermodal transport services. The service required by the customers usually involves different types of services, both physical movement of transport units and administration, as well as information handling. The physical services vary from rather simple one-mode transportation of transport units to combinations of up to three modes, some used more than once during the transportation. The administration services required by the customers mainly regard the paperwork that has to be completed, especially in international transportation. Preparing waybills and other such documents, e.g. for customs, is a typical service carried out by the intermodal transport service operators. The information service could give access to information about the transport unit's whereabouts, and maintaining such information is an important task.

The service provided by the intermodal transport service operator (later, intermodal operator) is to manage the physical movement of shipments from consignor to consignee by utilising intermodal transport units, such as containers, swap-body, semi-trailers, rail wagons, etc., as well as to manage administrative tasks, such as the necessary paperwork and other information handling. The intermodal operator is also expected to provide administration and information services previously mentioned as the requirement from the customer side. To receive and maintain such information is a rather complex task that requires quite advanced information technology, unless done manually, which, in turn, is very time-consuming.

The role of the railway operators in the intermodal transportation is to pick up and deliver wagons, owned by secondary wagon operators or themselves, from and to various locations. The wagons are often picked up and left at larger rail junctions as the first or last movements of the wagons can be operated by a smaller local railway company. The intermodal operators buy capacity from the railway operators, where the intermodal wagons make up part of a goods train running according to the railway company's specific timetable.

The rail wagon, trailer, swap-body and container operators (intermodal units operator) are companies that operate a number of such units, both owned by themselves or leased from other external parties. These units can be hired on different conditions, from long-term engagements to short-term. The long-term rentals are often designed with some special needs of the customer in mind, especially with regard to the cargo. The short-term engagements are often standard units that can be hired from several weeks to days or just one single trip, even one way only.

The role of the road haulage companies or truck companies in intermodal transportation varies significantly. Here are a couple of examples:

- A truck can be part of combined truck-train transportation used at the beginning, end or both ends of a transportation involving a container or a swap-body. This would be the case if one or both of the parties do not have direct access to a railway track.
- A truck can be used just to pull a semi-trailer to and from a railway operator's terminal that transports the trailer on special rail wagons. The railway movement leg is then often rather long, typically 500 km or more.

The truck companies are often intermodal transportation operators themselves, or they can be subcontractors to other intermodal transport operators.

The role of the shipping lines in intermodal transportation is to run the involved sea link. The sea link can vary a great deal in length, from short sea shipping to days of sailing.
The terminal operators can be divided into three categories: 1) inland 2) port, and 3) ferry terminal operators. There are major differences between these three types of terminals and such terminals are rarely operated by one and the same organisation. Still more exceptional is that one and the same terminal has all three functions or is located on the same site.

A company providing a forwarding service is considered an intermediate company that administrates the movement of goods between two places, door-to-door, including all the in-between services and administration. Many intermodal transport service providers can therefore be considered forwarders.

AVAILABLE INFORMATION SYSTEMS IN INTERMODAL TRANSPORT

Information access is a key element in any competitive intermodal chain that requires some degree of interoperability between the systems of the organisations involved in the chain and also with authorities who require reporting and bodies that provide traffic information (freightwise, 2008). Rapidly changing business and administrative requirements demand a high level of flexibility from the transport industry, both in terms of the services offered and the management systems (ibid). Software tools and it services to support the management are developing, but they do not adequately serve the entire business community.

The information systems in intermodal transport are mainly the systems of different stakeholders and do not function together. The transport-related stakeholders have a great number of individual solutions in use (Giannopoulos, 2004). A key characteristic of intermodal transportation is that the responsibility for the transported units is exchanged between many different parties during the time the transportation takes place. This, besides the physical transfer of the responsibility, includes the interchange of various related information between the involved parties. This information is exchanged by various means, stretching from simple telephone conversations between parties, faxes or electronic mail exchange to yet more advanced and complicated automatic electronic data interchange, often referred to as EDI. The stakeholders have a need to communicate with each other with fixed resources (production plants, warehouses, etc.) and mobile resources (trucks, etc.). Furthermore, the mobile resources have a need to communicate with the fixed resources.

There are no information systems on the market as off-the-shelf products that operators can buy for a moderate amount of money. The available information systems have to be adapted from systems that were originally designed for other purposes, such as manufacturing administration, or be developed in-house - something that is not feasible for a small or medium-sized operator due to a lack of resources. This results in most SME transport operators lacking more modern information technologies, which, in turn, becomes a barrier to the necessary information exchange in many supply chains. However, if smaller companies have implemented some kind of information system, the systems are in most instances isolated and not capable of executing electronic communication as no communication modules are implemented, resulting in information handling being done manually by all parties whether or not they have advanced information systems. The communications are consequently done using traditional methods like phone and fax, which involves a great deal of manual work for all the involved parties.

In larger companies the communication routines are often automated. They have already established more advanced electronic data interchange systems (EDI) and other advanced communication modules for the most common information flows with the most important partners. The communication is mostly automated and up-to-date information is present when needed. Information technology is not a barrier to transport solutions. The main barrier is that the data from smaller parties has to be keyed into the system, which, in turn, lowers the economic benefits of the system as a whole and increases the risk of a lower quality of the information as repeated manual input increases the risk of mistakes.

THE REQUIREMENTS FOR DECISION SUPPORT SYSTEMS FOR INTERMODAL OPERATOR

Our pilot application will focus on the intermodal operator business where the operator manages the rail wagons throughout the whole supply chain. The general idea is to have a module that transmits information (e.g. location and the status of the wagon) to a data server attached to the wagon. From there, the information is available to all necessary stakeholders in real time through relevant IT systems and a dashboard. On the other hand, the intermodal company needs an ERP system for managing orders and operations. This means that the EURIDICE system's role is to gather the data from the wagon fleet and refine it into a usable form of information for the decision makers and other stakeholders. The EURIDICE system should interact with all necessary stakeholders in the following four areas:

1. Information sent from the device attached to the wagon. This information includes real-time location as well as status information.
2. Possibly information sent from the wagon device about communication with the cargo inside, or information sent to the EURIDICE system directly from a device attached to the cargo.
3. Information fed to the EURIDICE system by stakeholders. This information can be fed either automatically from their information systems or manually.
4. An interface to the users, which we call the EURIDICE Operation and Decision Support System (EODSS). This includes a business management support and analysis system for the intermodal operator and its business partners as well as an operator's dashboard (OD). These provide a versatile management support system for the intermodal operators and their customers and include elements of simulation, intelligent alerting, exception management, route selection and other decision support for different levels of decision makers.

These four areas are the general requirements for the system to be developed.

The fourth area is the most innovative part of our pilot application. The management support for supply chain level operation in intermodal operation does not exist. The management system is basically intended to be a tool for the intermodal operator's decision makers. On the other hand, the intermodal operator's customers and other business partners need to have access to the management system. The intermodal operators can offer their customers a tracking service and other reports. There are some common requirements for the management system:

- versatile reporting properties (software tools with which users can create their own reports, configurable reports for users, etc.)
- some plug-in software
- user access to the data and the data transfer to the user's computers
- almost real-time data and, possibly, adjustable updating frequencies
- history data warehousing
- browsers as the user interface
- configurable data transfer properties from the company's ERP system
- the management system could be designed according to the open-concepts idea.

The main challenges for the management and decision making for an intermodal operator are described in the Figure 1.

	Planning phase	Operational phase
 Top management	⇒ Market decisions ⇒ Customer selection ⇒ Collaborative partner decision	⇒ Cost monitoring ⇒ Profitability monitoring
 Sales personnel	⇒ Pricing decisions ⇒ Delivery time decisions ⇒ Customer service ⇒ Contract making	⇒ Cost monitoring ⇒ Profitability monitoring ⇒ Realization / deviations monitoring ⇒ Satisfaction monitoring
 Transport planner	⇒ Wagon choices ⇒ Route decisions	⇒ Efficiency monitoring ⇒ Success monitoring ⇒ Realization / deviations monitoring ⇒ Satisfaction monitoring ⇒ Interventions
Other stakeholders have their own tasks		

Figure 1. The requirements for the Decision Support System in the planning and operation phases.

All of these requirements need good security properties in the EURIDICE system. There is a need for tools for users to adjust their customers' access and rights to the system.

CONCLUSIONS

The political aim in Europe is to increase the use of intermodal transport in supply chains. The transport buyer is supposed to select the mode of transport offering the best combination of transport quality, cost and environmental effect (Floden, 2007). One of the main challenges for intermodal transport is to achieve competitive delivery times (ibid). Our purpose is to develop new ICT solutions for intermodal operations. With intelligent cargo solutions and advanced decision support, the system could improve the cost efficiency, visibility and supply chain level operations in intermodal transport processes.

The business impacts in EURIDICE are the improved transport processes and the new business opportunities. The improved transport processes can be measured and verified with KPI's, like turnaround of the wagons, loading and unloading times, the haulage of empty/loaded wagons, delivery times and some cost indicators. The new business opportunities are achieved by the possibility to measure various types of real-time information during the transport process and by the improved performance of the intermodal transport. This can possibly be measured with the increase in sales and the transported tons. On a more general level, the metrics could include calculation of environmental impacts in terms of CO_2 emissions and modal shift to rail and short sea shipping in terms of tons. The costs and delivery times of intermodal transport can also be measured and verified. An important factor with the EURIDICE system is that it will allow the involved parties to continuously analyze the performance of different operators and links. A system providing real-time performance data from the operations does not exist. The cost calculations could be done in ERP systems after the realised transportations, but the information from the operation level is not available with existing solutions. Our idea is to utilise the order and business level information from the ERP systems and integrate that data with real-time information from the operations. A better understanding of whole intermodal operator business could be achieved by combining the wagon level data and business information. The business improvement is possible when we have data available from back office systems and real-time transport-related data.

There is huge potential for intermodal transport to take a bigger role in global transportation chains. Our development of new innovative ICT solutions will contribute to the success of intermodal transport in the future.

ACKNOWLEDGEMENT
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TOWARDS A METHOD OF DESIGN AND GOVERNANCE OF A LOGISTICS CITY TO SUPPORT SUPPLY CHAIN MEMBERS

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ABSTRACT
Purpose: This research examines the design and governance of a 'logistics city' which exists to provide logistic and business services to manufacturers, distributors and transport companies in an international supply chain. It considers how the governing body of such a city will help the players involved to achieve their business objectives. A logistics city is defined as a concentrated area attached to a seaport and other cargo transport modes.

Approach: The parameters which are considered likely to influence the choice of the preferred type of governance are set down. The governance methods available are described. The research reviews existing 'logistic cities' and port cities containing *de facto* logistics cities to ascertain how they are governed and how effective they are. The logistics cities found are arranged on the 'driving' parameters to ascertain what clusters are formed.

Findings: Recommendation that the body responsible to govern a logistics city should be market reactive and incorporate a public/ private partnership.

Practical Implications and Value: The findings can be applied to future logistics cities in Melbourne and other suitable sites throughout the world.

Governing a 'logistics city'
This section defines a logistics city, the players involved in the city and the tasks the governing authority needs to achieve**.**

A logistics city is a concentrated area attached to seaport, cargo airport, rail network and road infrastructure (Nagel, 2007). It is a type of dense trade cluster which emphasises the close location of many firms feeding each other and, collectively, justifying a range of services (information communication systems, transport and warehousing and financial) which no individual firm could afford. A logistics city is a business area in which manufacture and service is carried out. This work serves imports to, or exports from, the local economy or adds value to goods in transit to destinations around the world.

Three key prerequisites are required to enable a logistics city to be formed (Nagel, 2007): Firstly a 'logistics hub' in a designated development area provides transport and storage connections for sea, air, road and rail cargoes. Such a hub comprises inter-modal terminals, distribution and consolidation centres, bonded warehouses, cross-docking and loading facilities and the requisite information communication services.

Secondly, a 'business services hub' provides adjacent professional and business help in, for example, accounting, marketing, information systems, office services, staff training and legal advice. It can be argued that such services can be provided quickly by electronic communication from the city centre or elsewhere. However there is a trend for major cities to have several business districts and there is evidence that proximity to effective services and a good public transport service (Duggan *et al.*, 2006) is a major plus for businesses. Since managers often require face-to-face contact with advisers, we believe a business services hub is an important enabler of a logistics city. Thirdly, high capacity transport systems are needed between the logistics city and cargo gateways to provide the required capacity over many types and urgencies of movement at acceptable costs.

Players Involved
A logistics city comprises:

- A number of manufacturers
- Organising management including lead authority

- Transport companies and third-party logistics operators
- Information systems and business services providers
- Inter-modal terminals including container loading and unloading depots
- Government offices
- Employees who work in the City and require transport and retail services

In a putative Logistics city in Melbourne, there will be existing manufacturers, transport, etc. plus new enterprises moving into the city. Organising management has a greater task looking after new enterprises, which are setting up in the City for the first time, than existing businesses, which already know the situation.

Tasks

The governing body of the logistics city must carry out or delegate the following tasks:

- Creating an environment which is attractive to business, so they choose to set up in this logistics city rather than elsewhere.
- Assisting with the provision of licenses to manufacture and operate.
- Governance: to ensure that the major stakeholders (government, the enterprises, the workers) are satisfied with the facilities and services provided.
- Providing information and communication technology services to businesses.

DEFINING GOVERNANCE AND A 'LEAD AUTHORITY'

The OECD's definition of corporate governance is used as a guide to city governance:

Corporate governance is the system by which companies are directed and controlled, in the interest of shareholders and other stakeholders, to sustain and enhance value. (OECD quoted in Ernst and Young, 2003)

For private companies, *Governance* comprises the relationship among various participants in determining the direction and performance of corporations. (Monks & Minow, 2001). Primary participants are shareholders, management, lead by the CEO, and the Board of Directors. Other stakeholders include employees, customers, suppliers, creditors and the community

The core capabilities of a firm comprise (Leonard-Burton, 1992 cited in Croom and Batchelor, 1997):

1. Skills and knowledge of employees
2. Technical systems
3. Managerial systems
4. Values and norms associated with embedded knowledge in the organisation.

By comparison, governance of a logistics city comprises:

a. Governing board
b. Management
c. Businesses located in the City.

Lead Authority

The most important contributions of a 'lead authority' (or 'champion agency') are to set the industry areas that will be covered in the logistics city, to engender a climate attractive to business, provide support services and to administer the achievement of the businesses in the city. These duties will be carried out in consultation with the primary participants and other stakeholders. The lead authority will conduct the policy, actions and affairs of the city.

EXAMPLE OF LEAD AUTHORITY

The Working group on Logistics (International Enterprise, Singapore, 2002) argues for a lead authority, which it calls a Champion Agency (CA) "to coordinate the government's efforts and act as a one-stop shop for logistics promotion". This Agency must have four attributes:

1. **Mandate:** must be empowered by its Government Ministry to promote and develop the logistics and transport industries in Singapore.
2. **Authority:** needs to be lead by a CEO with sufficient experience to command the respect of industry. The CA is a bridge between the private and public sectors, so it must understand industry needs.

3. **Resources:** must be given sufficient resources to do a good job of promotion and development. This should include incentive tools to promote desired activities in transport and logistics.
4. **Deliverables:** measured by the achievement of value-adding industry performance.

Tasks of the lead authority are:

1. Work with government agencies and industries to provide a one-stop shop for promoting logistics.
2. Work with government agencies to remove all unnecessary regulations which hinder the development of a supply chain management (SCM) hub.
3. Identify industry's development needs and work with the requisite government agencies and industry to address those needs.
4. Promote the City as a hub for SCM, transport and logistics activities.
5. Assist locally-based players to expand overseas.

PARAMETERS TO PREDICATE GOVERNANCE

Three parameters which are considered likely to predicate the required governance as follows (This assumption is derived from the governance situation):

1. Public or private ownership of lead authority. There are a number of hybrid forms between the extremes.
2. Centrally planned or market-oriented philosophy.
3. Size of logistics city. This would be influenced by the size of the metropolitan area in which the logistics city, or cities, is located.

This approach establishes criteria to show where a particular logistics city sits on each dimension.

Parameter 1, Ownership

Public ownership means that the lead authority is an arm of government directly responsible to a minister in government and responsible to him/her for all operations. Private ownership means that the lead authority is a monopoly operated under license from government but without direct government interference.

Parameter 2, Planning Philosophy

Centrally planned means that all operating regulations are permanently determined by the government, to which the authority reports. Market philosophy means that the authority responds as a 'clearing house' for the wishes of its 'tenant' companies and other stakeholders, so that regulations will change from time to time.

Parameter 3, Size

The size of the logistics city is preferably measured by the value added by the businesses in it. In the absence of value added figures, turnover, area occupied and number of companies are practical surrogates.

The methods available and existing examples are given in this table and compared in Table 1:

METHODS AVAILABLE	**EXAMPLE**
Government department	Dubai Logistics City; Aqaba SE Zone; Lingan, Shanghai
Private company	Rotterdam
Quasi-autonomous government Organisation (Quango)	Singapore Statutory Boards, e.g for the port

Table 1. Comparison of various methods of governance

Method	Advantages	Disadvantages
Government dept.	Can dismantle barriers	Less business efficiency
Private company	Less bureaucratic, more effective	Less response to government wishes
Quango	Arms length relationship with government provides some of the benefits of private companies.	May not be as efficient as a private company

Using the information from the following section, Figure 1 shows how various logistics cities are placed on the three parameters stated above:

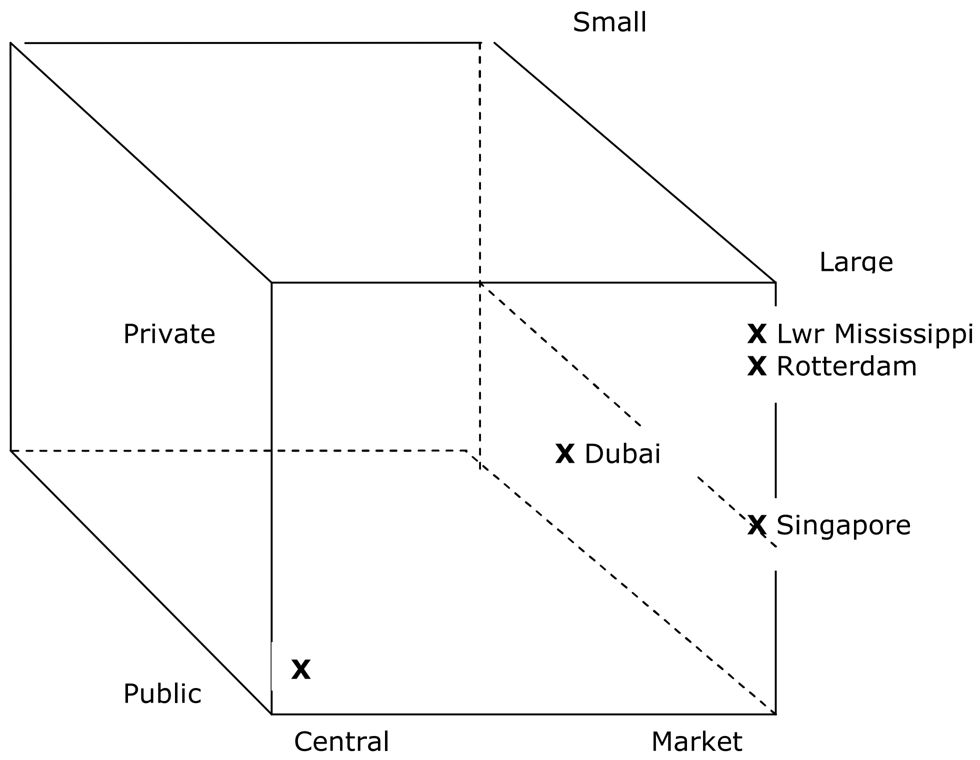

Figure 1 Cities against parameters (* means planned)

State control is repeatedly found to be detrimental to market efficiency of business (Goh, 2005, p 216). The role of government (in assisting innovation) is to dismantle and minimise barriers and restrictions (Goh, p 221).

Where private Free trade zones have been attempted, most face unfair competition from government run zones operating on subsidies. This is a major factor in FTZ development in Turkey, Egypt and Jordan (Hockman & Kheir, 2000). Most notable trend over the past fifteen years (to 2000) is the growing number of privately owned and operated zones and industrial cities worldwide. Most private zones are found in Latin America and the Philippines.

The increasing role of the private sector in zone development is changing public/private sector interactions. In traditional projects, government provides on- and off-site infrastructure, facilities and basic services. To help private zone development, innovative public/ private partnerships are used.

REVIEW OF EXISTING 'LOGISTICS CITIES'

This section examines some existing logistic cities to see how they are governed and how effective they are in their own contexts.

1. Singapore

A distinctive characteristic of Singapore that directly impacted the Port of Singapore Authority (PSA) is the use of a free market economy combined with state control by Statutory Boards (SB). The SB is an autonomous government agency institutionally separate from the Singapore Civil Service and expected to be financially independent and profitable. By the 1980s, Singapore had

86 SBs. As an SB, the PSA possessed a rationalised commercial environment that allowed it to be far more competitive than other regional ports (Airriess, 2001).

Critical to Singapore's goal of becoming a competitive global ICT hub was the creation of a national ICT infrastructure enabling inter-industry exchange of information and an interfaced network between domestic and international activities.

A further important ICT- based development is linked to the city-state's role as a product logistics centre in the regional production system. The PSA has adopted the concept of a 'distri-port' to add value to trans-national corporation products by operating large multi-stored warehouse space in four separate 'distri-parks'. These parks allow for consolidation, deconsolidation and other functions of cargo handling, promoting seamless movement between the distri-park and container terminals. The space intensive Keppel Distri-park is located in a free trade zone and is the most IT automated (Airriess, 2001).

2. Dubai

Free trade zones (FTZ) in United Arab Emirates have become the primary source of employment, inward investment and exports in non-oil industries. The Jebel Ali FTZ accounts for more than half the non-traditional exports from Dubai. Inward investment grew to 5500 companies in 2006. Purchase of zone-based enterprises from the domestic market exceeded $700 million in 1997 (Hoekman & Kheir-El-Din, 2000).
However, the UAR free zones are criticised on three grounds:

1. Most FTZ enterprises are engaged in trading, rather than manufacturing.
2. FTZs employ expatriate labour from India paid at low wages compared to UAE.
3. It is unclear whether FTZs in UAE have made a net positive contribution to the country compared to large public sector expenditure.

Dubai has an important advantage as a logistics city because its leadership 'has been strong and endowed with great vision' (Melodena *et al.,* 2008). This is demonstrated by the construction of the city metro rail which has proceeded from a vision in 1997 until it now carries 1.86 million passengers per day. A new airport, being built in Jebel Ali, is expected to handle 12 million tonnes of cargo p.a. rising from the current 1.5 million tonnes. Dubai is ranked fifth in the world for positive image abroad encouraging business development in the World Competitive Yearbook (IMD, 2005)

3. Lingang, Shanghai

Lingang New City, near Shanghai, P.R. of China, is being constructed 75 km. outside Shanghai CBD. It will cover 300 Km^2 with borders on the Yangtze and Dazhi rivers and a major highway. Lingan will comprise a heavy equipment industry and logistics park, a main industry park, a CBD area and a multi-purpose area. The heavy equipment park is being built first. (www.investment.gov.cn/ 2005.10.27 accessed 16.9.2008).
Lingang aims to be a centre for 'international producer service industry', focusing on logistics and a 'state-level' modern production base. Its modern and high-tech industry is planned to comprise advanced manufacturing, distribution, export processing and education. Lingang has policy support from the 'most open and protective policies' (sic). The country has granted bonded port policies to attract investors, so that it is outside the customs administration.
At least during the construction phase, the new city development is run by government agencies and officers. The 'leader in charge' is the vice-mayor of Shanghai. The relevant government department is the Economy and Trade Division.

4. Lower Mississippi port cluster

Work by de Langen and Visser (2005) shows that the competitiveness of a seaport's trade cluster depends upon the importance of local governance and collective action regimes. Five variables that influence the quality of a collective action regime are:

- Presence of leader firms
- Participation of public organisations
- Presence of an organisational infrastructure

- Presence of community argument (i.e. voice in support)
- Voice of individual firms

The Lower Mississippi port cluster (LMPC) is the largest port in the continent of America by volume of cargo throughput, some 420 million tonnes in 2002 (ibid). It contains New Orleans. Five municipal authorities administer the LMPC through boards of commissioners but the trade clusters are believed to be market governed. de Langen and Visser conclude that the LMPC has performed poorly over the last decades (2005).

5. Rotterdam

The Port of Rotterdam and its industrial complex cover 10,500 Ha and stretch 40km from the city to the Maasvlakte along a canal (Port of Rotterdam 2008). The Port is directly situated on the North sea and has excellent hinterland connections via five modes of transport. Rotterdam was the world's busiest port from 1962 to 1986, now overtaken by Singapore and Shanghai. In 2006 it was the world's seventh largest container port by volume.
The Port added the following value, in million Euros in 2005:

Transport including services and storage	5,551
Business located in industrial complex	5,349
Total	10,900

Annual throughput was 400 million tonnes
Most important industries are petrochemical and general cargo trans-shipment.

Governance of the Port of Rotterdam is undertaken by the Port of Rotterdam Authority, a government corporation called 'Havendrift Rotterdam NV' Its objective is to operate the business of the port and strengthen the position of Rotterdam port and industrial complex in a European perspective. That is, its development, construction, management and operation. The company is managed by the Board of Management, under the supervision of the Supervisory Board, members of which are appointed by a general meeting.

RECOMMENDED BODY TO GOVERN A LOGISTICS CITY

The above investigation of five logistic cities, in the broad sense, shows that all except Lingang are large and operate in a market domain (rather than being centrally planned). There is a range of public and private ownership.
With the limited information available, it is recommended that the most appropriate form of governance for a logistic city in Australia would be market reactive under a public/private partnership. It should be noted that a future Australian logistic city is likely to be much smaller than the cities investigated. This could affect the relevance of comparisons with global leaders.

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NEW INLAND TERMINALS - IMPORTANT STEPS WITHIN THE DEVELOPMENT OF THE PORT OF KOPER

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ABSTRACT

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. 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. Penetrating and exploiting these markets demands cooperation with existing inland terminals (logistic centres) and establishing of new ones positioned between Eastern and Western Europe (Adria Terminali, regional logistics center "Panonija", inland container hub-rail port Arad, Romania…).

This paper aims to present: (I) supply chains of the flow of goods through the Port of Koper to/from the countries of Central and Eastern Europe (II) the current state and strategies to optimize the flow of goods, (III) market potential, investments in new terminals and capacities.

Key words - Port of Koper, strategies, goals, supply chains, new terminals, market potential, investments, competitiveness

INTRODUCTION

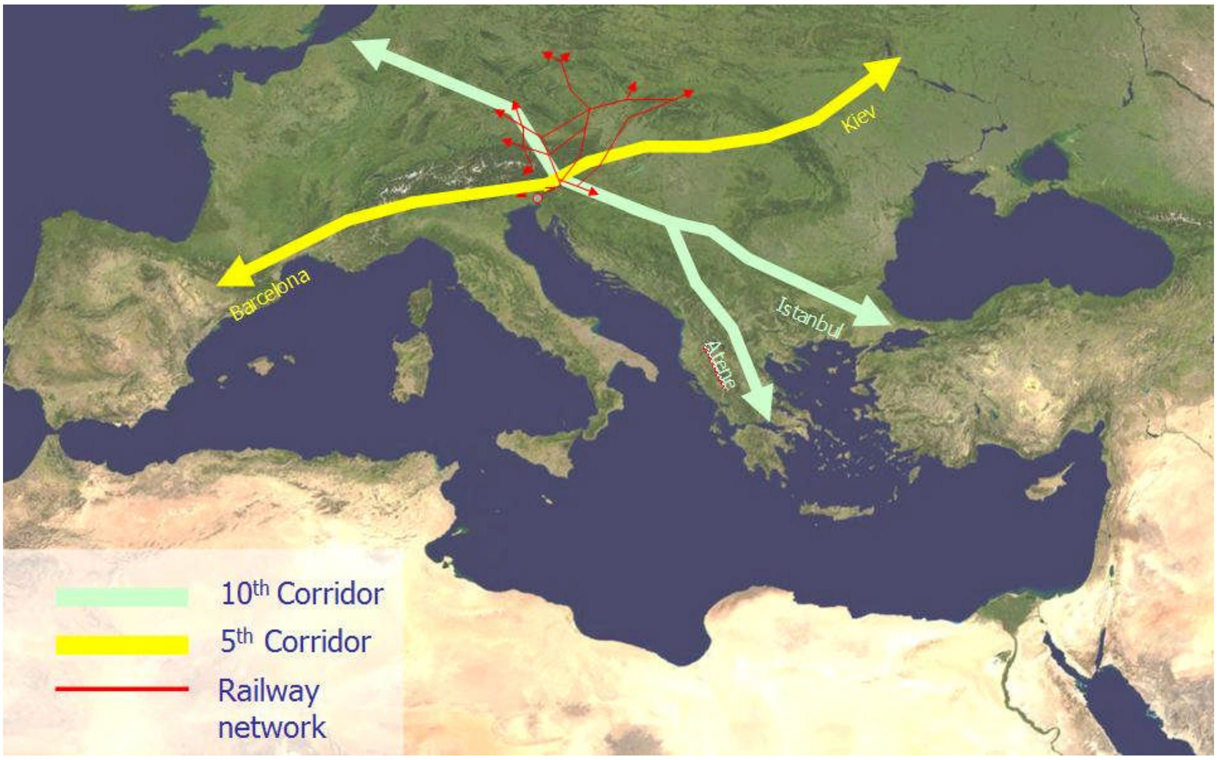
Today, the Port of Koper must direct its efforts more to the hinterland and to the foreland to initiate and organise various participants. Operational efficiency of the transport-logistics cycle is affecting, by all actors involved: linear companies port authorities, stevedores, forwarders, agents, hinterland transportation modes as well as inland terminals. With the development of inland terminals, a new dimension is being added: logistics players are now making best use of the free time available in seaports terminals and inland terminals, thereby optimizing the terminal buffer function.

As a result, transport terminals are achieving an additional level of integration within supply chains that goes beyond their conventional transshipment role. Given increasing levels of vertical integration in the market and an increasing pressure on port capacity, a further terminalization of supply chains is likely to occur, which will strengthen the active role of terminals in logistics. (Jean-Paul Rodrigue & Theo Notteboom 2008).

THE PORT OF KOPER

The Port of Koper is some 2000 nautical miles closer to destinations east of Suez than the ports of Northern Europe. From Koper there are regular and reliable shipping container lines to all major world ports. More than thirty container lines use the Port of Koper. Land transport from Koper by road and by railway to the main industrial centres in Central Europe is approximately 500 km shorter then from North European ports. Some two-thirds of cargo is transported by rail, which means that more than 500 wagons arrive and leave the port on a daily basis.

Fig. 1: Maritime connections and main transport corridors important for Slovenia



The Port of Koper is a public limited company and operates as a holding. The strategy of the port company, as well as the changes in functional policies should contribute to build up a higher competitiveness and a more efficient operation.

The strategy of the Port of Koper is based on the following basic directions:

- 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 entire area of the Port of Koper including the development area extends over 1,600 hectares.

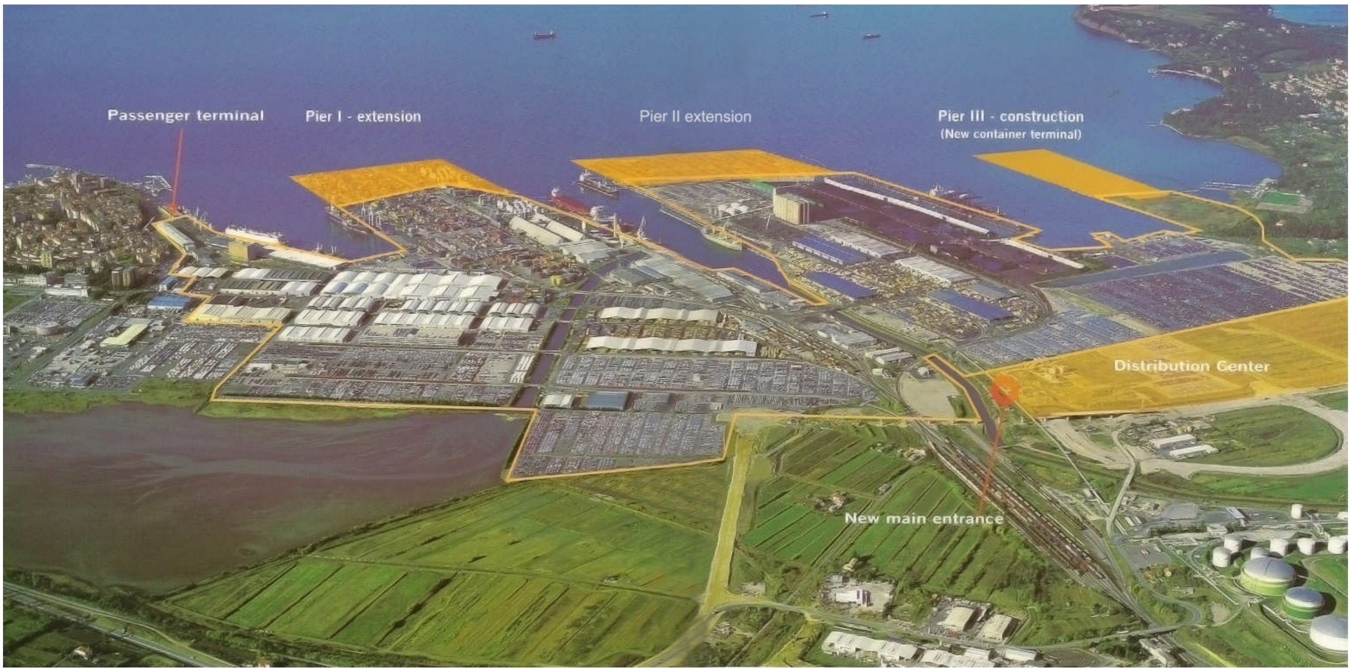
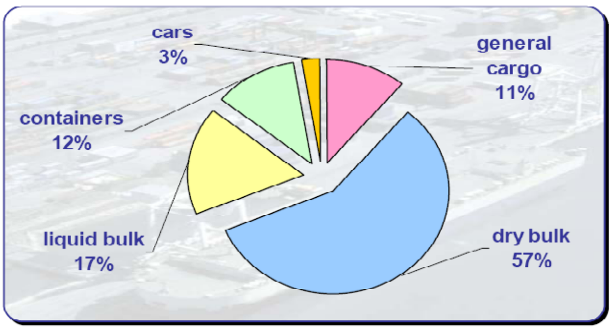


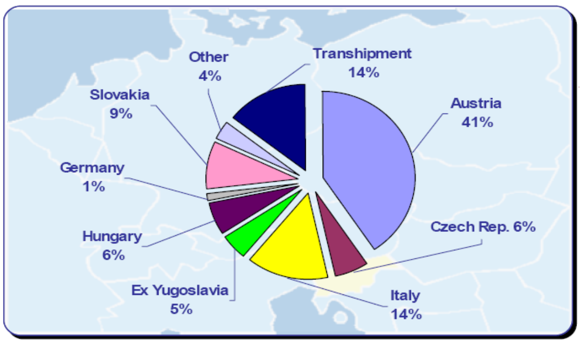
Fig. 2: Location of the Port of Koper

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. It 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 and also for Ukraine and Russia. 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.

Graph 1: The Port of Koper is a multipurpose port



Graph 2: The Port of Koper is a transit port



Source: The Port of Koper

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, Terminal for Minerals, Terminal for Cereals and Fodder, European Energy Terminal, Alumina Terminal, Liquid Cargoes 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.

The entire territory of Port of Koper has a status of a Free Trade Zone a part of which is used for storage, distribution and processing, remaking of commodities, a part is intended for performance of various industrial, trade and financial activities. The Port of Koper has the certificate for quality for complete port services. ATNET - the information exchange network has been established for support and easier distribution of documents between Port of Koper authorities, Custom, Shipping and Forwarding Agencies. In the Port of Koper a lot of attention is devoted to the environmental concern. For several years the Port of Koper is actively collaborating with the competent institution. In April 2000, the Port of Koper acquired the certification of its system according to the ISO 14001 standard, whilst in May 2006 this certification was upgraded to ISO 14001:2004. On the basis of survey results, the management of the company decided to initiate a project for establishing a system of human resources development. A special place in the Port of Koper is dedicated to the development of programmes to further innovation: a substantial rise in innovation can be attributed to that policy. The innovation concerned have contributed to productivity rise, improvement in the quality of services, or savings in material or time, safety at work improvement, or ecological friendliness, resp.

The year 2008 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 -16 million tons (record was also reached in the container traffic with 353,000 TEUs). In addition to investments in technological modernisation, in connection with the further development of container services, the preparations for the construction of a new container terminal (Fig. 2) on Pier III are accelerated (enabling total transhipment of 1,000,000 TEUs). In all, 36% of the handled cargo was designated to or coming from the Slovenian market and 64% to or from hinterland countries.

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 Port of Koper envisions its possibility of further development in highway and railway connections in the direction Ljubljana-Maribor with a branch to Austria and Hungary. Taking into consideration all that, the geo-transport position requires a more rapid construction of the highway and railway network, chiefly in the main transit connections through Slovenia – the 5^{th} and 10^{th} Paneuropean traffic corridor for which also the European Union is interested (and also prepared to provide the funds for the construction).

The Port of Koper is one of the most relevant generators of the development of transport. 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.

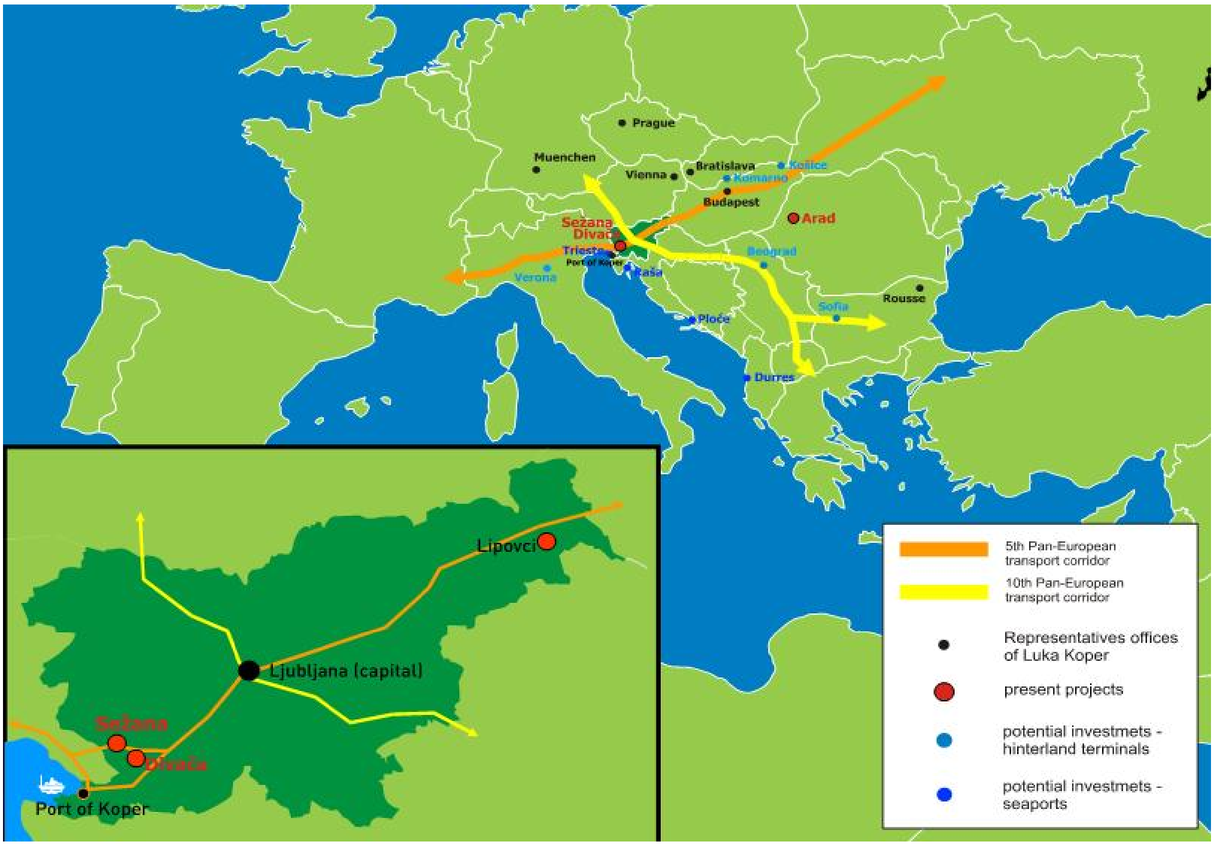
PRESENT PROJECTS AND POTENTIAL INVESTMENTS OF THE PORT OF KOPER

Beside the aforementioned activities, the Port of Koper wishes to develop new activities from which the cooperation of the Port of Koper with existing inland terminals (logistic centres) and establishing of new ones positioned between eastern and western Europe stand out.

THE ADRIA TERMINALI

Adria Terminali d.o.o., is the newest affiliated company in the Port of Koper (Luka Koper Group). Its primary objective is to provide customers with quality, safe and reliable services tailored to their needs and requirements. It is a part of the strategically important Sežana Logistics Centre (Fig. 3) located on the Pan-European Corridor V, adjacent the Italian frontier with excellent motorway and rail connections.

Fig. 3: Location of the Adria Terminali (Sežana), regional logistics center "Panonija" (Lipovci) and inland container hub-rail port Arad

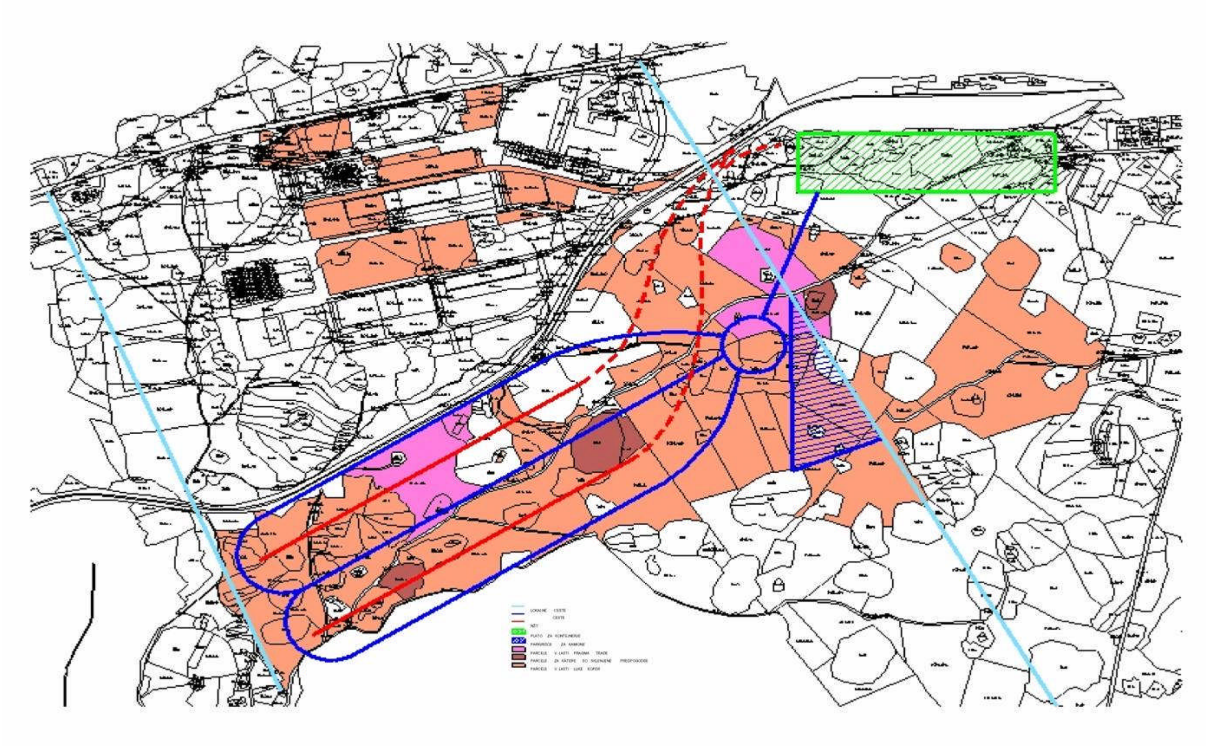


It has two primary orientations:

- To complement the services provided by Luka Koper at its terminals in the nearby Port of Koper
- To penetrate and exploit new markets as an inland logistic centre positioned between Eastern and Western Europe at the very head of Adriatic Sea, the northernmost reach of Mediterranean.
-

In Adria Terminali there are great development potentials, due to the possibility of expansion of facilities as well as the provision of new services in accordance with market needs.

Fig. 4: Development of European Distribution Centre



- 120,376 sqm area,
- 55,600 sqm storage area,
- 16,600 sqm enclosed storage,
- 37,800 sqm open storage,
- 3 x 2,700 m railway tracks,
- The greater number of cranes and forklifts,
- 98 employees,
- Fruit and vegetables packing facility.

The regional logistical centre "Panonija"

The rise of transport, needs of the market and the need to lower logistical expenses are one of the main reasons and pointers which urge the establishment of the regional logistical centre "Panonija" – Lipovci (Fig. 3). The transport of goods through the Port of Koper for Austria and Hungary has greatly increased, especially the transport with Hungary. Most of the transport for the Hungarian market is with containers and with grain cargo (wheat, corn). The most important groups of goods for the Austrian market are containers, wood and grain cargo (soy, minerals, ore).

Taking into account that the quantities of goods for the clients are continually rising and demands for punctual logistical services are continuously being pointed out (ex. the delivery of smaller (non-container) consignments through the just-in-time system)) it is a logical consequence that companies are considering concentrating the needed goods in the vicinity of markets in the western part of Hungary and eastern Austria.

Inland container hub – rail port Arad (Romania)

The Romanian Arad is interesting for the Port of Koper because it is located on the axis of the fourth European corridor. It connects Germany, the Czech Republic, Slovakia and Hungary but right in western Romania it splits into branches to the Black Sea and the Aegean sea. The Port of Koper and also the ports emerging European logistical centre in Sežana will be connected with the terminal in Arad with block trains. The land container terminal in Arad is otherwise part of a greater terminal centre there, which measures altogether 55 hectares. It is managed by the Slovak multinational Trade Trans Terminal in which the Port of Koper has entered with a 26 per cent share, which assures control over the management of the entire logistical centre. The Port of Koper and the Slovak logistic are also connecting crosswise. The Port of Koper has recently sold a 49 per cent share in the Adria Terminals company, which manages the European logistical centre in Sežana, to the Trade Trans Terminal company.

Fig. 5: Location and distance comparison of the inland container hub – railport Arad (Romania)

Distance comparison

Distances to major cities:

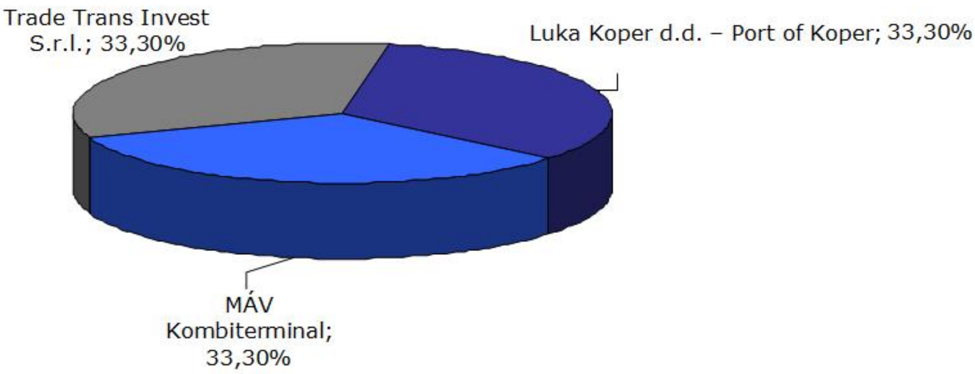
Budapest	274 km
Beograd	211 km
Sofia	597 km
Skopje	641 km
Sarajevo	513 km
Kiev	1288 km
Bratislava	468 km
Ljubljana	744 km
Milano	1242 km
Wien	511 km
Chisinau	815 km

Distances to ports:

Port of Koper	845 km
Constantza port	770 km
Burgas	884 km
Varna	803 km
Rotterdam	1682 km
Hamburg	1444 km
Antverpen	1620 km
Thessaloniki	905 km

The Port of Koper has become the third owner of the company Rail Port Arad, which will construct a land container terminal. The other two partners are the Hungarian MAV Cargo and the Slovak Trade Trans Invest. The new terminal will cost 1.5 million euros. It will spread over ten hectares and there it will be possible to move 60.000 TEUs a year, which will influence the increase of transport of containers in the Port of Koper.

Graph 3: Ownership and strategic partnership



Adria transport d.o.o. – the first private railway operator in Slovenia

Adria transport d.o.o. is the first private railway operator in Slovenia which objective is to give a strong support to the terminal activities in the Port of Koper. It was found in the year 2005 with the ownership and strategic partnership of: 50% Port of Koper and 50% GKB (Graz Kőflacher Bahn und Bustrieb - Austria). It has safety certificate (via GKB licence) for railway operations on Slovenian territory, enabling fast delivery of goods to/from the Port of Koper, offering afficient block-train connections between the Port of Koper and inland terminals (Sežana, Lipovci, Arad …)

The firm has until now invested in transport equipment, mainly wagons which are not easy provided by other operators:

- 3 locomotives Siemens Taurus
- 25 Rgs wagons for transportation of containers, additional 40 orderd
- 40 Laekks wagons ordered for transportation of cars

CONCLUSION

Today, the countries of Central and Eastern Europe (CEE) have developed into a fast growing and promising part of Europe. The vision of the management of the Port of Koper is to become the most important logistic centre for these countries. Penetrating and exploiting these markets demands inland terminals positioned between Eastern and Western Europe. Transport terminals are the main regulators of freight flows and as such considerably influence the setting and operation of supply chains in terms of location, capacity and reliability. That's why present projects and potential investments are important steps within the development of the Port of Koper.

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LOGISTICS AND TRANSPORTATION OF PERISHABLE GOODS IN PORT OF KOPER

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ABSTRACT
In the last decade the growth of import and export of fresh fruit and vegetables in Europe was about 8 % per year with the trends of further growth. The main characteristic of the fruit and vegetables industry is a need to meet delivery deadlines in a very short time and reduction of total costs. Creation of logistic platforms is one of solutions to improve efficiency. In the paper will be analyzed the new logistic model for distribution of highly perishable goods in the Port of Koper.

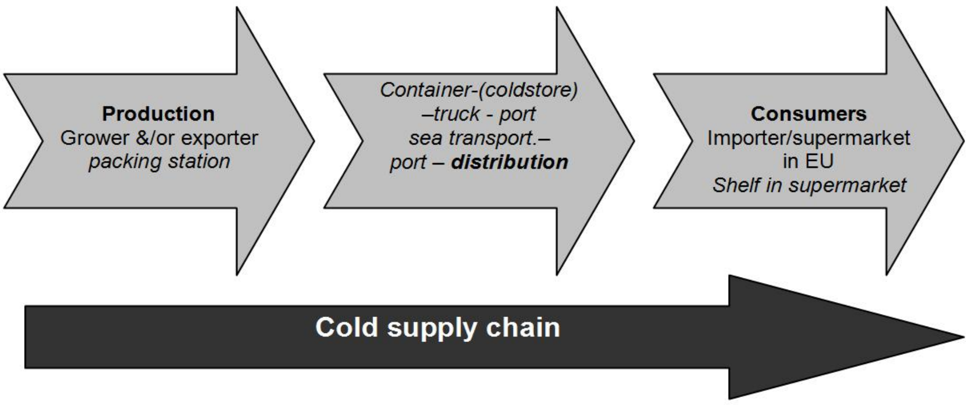
KEY WORDS: perishable goods, logistics, Port of Koper

INTRODUCTION

In the distribution of the fruit and fresh vegetable logistics plays an important role. The high quality of logistic services could be achieved if the partners are aware of the supply-chain system and its behavior in order to have an efficient response to the customer needs. Changes in the business environment have contributed to the development of supply chain networks, change in products etc.

The difference between "normal" supply chain and fresh produce supply chain is that during the process of unloading the container and loading the pallets on truck as per received order from buyer (via coldstore or in direct manipulation), the goods have to be released from phytosanitary and health inspection, inspected by the surveyor (sorted if necessary) and customs cleared.

Figure 1: Fresh produce supply chain



Good information flow within the supply chain is of vital importance to perform fast distribution from arrival of goods into the entry port till delivery to final destination. One of solutions to improve transport efficiency is in creation of logistic platforms witch have different functions regarding (E. Twrdy, L. Lanini, 2008):

- change of modality - the infrastructure is used as "transit point" where the change of modality or of means of transport can take place without necessarily proceeding with storage (cross-docking)
- integration of in/out flows - the infrastructure is used as a "hub" for activities such as consolidating/de consolidating goods and optimisation of the freight near either production areas or destination markets.
- integration of logistic services - the infrastructure is used as a place to organise and carry out logistic activities or services such as: multipick, multidrop, flow integration for

more companies and outsourcing to the third parties, outsourcing of the stock management, change of packaging, unitization and emptying containers.

The three functions are not alternative to one another and they jointly contribute to the increase in value of the product in terms of service content and market proximity.

FRUIT TERMINAL IN THE PORT OF KOPER
Fruit terminal in the Port of Koper is a modern terminal equipped with modern computer-controlled storages, where the temperature, humidity and air circulation can be regulated. There are 450 m of quayside with 3 berths and the sea depth is -8 to -11meters.

Figure 2: Location of fruit terminal

The fruit terminal at the Port of Koper handles cargo arriving mainly from: Ecuador, Costa Rica, Colombia (bananas), Israel, Egypt, Latin America and South Africa (citrus and other fruits) and vegetables from Egypt, Israel and Cyprus. In 2008 they had handled almost 200.000 pallets of fresh produce, 94.000 tons of bananas and the remaining quantity in container arrivals, mainly from Israel and from Egypt. Similar increasing trend has been noticed in banana arrivals – from 27.000 tons in 2007 to 94.000 tons in 2008 and being followed by a further growth in 2009 (till mid of March already 40.000 tons)(M. Jerman, 2007).

Table 1: Cooling facility in Port of Koper

warehouse from 0°C till +20°C	18,600 m2
refrigerated spaces up to -25°C	2,000 m2
ripening capacities for bananas	1,800 tons/month
palletize	600 pal/day
max. storage capacity	12,800 pallets

Additional services are sorting, ripening and palleting of bananas, weighing, selecting, packaging, labeling… The terminal provides its services 24/7. Port of Koper is the only Adriatic port that is able to load empty frigo containers back on the same ship that brought the cargo to the port (same ship / same voyage).

Table 2: Unloading capacity

Break-bulk (loose cartons)	1,000 tons/day
Pallets	2,000 pallets/day
Vessels at a time	3
Unstoring of reefer containers	120 ctns/day

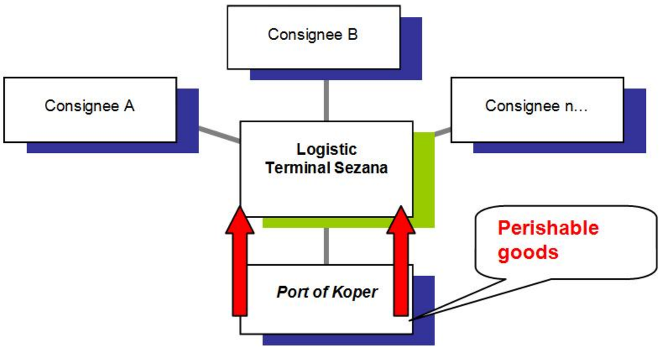
Challenges for Port of Koper are based on:

- growing demand in Central & Eastern Europe
- serving Europe from the South - request for deliveries from Adriatic
- direction to seafreight as alternative to airfreight deliveries
- shorter transit times,
- cost competitiveness & direct distribution to destinations,
- freshness, efficient connection between consumption and production areas.

POTENTIAL OF KOPER PORT TO FURTHER DEVELOP A FRESH GATEWAY INTO EU

The success of a seaport depends on the ability to effectively integrate the port into the networks of business relationships that shape supply chains. Well organized and managed supply chain for fresh produce via Koper is a good case. Adria Terminali, d.o.o. a new company, the youngest in the Luka Koper group is operating the inland terminal in Sežana (30km from Koper, access via Italy only 20 km). Terminal in Sezana is now operating at 50.000 sq meters of storage facilities, they provide storage and distribution services for various types of cargo. This terminal has a favorable location adjacent the 5th and 10th pan-European transport corridors, direct connection to railway and motorway network. New coldstore capacities in Sežana are 800 pallets in 2 chambers. In the refrigerated (125 m2) and freezer (70m2) warehouses they store packed products with vegetable or animal origin by the temperature from -26 º C to 15º C. This terminal is dedicated to develop fresh produce distribution, there is also packing option of fresh produce (lack of space at the Fruit terminal) besides dry cargo distribution.

Figure 3: The role of "cold platform" in Sežana



Terminal Sezana could perform the functions of collection, sorting and distribution of highly perishable goods, mostly fruits and vegetables. The location close to all three North Adriatic ports (Koper, Trieste and Rijeka), the possibility of applying the rail transport would contribute to the optimisation of road freight vehicles operation and its environmental impact in the wide area. In the next step this terminal could develop all three main functions of logistic platform for perishable goods in area of North Adriatic.

CONCLUSION

The ports of Northern Adriatic do not just cover the needs of national economies but also the needs of hinterland economies, and when it comes to (fresh) fruits and vegetables also the demand of EU market and industry. This is possible because of favorable geographical position, modern terminals with state of the art manipulating equipment and storing capacities and good inland connections. Terminal in Sezana could be a good starting point for the creation of new logistics chains and platforms in the connection of the Mediterranean countries with North and Central Europe. Developing additional value added services on arrived goods at the port and at the inland terminal in Sezana would give additional incentive in gaining of new volumes (initiative to build an Egyptian Distribution Center, attracting more dry cargo potential on the same vessels…)

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LONGEVITY OF TECHNOLOGICAL COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDERS? A COMPLEXITY SCIENCE BASED ANALYSIS OF AUTONOMOUS CO-OPERATION TECHNOLOGIES

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ABSTRACT

This paper intends to analyse the problem of longevity of technology based competitive advantages for logistics service providers, as it is important from the view of investment theory. Autonomous co-operation technologies are illustrated as an example for technologies that can lead to competitive advantages for companies within international supply networks. However, suchlike technologies can lead to path dependencies, which affect the longevity of these advantages in positive as well as negative ways.

INTRODUCTION

The market for logistics services has become more and more competitive during the last years caused by similarities of offered services as well as an increased number of competitors, resulting beside others from open boundaries (Klaus & Kille 2006). Therefore, these services can either be differentiated through price variations, which can lead to price wars and to a decrease in the margins of logistics service providers. Or a differentiation can be reached by enriching the logistics services with additional value for the customer (Christopher 2005). One possibility to generate "value added services" in so-called International Supply Networks (ISN) (Hülsmann and Grapp 2005) is the implementation and usage of new autonomous co-operation technologies like RFID or Sensor Networks (Hülsmann et al. 2008). They can be used to provide services like quality control for perishable goods or a higher adherence to schedules (Hülsmann and Grapp 2008). Due to the fact that technologies could possibly be copied, imitated or substituted by other competitors, the longevity of suchlike competitive advantages is in doubt (Barney 1991). Hence, this paper aims to answer the following questions: Are autonomous co-operation technologies able to create long-living competitive advantages? Which determinants influence the longevity of suchlike technology based competitive advantages and are there possibilities for logistics service providers to control them? Hence, the objectives of this paper are threefold: (1) A description of autonomous co-operation technologies based competitive advantages for logistics service providers shall be given. (2) A causal identification of challenges resulting from the problem of longevity of technology based competitive advantages and possible drivers for this longevity shall be deduced. (3) Possibilities for the management practice of logistics service providers regarding the extension of the longevity of technological competitive advantages shall be given.

Hence, for a description of technological competitive advantages of logistics service providers, the paper sketches challenges and characteristics for the longevity of technology based competitive advantages in ISN (Hülsmann & Grapp 2008) (section 2). Following that, a brief description of autonomous co-operation technologies will be given and used as an example for technologies that might enable logistics service providers to provide their customers additional values in order to differentiate from their competitors (section 3). Then, positive as well as negative effects on the longevity of technological based competitive advantages resulting from path dependencies will be analysed (section 4) in order to be able to derive implications for on the one hand the management of logistics systems and on the other hand for further research (section 5).

THE RELEVANCE OF LONGEVITY OF TECHNOLOGY BASED COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDER

Nowadays, phenomena like real-time economies (information are available and interchangeable in real-time caused by the performance of computer systems) (Siegele 2002) and hyper-competition (increasing rivalry of competitors due to global interdependencies of purchasing, producing, and sales) (D'Aveni 1995), logistics service providers have to face complex and perpetually changing settings of environmental requirements (Hülsmann and Berry 2004). Beside the increasing rivalry and increasing number of competitors (Klaus and Kille 2006), this results from cost increases (e.g. gasoline) (Pfeiffer 2008), and increasingly ambitious customer demands regarding quality and speciality of logistics services (Ullmann 2006). Furthermore, the margins of Logistics service providers are decreasing over time. This can be reasoned in difficulties to pass increasing costs down to customers, which is a result of long-term contracts, a rise of customers' bargaining power, and price competition, provoked by the high number of competitors (Klaus and Kille 2006). Hence, growth potentials for logistics service providers can be realized through "Value Added Services" (e.g. packing of goods, mounting, quality control) (Pfeiffer 2008). Every added service, that allows customers of a certain company to improve its own services (e.g. Amazon`s Over Night Express) and therewith to demand higher prices from its own customers, constitutes higher values for this company (Porter 2008). In consequence, this influences their preparedness to pay higher prices for the logistics service provider's services. Moreover, if no competitor is able to imitate or substitute this service, its uniqueness entails, that no competition for prices will emerge and higher margins for logistics service providers are possible. Therewith, a logistics service provider's survivability depends on his ability to create competitive advantages by offering unique services and the possibility to reach higher margins (De Wit and Meyer 2005). However, to maintain this survivability the competitive advantages have to be long living. Hence, the longevity of competitive advantages is jeopardised by the competitors trying to offer the same or a similar service for the market. In this case, the longevity can be described as the ability of the advantage to resist against the behaviour of competitors, due to difficulties respectively impossibilities to imitate the companies' competences the advantage is based on (Porter 1985). Thereby, an advantage becomes long living, which leads to a durable unique selling proposition for the logistics service provider and a possibility to reach higher margins than competitors. Furthermore, the longevity of competitive advantages is also important from the view of investment theory. Technology based competitive advantages usually result from investments in the respective technologies and their implementation. Investments can be defined as target-oriented input of funds for the acquisition of goods or services (e.g. the several technology parts) (Perridon and Steiner 2002). To gain competitive advantages (target orientation), there are acquisition- and labour costs (input of funds) for the several technology parts and for their implementation into the working process. Due to the fact, that an investment with the aim to create competitive advantages commits capital, the importance of the longevity depends on the possibility of the investment's amortisation (Perridon and Steiner 2002). According to Müller-Stewens and Lechner (2005), the possibility to create competitive advantages as well as its longevity, presupposes several factors: Firstly, competitors have to be heterogeneous in order to be able differentiate themselves from others. This heterogeneity and therewith the longevity of technological competitive advantages depends on the market's characteristics, due to the fact that the longevity is determined by the market's imitation,- innovation,- and substitution-rate (Rasche 1994). To be heterogeneous they need to be equipped with different resources and competences. Regarding this, a higher rate of imitation and substitution can be a driver for homogeneity, whereas a higher rate of innovation, depending on the innovation-capability of several companies, can be a driver for heterogeneity and vice versa. Secondly, a logistics service provider must be able to use the heterogeneity for improving his own efficiency. That means competitive advantages cannot be created, if a logistics service provider is unable to create them by using the advance (e.g new technology) in opposite to the competitors. Thirdly, the value of a service offered by a logistics service provider is defined by the customers. Hence, the decision weather the company's service is useful is solely rendered by the customers and cannot be influenced directly by a logistics service provider. In consequence, the heterogeneity between companies can only lead to competitive advantages, if the logistics service provider is able to offer "value added services" for his customers and if that leads to the customers' willingness to pay higher prices for this service. In summary, the heterogeneity, which is essential for the possibility to gain competitive advantages depends on the market's characteristics and the customer's as well as the competitor's behaviour. This, in turn, influences again the characteristics of the market. The market can be seen as an aggregation of several competitors, operating independent from each other. Moreover, logistics service providers often act in so-called International Supply Networks (ISN). This results from co-operations of several logistics service providers with competitors during the different working processes (e.g. subcontractor), as well as from co-operations with other companies (e.g. bargainers, producers etc.). In consequence, logistics service providers can be embedded in the structures of different ISN (Hülsmann and Cordes 2009), leading to a higher amount of possible connections and linkages and co-evolutionary processes between competitors in ISN as well as between different ISN. Therefore, from the view of complexity theory ISN can be described as complex adaptive logistics systems (CALS) (Wycisk et al. 2008). Thereby, the question arises, how technology based competitive advantages can be achieved for logistics service providers.

COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDERS BASED ON AUTONOMOUS CO-OPERATION TECHNOLOGIES

One way to create competitive advantages can be seen in the use of innovations (Freiling and Reckenfelderbäumer 2004). One example for such innovations are autonomous co-operation technologies (Hülsmann et al. 2008). Autonomous co-operation describes *„[...] processes of decentralized decision- making in heterarchical structures. It presumes interacting elements in non-deterministic systems, which possess the capability and possibility to render decisions independently"* (Windt, Huelsmann 2007; p. 8). Its aim is to achieve a higher robustness of the whole system by enabling it to cope with dynamics and complexity (Hülsmann and Windt 2005). Its origins can be found in the idea of self-organisation, which was described in multiple academic fields (e.g. physics, biology and chemistry). The research field of self-organisation intends to analyse how complex systems create ordered structures autonomously. The concept of autonomous co-operation depends on different characteristics. These are decentralised-decision making (system elements render own decisions), autonomy (elements act without control of super-ordinate entity), interaction (elements interact with others to get relevant information for rendering decisions) and non-determinism (future system states are unforeseeable caused by unpredictable behaviour of the systems elements) (Hülsmann and Grapp 2006). Hence, no system is controlled autonomously as well as none is controlled externally to a degree of 100 percent. Therefore, these characteristics can only be realised to a certain degree. In spite of first research results, the field of self-organisation is still a young science at a stage of developing (Hülsmann and Wycisk 2005). Hence, to cope with logistical requirements in different ways, a need for intelligent systems with adaptive capabilities can be assumed (Wycisk et al. 2008). Autonomous co-operation can be used by the implementation of technologies like RFID or sensor networks, which enables the logistics service provider to control the temperature and humidity of goods and therewith might allow a logistics service provider to offer special transportation services for perishable food. The use of methods like autonomous routing as well as approaches like collaborative vehicle routing and scheduling, aims for decentralised intelligence and enables single system elements (e.g. the goods) to render decisions (Hülsmann and Grapp 2008). These single system elements, endowed with own decision-making rules and routines can be called "Smart Parts" (McKelvey et al. 2008). Hence, the question arises how autonomous co-operation can lead to competitive advantages. According to Hülsmann et al. (2008), the implementation and use of autonomous co-operation technologies can lead to a higher flexibility through supporting the replication of competences. Furthermore, a reduction of complexity is realised by arranging the complexity between the subsystems (autonomy) and the complexity the management has to absorb decreases as well as for the subsystems a smaller environment and less co-ordination efforts occur. The decentralised-decision making can lead to a faster availability of relevant information between the "Smart Parts", what allow them to render decisions in shorter times and leads to a faster adaptation to changing environments. Another effect, resulting from a higher degree of interaction, is the exchange of information between the "Smart Parts" instead of passing information from the management to the "Smart Parts". Due to the higher rate of interaction, it becomes easier for the "Smart Parts" to get relevant knowledge for solving problems, rendering decisions and developing own competences. In result, the flexibility enables a system to react faster on changing environments than other systems. Thereby, a competitive advantage might be realised (Hülsmann et al. 2008). Another way to gain competitive advantages can result from the access of the "Smart Parts" to competences of other system elements. These competences can be combined with own competences and developed to new ones. So, the advantage results from a higher amount of competences alternatives and the possibility to meet challenges from the environment in a more adequate way. Nevertheless, a higher degree of flexibility can have negative impacts. The increase of information on individual processes and the unpredictability of the behaviour of the "Smart Parts" can lead to the management's inability to regulate the "Smart Parts". Moreover, the "Smart Parts" can aim for their own goals, which are possibly indifferent to the environmental requirements or the goals of the whole system. Therefore an egoism of the "Smart Parts'' can hamper the creation of competitive advantages (Hülsmann et al. 2008). In conclusion, an implementation of autonomous co-operation technologies can lead to a higher flexibility and therewith to a possibility to gain competitive advantages. Therefore, the question arises, which aspects determine the longevity of those competitive advantages based on autonomous co-operation technologies.

ANALYSIS OF DRIVERS AND BARRIERS FOR THE LONGEVITY OF COMPETITIVE ADVANTAGES BASED ON AUTONOMOUS CO-OPERATION TECHNOLOGIES

The longevity of technology based competitive advantages can be affected by the phenomenon of path dependency in different ways. Path dependencies describe processes of reducing action-alternatives over time, caused by positive feedback loops. They can lead to so-called lock-in situations in which one technology dominates others, although others might be technologically superior (Arthur 1989). According to Sydow et al. (2005), path dependent processes include three stages. Stage one describes the search process, in which different action-alternatives (e.g. different technologies) are available and decisions are rendered more or less randomly. Once a self-reinforcing process, which means that the selection of one alternative increases the probability that it will be selected again, has started a so-called "critical juncture" occurs. This initiates the second stage, which is called "path formation". Different alternatives are still available but their probabilities to be selected decrease irreversible with every further selection. The "lock-in" initiates finally the path dependency, in which only one action alternative respectively only one technology is left being attractive despite the possibility that other action alternatives respectively technologies are superior (Sydow et al. 2005).

In the context of ISN the scenario of a technological path dependency regarding the implementation of autonomous co-operation technologies can be described as it follows: In the first stage just a few logistics service providers might implement autonomous co-operation technologies (e.g. RFID-chips). Interactions and interdependencies between actors in ISN might lead to an increase of the attractiveness for other actors to invest in the respective technology as well (e.g. RFID-readers). With an increasing amount of actors in the network that use the same technologies and that are dependent on each other, the probability that actors invest in the same or similar technology in order to be able to co-operate with them might increase as well. These self-reinforcing processes might, in turn, lead to an increase of the imitation- and substitution rate and therewith to an acceleration of the respective technology's diffusion in the network. This can finally lead to a lock-in situation in which logistics service providers need to implement a certain technology in order to be able to participate in the respective ISN.

On a system level, which refers to the perspective of an ISN, path dependencies and the resulting homogenisation tendencies can lead to a decrease of the whole systems' innovation capabilities (Hülsmann and Cordes 2009). The less heterogeneous the elements within a system are, the less incentives do they have to interact with each other (Wycisk et al. 2008). Hence, the possibilities to react on other elements' actions with changed behavioural rules decrease as well, which refers to a decrease in the element's learning abilities. In consequence, the respective system forfeits innovative capabilities (Hülsmann and Cordes 2009). However, path dependencies can as well function as drivers for systems' common identities. According to Luhmann (1984) the survivability of systems depends, beside others, on their abilities to differentiate from their environment by creating boundaries. Therewith, the systems�supposed stability can be assured (Luhmann 1984).

On the level of the systems‘ single elements, which means in an ISN of the involved companies, a path dependent homogenisation might lead on the one hand to decreasing possibilities to differentiate from competitors. Difficulties in gaining respectively maintaining competitive advantages by implementing respectively using autonomous co-operation technologies increase with every additional company within the ISN that uses this respective technology as well. In consequence, the longevity of technology based competitive advantages might decrease with an ongoing homogenisation resulting from developing path dependencies. On the other hand, the development of technological path dependencies presuppose that involved organisations learn from each other in terms of repeating respectively imitating action alternatives that lead to success in the past (e.g. investments in autonomous co-operation technologies). Furthermore, once a path has emerged learn effects occur from long-lasting usages of certain technologies. This, in turn, might lead to economies of scale (e.g. decrease of transportation costs while transporting a higher amount of goods) as well as economies of scope (synergistic effects e.g. common attendance of technology parts). From the perspective of single logistics service providers these effects might extend the longevity of competitive advantages gained through the usage of autonomous co-operation technologies.

CONCLUSIONS

One major strategic question logistics service providers have to face is the problem of creating long-living competitive advantages based on technological developments in highly competitive markets. Those competitive advantages are necessary in order to differentiate a company from its competitors by offering a certain technological-based value added service for customers. Therefore, the paper intended to provide an analysis of chances and risks for the longevity of competitive advantages induced by autonomous co-operation technologies (e.g. RFID, Sensor Networks).

Competitive advantages result from the heterogeneity of logistics service providers on a distinct market, which allows differentiating one competitor from each other. The development of a certain technology might result in the emergent creation of technological paths, which comprise processes of reducing decision-making alternatives regarding the adaption of technologies to environmental changes over time, caused by positive feedback loops. Therefore, the effects of technological developments on the longevity of such competitive advantages can vary in the range of positive as well as negative impacts on the level of ISN and of one single company. On the level of ISN one positive effect can be an increasing capability of the whole system (ISN) to differentiate itself from other value-adding networks based on a certain advantage in the use and application of a distinct technology. This might result in an improvement of the system’s stability. On the same level (i.e. ISN) one exemplary negative effect might be the reduced capability to invent new technologies, because the positive feedback loops of the past can result in a homogenous system’s behaviour, which prevents the actors within such a system from learning. Therefore, the system might erroneously rely on previously successful technologies, which might be not capable to deal with changed environmental demands of the future. Similar positive as well as negative effects can be assumed on the level of individual companies (i.e. logistics service providers) within an ISN. Examples for this are economies of scale based on inter-corporate learning (positive effect) and a reduction of technological-based options for a strategic differentiation on the long run (negative effect).

Therefore, it cannot be stated in general for the management practise that a technological advantage might automatically result in a strategic one. Furthermore, it depends on the net effect of a technology. Positive as well as negative impacts on the longevity of a technological-based advantage of an ISN or a logistics service provider have to be taken into account for strategic investment decisions about the development and implementation of technologies. Hence, the management of such organisations has to control the development of emerging technological paths and their implications for the respective organisation in order to reduce the risks resulting from homogeneity and in order to utilize chances of learning. Therefore, further research has to provide the management of ISN and logistics service providers with methods and instruments that allow evaluating technologies regarding their strategic implications.

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SIGNIFICANT VALUE-ADDED ATTRIBUTES IN PORT LOGISTICS CHAIN-SYSTEM

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ABSTRACT
Purpose – The theme of this study is to identify and prioritize value-added attributes in the port logistics chain-system, specifying significant value-added attributes revealed by various domain perspective.
Design/methodology/approach – To prepare this paper, literature sourcing covered six journals and two textbooks, only peer-reviewed articles and textbooks addressing the port in global logistics arena and supply chain discipline published within the period 1998-2008 were selected. On this basis Delphi technique implemented to rank the identified value-added attributes from experts' opinion and to downsize their number, in order to suite Analytical hierarchy process AHP model. Followed by pair-wise comparison to determine the significant attributes from the port key management perspective. The data collected for pair-wise comparison was conducted throughout semi-structure interview, in order to explain the presumed methodology and to eliminate potential bias.
Finding – The aggregate result from the work cluster analysis shows that information communication value is the most valuable attribute according to both experts and port decision makers. Other consensus among experts and port key management indicate that access to distribution network, logistics and transport integral facility and reliable customs clearance services are the most rewarding value-added among other attributes in category two. The study presents a framework for prioritizing the identified value-added attributes and insightful method for ranking for ranking purpose.
Practical implications – The study identifies and classifies the value-added attributes related to the port logistics chain-system. The applied methodology might enhance port key management to discover the most rewarding value-added attributes and value relevance as a source of competitive advantages.
Originality/value – This paper combines both literature analysis and interviews with experts and decision makers, which offers an integrated framework of cluster analysis. It is assumed to adds value to the port logistics and supply chain literature by identifying and categorizing an important set of value-added attributes. Finally the study combines different methods, in order to reveal various respondents perspective.
Keywords – Analytical hierarchy process; Delphi Technique; Value-added attributes; Chain-system; Decision maker.
Paper Type – Research paper.

1. INTRODUCTION

1.1 Background

The growing notion of value-added logistics services has changed the role of ports and promoted the new concept of the port as a logistics platform (Carbone and De Martino, 2003; Bichou and Gray, 2004; Ferrari *et al.*, 2006; Daniel *et al.*, 2007; Almotairi and Lumsden, 2009). Ports, traditional product transit points, have experienced a process of growth and development in recent years, evidenced by the extension and modernization of their infrastructure, the increased number of services available and improved quality (Cuadrado *et al.*, 2004). In their contemporary role as members of supply chains, seaports are considered to be part of a cluster of organizations in which various logistics and transport operators are involved with the ultimate aim to bring value to the final consumer (Panayides and Song, 2008).

The provision of distribution and value-adding services has derived the port to engage in activities beyond simply providing berth for ship and other core port activities (Mangan *et al.*, 2008). Thus, the port system not only serves as an integral component of the transport system, but is also a major sub-system of the broader production, trade and logistics systems;

especially with many ports in the world shifting to non-ship/cargo related activities (Bichou and Gray, 2005).

The World Bank has widened the definition of port activities to include a range of value-added services (both value-added logistics and value-added facilities), reflecting wider logistics and supply chain strategies. Many researchers highlight issues related to the importance of value-added logistics services, recognizing the competitive advantages and profit margin that can be made from those non-core port activities (Falkner, 2006; Analytiqa, 2007; Wall, 2007; Mangan *et al.*, 2008). Therefore, the approach towards value-added logistics services has becomes a source of competitive advantages and an important business model (Carbone and De Martino, 2003; Notteboom and Rodrigue, 2005). Eventually the gateway position of major seaports offers opportunities for the development of value-added logistics and other activities proximate to ports (Notteboom and Winkelmans, 2001; Mangan *et al.*, 2008).

Unfortunately the lack of effort in identifying and evaluating value-added attributes related to the port logistics chain-system has influenced port management investment decision (Ferrari *et al.*, 2006). Mangan *et al*. (2008) believed that there is a significant potential for ports to engage in more value-added activities, a potential which is quite latent in the case of many ports. This area is not sufficiently investigated despite being pointed out as strategically important by many researchers (Bichou and Gray, 2005; Mangan *et al.*, 2008). This evolving need for appropriate value-added attributes' framework becomes disturbing; especially what is the most significant value-added attributes in port logistics chain-system.

1.2 Objective
The main purpose of this research is to identify and prioritize value-added attributes in the port logistics chain-system from different perspectives. One important objective is to reveal various opinion through utilizing appropriate methods, and to find a methodological framework, which serves as a tool for mapping the value-added attributes. Given the relative importance of the major attributes and sub-attributes revealed by the research should indicate the directions to be explored by the port key manager in their effort to increase competitiveness.

1.3 Outline of the article
In the following section, 'Value-added and chain system fundamentals' a brief description of the basic terms and definition of the selected topics inter-relation is presented. The next section, 'Methodological procedural' encompasses a discussion of methodology procedures and how the methodology invariably entails the adoption of the research framework. The section 'Work cluster analysis' provides an analysis of the proposed framework outcomes—supported by literature finding which is further highlight the value-added importance from broader standpoint. Some insight are presented related to the research delimitation before the final section, 'Concluding discussion', which provides concluding remarks and suggestions for future research.

2. VALUE-ADDED AND CHAIN-SYSTEM FUNDAMENTALS
In the following discussion 'value-added' and 'chain-system' are viewed as interconnected and fundamentals for number of firms working in close collaborative environment. The strategic positioning of these firms involves value chain-system inter-relationship, which mirrored through the strategic choice to gain competitive advantage. As a result, the port logistics chain-system is seen as contributing to supply chains through the creation of value-added services and enhancing competitive advantage (Robinson, 2002).

2.1 Value-added
Bowersox *et al*. (2007) referred to value-added services as a unique or specific activity that firms can jointly develop to enhance their efficiency and effectiveness; and in turn, to foster customer success. Value-added activity is an activity along the chain that adds value to the product or services and which the final customer is willing to pay for (Carbone and De Martino, 2003). Thus, value-added is the ability of the port to add value to the provided services in the context of facilitating further the objectives of the supply chain-system (Panayides and Song,

2008). In business management context, the notion of value-added or value-relevance is expressed on how to grow a larger share of the profitable revenue by a willingness to perform a broader range of value-added services while enhancing managerial profitability. While, in maritime context there are a wide expression of value-added along—with chain-system. For instance, Robinson (2002) suggests that ports form part of a value-driven chain system and as such they can add value to the goods passing through them. Literature distinguish between two types of value-added; physical value-added, which refers to the world of resources that manger can see and touch, while virtual value-added made of information capability i.e. electronic commerce for example. However, those value-added components are mutually dependant and interacting elements (Sviokla and Rayport, 1996). As briefly discussed, value-added takes different forms, it might include the ability to launch new tailor-made services for the port users (Paixão and Marlow, 2003; Bichou and Gray, 2004) to cater for specific needs of market segments (Marlow and Paixão, 2003) and to be adaptable to the customer needs, playing the role of distributor, developing continues replenishment and providing cross-docking activity (Paixão and Marlow, 2003).

2.2 Chain- system

The theoretical foundation for the 'chain-system' or 'supply-chain' concept could be traced back to Porter (1980, 1985) where being considered central notion of competitive advantage. Porters' model emphasis the optimization of different chain-system linkage (between customers and suppliers) in order to create superior value and to enhance performance. Omta *et al.*, (2001) has defined chain as the processes linking supplier and user companies, from initial raw materials to the ultimate consumption of the finished product, and actors within chains are considered to be working together to add value to the ultimate customer. While system is an analytical framework that seeks to accomplish the total integration of the components essential to achieving stated objectives (Bowersox *et al.,* 2007). The system concept is rather expressed as encompassing inter-connected components separated from their environment by a system border (Holmberg, 2000). Literature discussed chain-system has emphasis the importance of value proposition and chain-system coordination, synthesizing their critical if the firm is to add value to its product and service offerings (Haugland and Rokkan, 2000; Robinson, 2002; Robinson, 2006). For instance, Robinson (2002) who introduce the port chain-system concept, stated that; 'ports are elements embedded in value-driven chain systems …and that it is important for the port and its service providers to offer sustainable value to its user's vis-à-vis other competing value-driven chain systems'. Therefore, a sequential set of separate logistics 'operations'-warehousing, depot operation, shipping, trucking, freight forwarding that deal with end-to-end movement of freight where these separate functions are carried out by separate firms could be seen as an example of chain-system (Robinson, 2002). Inevitably, as chain-systems develop, those firms within the chain which appropriate and accumulate 'inordinate' value may be seen to be exerting value superior and experiencing competitive advantages. In particular the organized network of firms working together by sharing resources and rewards in the pursuit of targeted markets and consumers' (Poirier, 1999).

3. METHODOLOGICAL PROCEDURES

The methodological procedures in this paper are driven by the research objectives. To identify the value-added attributes related to the port logistics chain-system, an extensive literature review and analysis across multi-disciplines such as management, transport and logistics field has been complemented. The aim was to identify the foundation of this article i.e. 'value-added attributes' from literature sourcing as shown in Table1.A blend of methodological construct considered to be valuable in order to evaluate and prioritize the identified attributes. As thus Delphi technique and Analytical hierarchy process AHP implemented to reveal different domain perspective. The methodological procedures are described and analyzed in more detail in the following sub-section.

Table 1. Value-added attributes in the Port Logistics Chain-system

Value - added Attributes CAT. 1	Authors																	
	UNCTAD (2002)	*Robinson (2002)*	*Robinson (2006)*	*Panayides (2006)*	*Wang et al.. (2007)*	*Mangen et al. (2008)*	*Cuadrado et al. (2004)*	*Roh et al. (2007)*	*Lpez and Poole (1998)*	*Notteboom and Winkelmans (2001)*	*Flaxao and Marlow (2003)*	*Marlow and Flaxao (2003)*	*Carbone and De Martino (2003)*	*Bichou and Gray (2004)*	*Bichou and Gray (2005)*	*Notteboom and Rodrigue (2005)*	*Song and Panayides (2008)*	*Panayides and Song (2008)*
D1 Electronic documentation	×			×	×													
D1 Tracking and tracing	×			×	×													
D1 Shipment sequence and status	×			×							×							
D2 Electronic link with supplier	×				×				×							×	×	×
D2 Electronic customs reporting	×																	
D2 Electronic link with customer	×				×											×	×	×
D3 Electronic invoicing	×				×													
D3 E-business services	×	×	×	×							×							
D3 Electronic booking	×																	
D4 Inter-connectivity of modes			×	×	×	×	×			×	×				×	×	×	×
D4 Inter-operability of modes				×	×							×					×	×
D5 Transport consolidation												×						
D5 Multi-modes transport synchronization				×	×							×				×	×	
D6 Controllability of modes												×						
D6 Cross-docking	×					×		×				×						×
D7 Procurement and pre-assembly	×				×								×				×	×
D7 Semi-manufacturer services					×	×												
D8 One-stop freight services	×																	
D8 Door-to-Door services		×	×	×		×	×			×						×		
D9 Time tolerance in positioning resources			×	×														
D9 Reverse logistics	×					×				×						×	×	
D10 Tailor made services					×					×			×	×			×	×
D10 Onsite storage services			×														×	×
D11 Customs clearance services	×									×								
D11 Customs interactive											×							
D12 Evaluation of alternative route																		×
D12 Carrier route selection	×						×			×						×		

3.1 Literature sourcing

A comprehensive literature review and analysis formed the basis of this research work. Starting with literature sourcing it might also bridge the gap identified by (Selviaridis and Spring, 2007) and others who views that logistics research lacks a theoretical basis (Kent and Flint, 1997; Mentzer *et al.*, 2004). Based on Gibson *et al.,* (2004) investigation of periodical usefulness, as well as the choice in previously published literature reviews of a more extensive kind (e.g. Stock, 1997; Spens and Kovacs, 2006). Cross-disciplinary review in management, transport and logistics field focusing on literature addressing the port on global logistics arena and supply chain discipline has been taken as representative to draw the value-added attributes. Out of the covered six journals and textbooks, 16 peer-reviewed articles and two textbooks published within the period 1998-2008 were selected. The literature sourcing identify 27 value-added attributes, and assumed implicitly important in the port logistics chain-system. Each article indicated against the identified attribute, and the importance 'weight' of each attribute is defined by the number of occurrences as shown in Table 1.

3.2 Delphi technique

Delphi technique is a systematic qualitative method used to evoke expert opinion. The technique is not a substitute for other scientific testing, but rather an option for complex and intertwined subject that cross over disciplinary boundaries (Grisham, 2008). Brill *et al*. (2006) described Delphi as a particularly good research method for deriving consensus among a group of individuals having expertise on a particular topic where information sought is subjective and participants are separated by physical distance (Linstone and Turoff, 1975).

Delphi' panel of experts are typically selected, not for demographic representativeness, but for the perceived subject matter expertise that they can contribute to the topic. Scheele (1975) suggested that the panel must be selected from stakeholders who will be directly affected, experts with relevant knowledge and experience, and facilitators in the field under study. There are no minimum limits on expert numbers involved in the Delphi technique, and 'non-overlap rule' was easy to follow (Lirn *et al.*, 2003). In this research two panels of expert having expertise in the field of logistics, transport and management constitute 5 practitioners from world-class port and 5 professional' academics pupils has been selected, in order to obtain the results.

Associated with the study undertaken by Duffield (1993), in order to provided pre-existing information for ranking purposes, and online with Lirn *et al.*, (2003) to identify independent attribute through repeated survey round in the process of inclusion of related attribute. This study utilizes Delphi technique for two main reasons:

(1) To rank the identified value-added attributes, in order to highlight their importance and relevance to each main attribute;
(2) To downsize the large number of the proposed attributes through appropriate groups of independent attribute in order to prioritize those independent attributes by the use of Analytical hierarchy process AHP as final step in this methodological procedures.

Therefore, tow round assigned to each panel, in order to fulfill the above objectives, on the first session each panel was asked to rank the attributes on a scale of 1-5 for the believed most important source of value-added, and a similar scale was used for the grouping purpose. The scale was selected to capture panels' member opinion more accurately. Figure 1 depict the mean rank of the perceived most important value-added attribute category 2 as revealed by Delphi technique.

To validate the result of this method, Kendall coefficient of concordance was calculated for both panels of expert, in order to find the degree of consensus over the necessity of evaluating value-added attributes in this ranking purpose. As thus, test between the initial and the final for both academic and expert opinions shows that a significant level of agreement was revealed by both panels ($W= 0.63\ p < 0.001$),and ($W= 0.54\ p < 0.004$) accordingly, which emphasis that they agreed amongst themselves in the ranking of the necessity of these value-added attributes. Furthermore, Spencer-Cooke (1989) suggested that the composition of the panel relate to the validity of the results of the research.

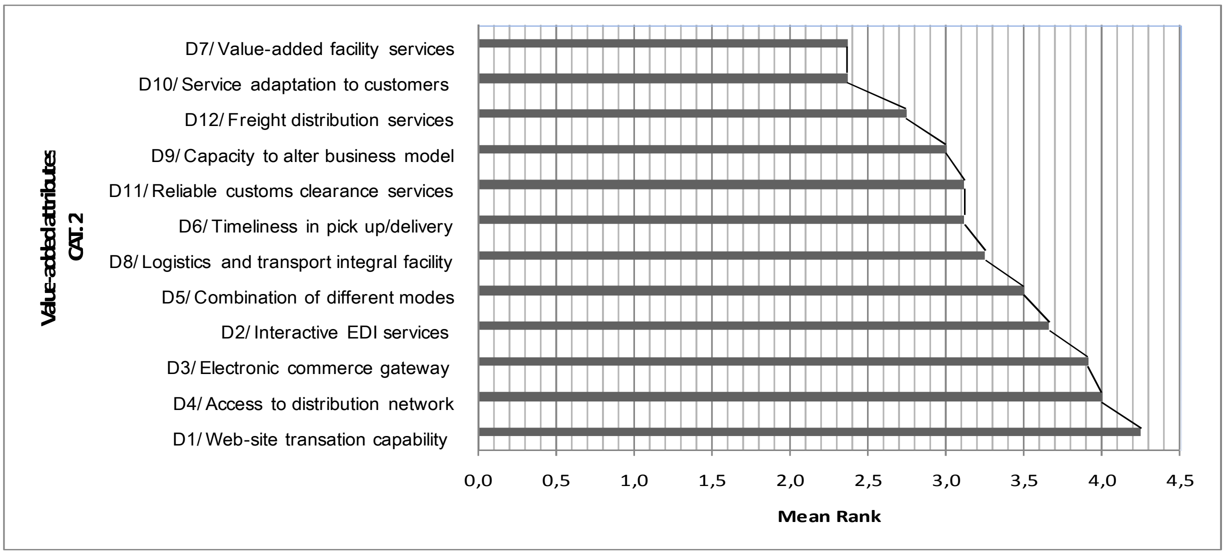


Figure 1. shows the mean rank of the perceived most important independent value-added attribute category 2.

3.3 Analytical hierarchy process

The Analytic hierarchy process (AHP) is a theory of measurement through pair-wise comparisons and relies on the Decision maker (DM) judgments to derive priority scales. Saaty (2008) stated that the comparisons are made using a scale of absolute judgments that represents, how much more, one element dominates another with respect to a given attribute. Not only does one need to create priorities for the alternatives with respect to the criteria or sub-criteria in terms of which they need to be evaluated, but also for the criteria in terms of a higher goal, or if they depend on the alternatives, then in terms of the alternatives themselves.

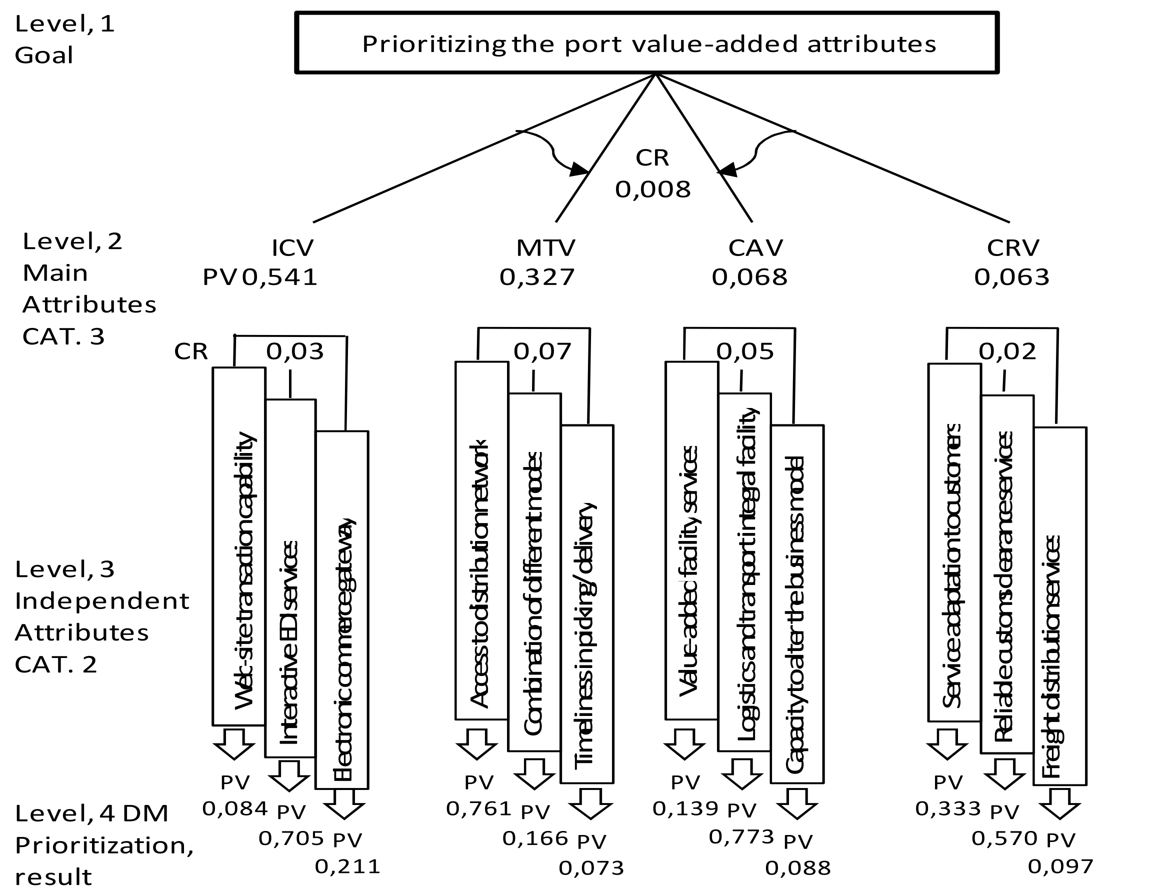
The Analytical hierarchy process (AHP), axiomised by Saaty (1990, 2008) is a multi-criteria decision making method and has been utilized in this study to prioritize the identified value-added attributes from decision maker of a major world-class port under study through the following order:

(1) Define the goal, and determine the kind of knowledge sought. A statement of overall objective in this study is to prioritize the port value-added attributes.
(2) Define attribute and sub-attribute that can determine decision hierarchy. Figure 2 depicts the hierarchical structure of the AHP model. In this paper four main construct of value-added attributes synthesis from the work of Almotairi and Lumsden (2009) namely; Information communication value (ICV), Multi-modal transport value (MTV), Critical asset value (CAV) and Customer relation value (CRV) are utilized to form the upper hierarchy level. While independent value-added attribute spur from Delphi technique formed the second level of the proposed hierarchical model.
(3) Construct a set of pair-wise comparison matrices. Each element evaluated against its peers with respect to the parent nodes. The pair-wise comparison are done in terms of which element dominate the other. In this step, the decision maker can express his preference between each pair of elements as equally, moderately, strongly, very strongly and extremely preferable 'important'. These verbal judgments can be translated into numerical values in the relative scale of measurement from 1 to 9. However, there are *n(n-1)* judgments required to develop the set of matrices in this step, where reciprocals are automatically assigned in each pair-wise comparison. In this paper five matrices of judgments has been constructed, since there are four element in level 2, and one element in level 1 to be pair-wise compared to each element.
(4) Use the matrix of pair-wise comparisons in each set of attributes to calculate the Priority vector (PV). The Priority vector is the principal eigenvector of the matrix. It

gives the relative priority of the attribute measured in ratio scale (Saaty, 1990). Figure 2 depict the AHP model.

To validate the judgment consistent of each matrix obtained, the Consistency ratio (CR) has to be calculated. As the value of CR determine the judgment consistency, it's been acceptable if it does not exceed 0.10 percent, otherwise the judgment consider to be inconsistent. Thus To obtain a consistent matrix, judgments should be reviewed and improved until the desired valid level achieved.

Synthesizing from the above described procedures, the final hierarchical model can be developed as shown in Figure 2. The calculation can be done manually or automatically. In this research we obtain prioritization result by the AHP software, Expert Choice. The model indicate the Priority vector (PV) 'weighted value' for each attribute in each level, and the Consistency ratio (CR), which works as a validation tool for this type of methodology i.e. if the judgment of Decision maker (DM) CR < 0.10 percent then the decision made consider to be consistent.



Notes: ICV = Information communication value; MTV = Multi-modal transport value; CAV; Critical assets value; CRV = Customer relation value; PV = priority vector and weighted value; CR = Consistency ratio

Figure 2. Value-added attributes hierarchy by AHP

4. WORK CLUSTERS ANALYSIS

The work cluster analysis embraces literature sourcing, Delphi technique and AHP methods in turn to enrich the study with breadth in identifying the most important attributes from a wide perspective. As shown in Figure 3 the evaluation factor for each method differ according to the research objective. For instance to highlight the literature contributed to the study, each attribute identified accompanied with number of literature indicating that attribute i.e. 'literature weight'. While Delphi technique measured by Standard deviation (SD) and Arithmetic mean value (M) out of the ranking survey and then average mean value (AVG/M) calculated. Ultimately AHP ends up the work cluster with Decision maker (DM) prioritization, which is indicated through Priority vector (PV) and associated with Consistency ration (CR) to show the judgment accuracy.

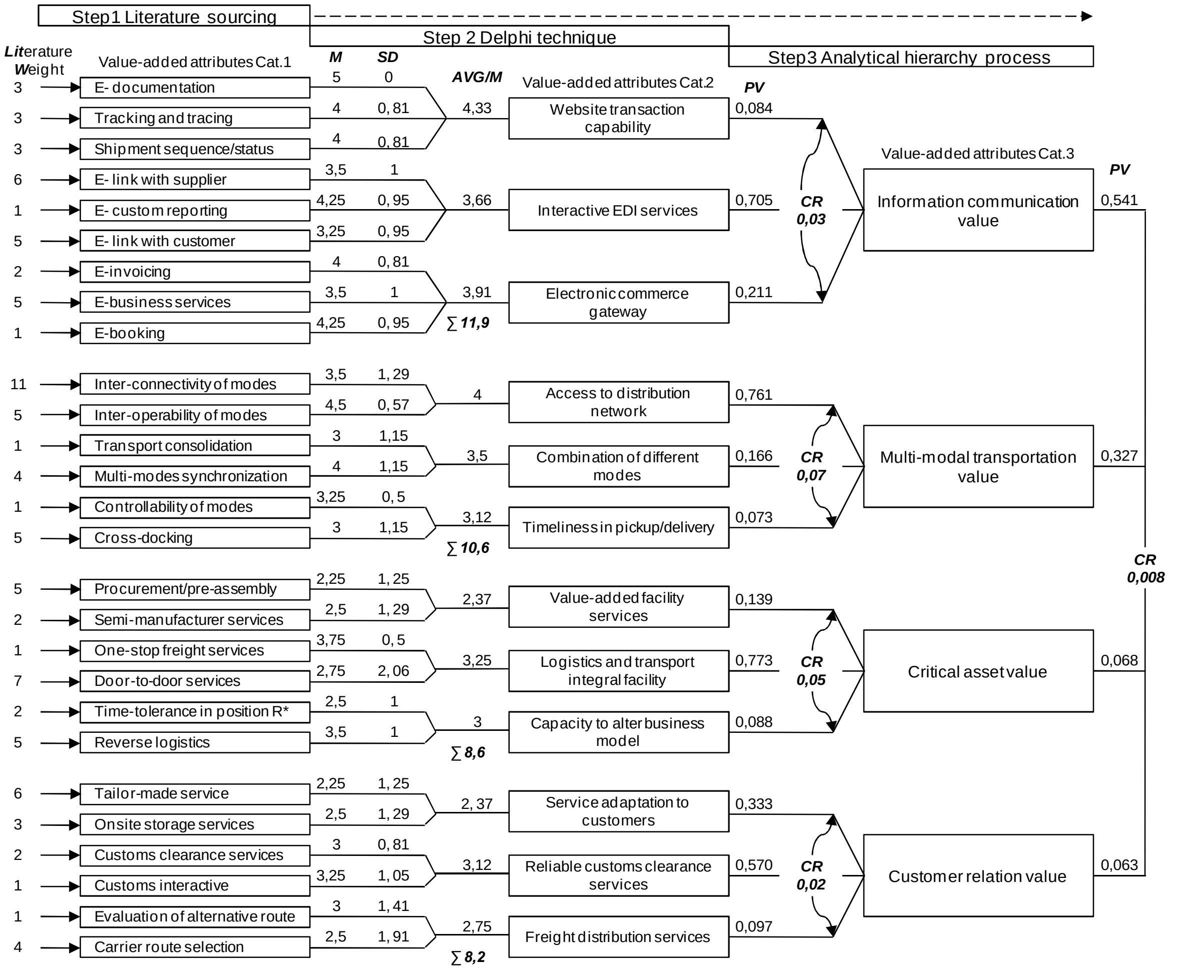


Figure 3. Value-added attributes evaluation by work cluster analysis

4.1 Aggregated result

The significant indication disclosed from the work cluster shows that Information communication value (ICV) is the most rewarding value-added attributes, and there is a consensus among the spectrum of respondents, with nearly accumulation of 11,9 AVG/M and 0, 541 PV as indicated from both Delphi and AHP methods in category 2 and 3 accordingly. In fact, information communication value has been a recent concern by both academics and practitioners (Ketzenberg *et al.*, 2007). In particular, handling customs filling, transmittal of manifests, processing bills of lading and other document initiated within logistics chain-system, whereas the power and speed of information processing is the main source of value-added (UNCTAD, 2002).

Stefansson (2002) discussed the beneficial outcome of information communication system implementation, in particular to reap value-added networking between partners in the supply chain. Establishing electronic links with their suppliers and customers enables companies to transmit and receive purchase orders, invoices and shipping notifications with much shorter lead times, which gives the potential to speed up the entire shipping transaction (Murphy, 1998).

The other important evaluation attribute involves 'access to distribution network', 'Logistics and transport integral facility' and 'reliable custom clearance' as equally important for both experts and Decision maker (DM) as well. In this context, Carbone and De Martino (2003) asserted that ports are potential member of different supply chains and that determined by their contribution to the satisfaction of specific customer's requirements will depend on:

(1) The availability of efficient infrastructures and inland connections, in making it attractive to specific supply chains;
(2) The ability of logistics and transport operators to contribute to the value creation.

Furthermore, Parola and Sciomachen (2005) referred to the efficient use of multiple modes of transport inter-connected by facilities at the port terminal has received extensive attention, especially where port considered to be a bidirectional logistics system and this required a high level of co-ordination (Paixão and Marlow, 2003). With the growing use of electronic links in cargo booking, tracking, and delivery by major shipping lines, as well as in customs clearance, all ports are required to become efficient interfaces for shipping services in a world closely connected through logistics chains (UNCTAD, 2002).

4.2 Delimitation

The data utilized in this research was limited to the identified value-added attributes as a result of the literature sourcing procedure. This might not reflect all attributes existed within the port logistics chain-system.

The evaluation of the identified set of data was tied up by the methodology criteria applied, which is suitable for certain kind of domain. As thus there is a potential scope for improving the methodology adopted in the future. However, the methodology deployed in this paper allow the researcher to test the result validation and accuracy. Consequently, the findings of this research mirror the participants' point of view related to the port logistics chain-system.

5. CONCLUDING DISCUSSION

The result of this study entails a framework for prioritizing the identified value-added attributes. The work cluster analysis shows that information communication value is the most valuable attribute 'in the higher construct cat3' according to both experts and port decision makers. Other consensus among experts and port key manager indicate that access to distribution network, logistics and transport integral facility and reliable customs clearance services are the most rewarding value-added among other attributes in category two. The methodological framework deployed in this paper designed to reveal various domain perspectives, which might serves as a tool for mapping the value added attributes. Given the relative importance of the major attributes and sub-attributes revealed by the research should indicate the directions to be explored by the port key manager in their effort to increase competitiveness. Given the limitations of the research underlying this article, suggestions for future research are primarily directed to investigate each of these identified value-added attributes' contribution to facilitate the port supply chain objectives. Furthermore, is to highlight activates within the port logistics structure that might streamline the integration process across supply chains. More research is needed in this area also in order to support development of system-chain relationship.

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EFFECT OF GETTING BACKHAUL LOADS IN LONG-DISTANCE TRANSPORTATION

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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. We have presented a simple backhaul model connecting 3 points. We clarified the criteria of decision making along the model. And we found that a criterion of load efficiency contributed to the reduction of CO2 emissions and the increase of contribution margins. In this Paper, we generalize our logic with a simple backhaul model connecting 6 points.

The model includes highway interchanges. Moreover, we execute a numerical experiment in long-distance transportations. As a result of the experiment, we reconfirm that a criterion of load efficiency contributes to the reduction of CO2 emissions and the increase of contribution margins.

INTRODUCTION

Many truckload carriers pay attentions to backhaul loads as means to improve their load efficiencies, because the backhaul loads can decrease negative environmental impacts and increase carrier's profits. In Japan, the decrease of the load efficiencies is a serious problem as the number of small amounts of truckloads is increasing. As one of solutions, there are a lot of load finding services through the Internet. However, truckload carriers do not have clear criteria of decision making about getting backhaul loads.

We have presented a simple backhaul model connecting 3 points: a starting point, a destination point and a backhaul pickup point. And we clarified the criteria of decision making about getting backhaul loads along the model (Fujita et al., 2007). Moreover, we executed a numerical experiment according to the criteria. As a result of the experiment, we found that a criterion of load efficiency contributed to the reduction of CO2 emissions and the increase of contribution margins (Watanabe et al., 2008).

In this Paper, we generalize our logic with a simple backhaul model connecting 6 points: a starting point, a highway interchange 1, a highway interchange 2, a destination point, a backhaul pickup point and a backhaul destination point. And we clarify a criterion of load efficiency along the model. After that, we confirm the effect of getting backhaul loads from a numerical experiment in long-distance transportations.

CRITERION OF GETTING BACKHAUL LOADS

[1] Simple Backhaul Model Connecting 6 Points

To clarify the criterion of load efficiency, we present the simple backhaul model in long-distance transportations as illustrated in Figure 1.

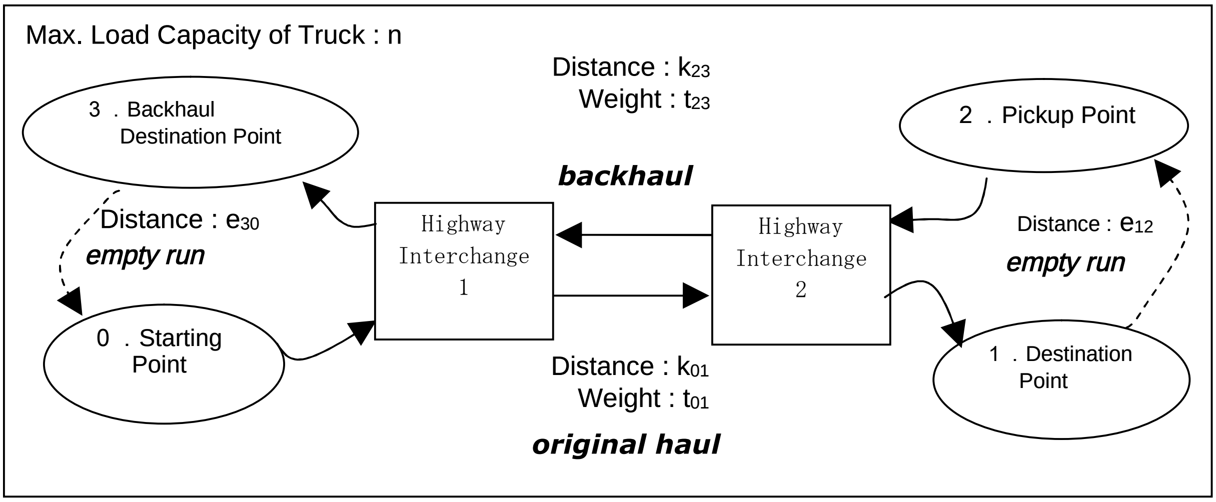

Figure 1: Simple backhaul model

The following conditions are assumed in the model.

$$n > 0 \tag{1}$$
$$0 < t_{01} \le n \tag{2}$$
$$0 < t_{23} \le n \tag{3}$$
$$k_{01} > 0 \tag{4}$$
$$k_{23} > 0 \tag{5}$$
$$e_{12} \ge 0 \tag{6}$$
$$e_{30} \ge 0 \tag{7}$$

[2] Criterion of Load Efficiency

In Japan, the Ministry of Land, Infrastructure and Transport issues the Annual Survey on Motor Vehicle Transport every year. In this report, freight ton kilometers and ability ton kilometers are announced (Ministry of Land, Infrastructure and Transport, 2008). The ability ton kilometer is the freight ton kilometer that assumes the case where a truck always runs at a maximum capacity loading. It is general that the load efficiency is calculated by the following computational expression (8).

$$lord\ efficiency = \frac{freight\ ton\ kilometer}{ability\ ton\ kilometer} \tag{8}$$

When a truck is shuttling in the starting point and the destination point without any backhaul loads, the load efficiency is expressible like the following expression (8) from Figure 1.

$$\frac{t_{01}k_{01}}{2nk_{01}} \tag{9}$$

On the other hand, the load efficiency with the backhaul load is expressible like the following expression (10) from Figure 1.

$$\frac{t_{01}k_{01} + t_{23}k_{23}}{n(k_{01} + e_{12} + k_{23} + e_{30})} \tag{10}$$

A total empty distance in one transportation TED is expressible like the following expression (11) from Figure 1.

$$TED = e_{12} + e_{30} \tag{11}$$

When the backhaul load is secured, a condition that improves the load efficiency is expressible like the following expression (12) from the expressions (9), (10) and (11).

$$\frac{t_{01}k_{01}}{2nk_{01}} < \frac{t_{01}k_{01} + t_{23}k_{23}}{n(k_{01} + k_{23} + TED)} \tag{12}$$

Moreover, the expression (12) can be transformed into the following expression (13).

$$TED < \left(\frac{2t_{23}}{t_{01}} - 1 \right) k_{23} + k_{01} \tag{13}$$

In addition, we try to show a backhaul distance and the total empty distance based on an original haul distance. A backhaul distance ratio BDR and an empty distance ratio EDR are expressed by the following expressions (14) and (15), respectively.

$$BDR = \frac{k_{23}}{k_{01}} \tag{14}$$

$$EDR = \frac{TED}{k_{01}} \tag{15}$$

In addition, we try to show a backhaul weight based on an original haul weight. A backhaul weight ratio BWR is expressed by the following expression (16).

$$BWR = \frac{t_{23}}{t_{01}} \tag{16}$$

The expression (13) can be transformed into the following expression (17) from the expressions (14), (15) and (16).

$$EDR < (2BWR - 1) BDR + 1 \tag{17}$$

In the criterion of load efficiency, the decision making about getting backhaul loads is done based on the expression (17).

NUMERICAL EXPERIMENT

To confirm the effect of getting backhaul loads in long-distance transportations, we executed the numerical experiment that followed the Monte Carlo method based on uniform distributions. Fundamental data of the experiment were decided depending on actual data of Japanese truckload carriers in year 2004, because only that data could be obtained from various statistical materials. As a result of the experiment, the backhaul loads brought the increase of the contribution margins and the reduction of the CO2 emissions.

[1] Experimental assumption

Distance

In Japan, transportations between the Chubu region and the Kanto region are especially active. Under the circumstances, the Komaki IC and the Atsugi IC were the important highway interchanges used most frequently by truckload carriers in 2005 (Ministry of Land, Infrastructure and Transport, 2007). Therefore, the Highway Interchange 1 and 2 in Figure 1 were assumed to be the Komaki IC and the Atsugi IC, respectively. In addition, the distances from the highway interchange 1 to the starting point and to the backhaul destination point were both assumed to be in the range of the distance from the Port of Nagoya to the Komaki IC. Similarly, the distances from the highway interchange 2 to the destination point and to the pickup point were both assumed to be in the range of the distance from the Atsugi IC to the Port of Yokohama. Each distance was determined as shown in Table 1 and the geographical coverage of the simple backhaul model was shown in Figure 2.

Route	Distance [km]
Port of Nagoya - Komaki IC	31
Komaki IC - Atsugi IC	332
Atsugi IC - Port of Yokohama	35

Table 1: Distance

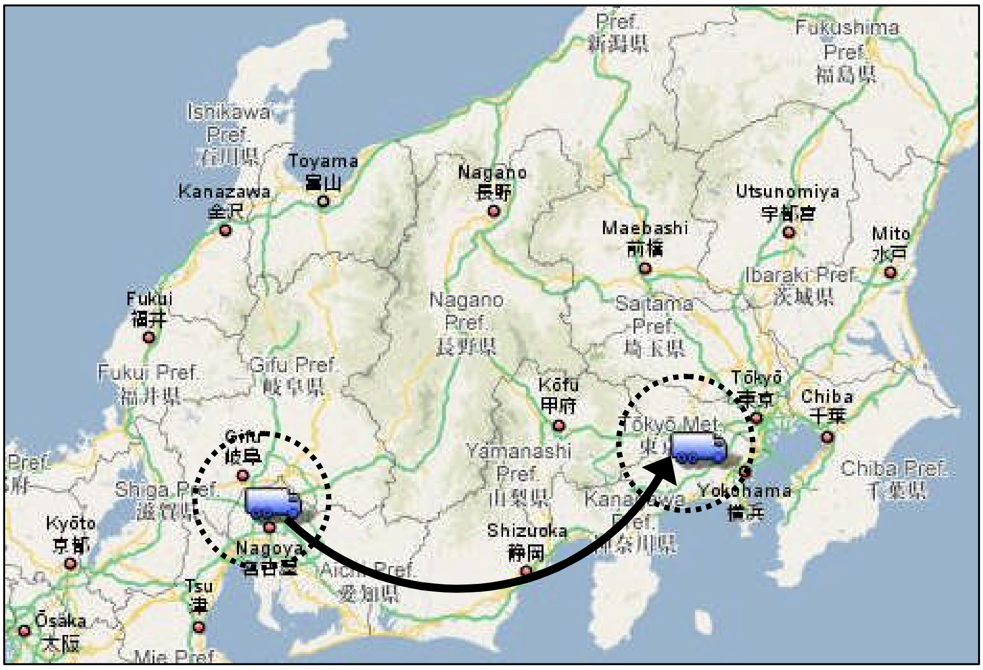

Figure 2: Geographical coverage of model

Truck

From the Report on Number of Automobile Possession According to Various Classifications, it was realized that 4t trucks were used most frequently in 2004 (Automobile Inspection & Registration Information Association, 2004). This situation has not changed now (Automobile Inspection & Registration Information Association, 2008). Therefore, the use of the 4t truck was assumed in the experiment.

To calculate CO2 emissions, mileages of trucks are needed. They vary with gross weights of trucks. The Ministry of Land, Infrastructure and Transport announced mileage targets by the gross weights of the trucks (Ministry of Land, Infrastructure and Transport, 2005). Data to make the targets covering a gross weight range of the 4t truck and their regression line could be illustrated as shown in Figure 3.

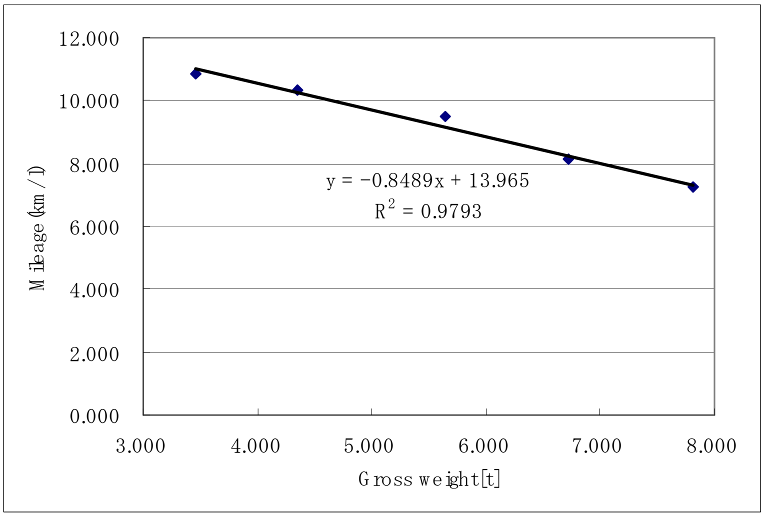

Figure 3: Mileage of 4t truck

From the regression line in Figure 3, it was assumed that the mileage of the 4t truck is calculated by the following computational expression (18).

$$mileage = -0.8489 \times \ gross\ weight + 13.965 \qquad (18)$$

In addition, it was assumed that the gross weight is the total of truck's body weight and loading weight. The experiment was executed using the 4t truck that had a standard body weight of
3.5 t.

Contribution Margin

In managerial accounting, contribution margins are recognized as the differences between sales amounts and variable costs amounts. Net profits are the differences between contribution margins and fixed costs amounts (Ghosh et al., 1988). Therefore, almost all managers always do efforts to increase the contribution margin.

In many cases, truckload carrier's sales amount is obtained from the freight charge that varies only with an actual haul distance. In the Report on Actual Freight Charges, average freight charges for the 4t truck in year 2004 were determined by the following Table 2 (Editorial Department of LOGI-BIZ, 2008).

Actual haul distance [km]	Charge [yen]
0< and =<20	12,381
20< and =<50	16,886
50< and =<100	23,688
100< and =<150	27,993
150< and =<200	33,358
200< and =<300	40,319
300< and =<400	48,599
400< and =<500	55,894

Table 2: Freight charge for 4t truck

In the experiment, it was assumed that the truckload carrier's sales amount for one of the transportations could be determined by the Table 2.

On the other hand, it was assumed that truckload carrier's variable costs amount varies linear with a travel distance. In the experiment, a variable costs amount per unit of travel distance was assumed to be 103.61yen/km as shown in Table 3.

Item	Amount [yen/km]
Maintenance and repairs	7.22
Road tolls	11.34
Ferry tolls	1.69
Variable driver costs	75.58
Fuel expense	7.78

Table 3: Variable costs amount per unit of travel distance (4t truck)

The amounts of maintenance and repairs, road tolls, ferry tolls and variable driver costs in Table 3 were based on data in year 2004 announced in the Management Index Report on Motor Vehicle Transport (Automobile Business Association of Japan, 2006). In particular, the variable driver costs amount was calculated to be 49.5% of a whole driver costs amount according to a material provided by the Japan Trucking Association (Japan Trucking Association, 2006). The fuel expense amount was calculated from the mileage of the 4t truck under a half loading condition and 70.65yen/l that was the average price of diesel oil in year 2004 (Kanagawa Trucking Association, 2008).

CO2 Emission

The CO2 emissions in the experiment were calculated using the mileage method presented by the Japan Institute of Logistics Systems (Japan Institute of Logistics Systems, 2006). The mileages for the original haul, the backhaul and the empty run were calculated by the computational expression (18). A CO2 emission coefficient was assumed to be 2.62 kg-CO2/l.

[2] Experimental Procedure

The following steps were executed for the numerical experiment.
Step-1: With aids of Microsoft Excel 2003, 5 data based on the uniform distributions were generated as shown in Table 4. One transportation was consisted of a group of these data. Each distance range was based on the distances in Table 1.

Item	Range
Original haul distance(k_{01})	332.00 km ~ 398.00 km
Empty distance(e_{12})	0.00 km ~ 70.00 km
Backhaul distance(k_{23})	332.00 km ~ 398.00 km
Empty distance(e_{30})	0.00 km ~ 62.00 km
Original haul weight (t_{01})	0.01 t ~ 4.00 t
Backhaul weight(t_{23})	0.01 t ~ 4.00 t

Table 4: Experimental data

Step-2: 200 groups of data were generated. They composed 200 transportations as a sample. 3 samples were obtained according to this procedure.
Step-3: The 3 samples were made to correspond to each case as shown in Table 5. For each case, 200 contribution margins, freight ton kilometers and CO_2 emissions were calculated.

Case 1	The truck always runs without any backhaul loads and shuttles between the starting point and the destination point.
Case 2	The truck runs with the backhaul load or shuttles without any backhaul loads depending on the criterion of load efficiency.
Case 3	The truck runs with the backhaul load in case where the contribution margin increases. In the other case, it shuttles without any backhaul loads.

Table 5: Case of transportation

EXPERIMENTAL RESULT AND DISCUSSION

[1] Contribution Margin

The sample mean values and standard deviations of the contribution margins were shown in Table 6, and the 95% confidence intervals of the mean values were shown in Figure 4.

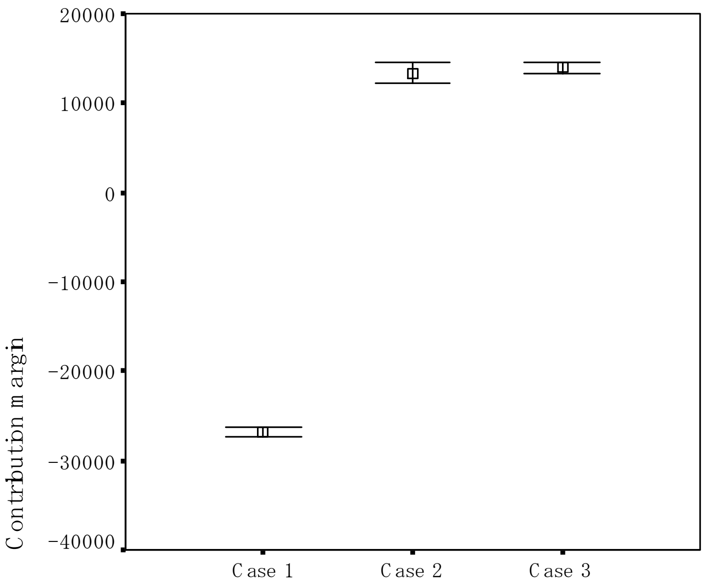

Figure 4: 95% confidence interval of mean value (contribution margin)

Case	Mean	Std. Deviation
1	-26815.24	4061.050
2	13402.50	8338.205
3	14017.35	4572.828

Table 6: Contribution margin [yen]

To confirm the statistically significant difference of the mean values, multiple comparison procedures were considered. The Games-Howell pairwise comparison test was executed with aids of SPSS 11.5, because the means had unequal variances (Games et al., 1976).

This result was shown in Table 7.

Pair (I)	Pair (J)	Difference (I - J)	Significance Probability
Case 1	Case 2	-40217.74**	< 0.010
Case 1	Case 3	-40832.59**	< 0.010
Case 2	Case 3	-614.84	0.632

Table 7: Multiple comparison (contribution margin)

From Figure 4 and Table 7, we confirmed that the case using the criterion of load efficiency (Case 2) and the case based on the contribution margin (Case 3) both increased the contribution margins compared with the case of no backhaul load (Case 1). However, we could not confirm the statistically significant difference between Case 2 and Case 3. If these cases have the same effect to increase the contribution margins, the criterion of load efficiency is the useful criterion because of its easiness of calculation.

[2] CO2 Emission

In Japan, many truckload carriers pay attentions to their CO2 emissions per unit of freight ton kilometer as an environmental target (Japan Trucking Association, 2007). Therefore, those values were calculated in the experiment.

The sample mean values and standard deviations of the CO2 emissions per unit of freight ton kilometer were shown in Table 8, and the 95% confidence intervals of the mean values were shown in Figure 5.

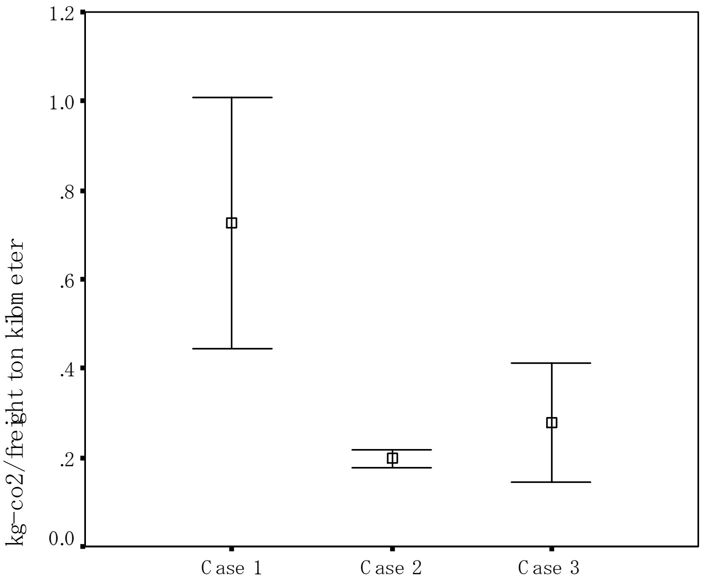

Figure 5: 95% confidence interval of mean value (CO2 emission)

Case	Mean	Std. Deviation
1	0.7268	2.01346
2	0.3665	0.46398
3	0.5374	0.95822

Table 8: CO2 emission per unit of freight ton kilometer [kg-CO2]

To confirm the statistically significant difference of the mean values, the Games-Howell pairwise comparison test was executed with aids of SPSS 11.5. This result was shown in Table 9.

Pair		Difference	Significance Probability
(I)	(J)	(I - J)	
Case 1	Case 2	0.5291**	< 0.010
Case 1	Case 3	0.4486*	0.013
Case 2	Case 3	-0.0806	0.463

Table 9: Multiple comparison (CO2 emission)

From Figure 5 and Table 9, we confirmed that the case using the criterion of load efficiency (Case 2) and the case based on the contribution margin (Case 3) both decreased the CO2 emissions per unit of freight ton kilometer compared with the case of no backhaul load (Case 1). However, we could not confirm the statistically significant difference between Case 2 and Case 3. If these cases have the same effect to decrease the CO2 emissions per unit of freight ton kilometer, the criterion of load efficiency is the useful criterion because of its easiness of calculation.

In addition, Figure 5 showed that the variance of Case 2 was extremely small compared with other cases. It is likely that the truckload carriers get stable CO2 emissions using the criterion of load efficiency.

CONCLUSIONS

In this paper, we presented the simple backhaul model connecting 6 points. And we clarified the criterion of load efficiency along the model. After that, we executed the numerical experiment in long-distance transportations using the model. As the result of the experiment, we confirmed the following points.

1) The case using the criterion of load efficiency and the case based on the contribution margin both increase the contribution margins compared with the case of no backhaul load.
2) We can not confirm the statistically significant difference of the contribution margins between the case using the criterion of load efficiency and the case based on the contribution margin.
3) The case using the criterion of load efficiency and the case based on the contribution margin both decrease the CO2 emissions per unit of freight ton kilometer compared with the case of no backhaul load.
4) We can not confirm the statistically significant difference of the CO2 emissions per unit of freight ton kilometer between the case using the criterion of load efficiency and the case based on the contribution margin.
5) The truckload carriers probably get stable CO2 emissions using the criterion of load efficiency.

Therefore, we think that the criterion of load efficiency is a good criterion to get the effect of getting backhaul loads because of its easiness of calculation.

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EFFECT ANALYSIS OF ABANDONMENT PALLET CAUSING AT PUBLIC TRUCK TERMINAL BY VSP METHOD

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ABSTRACT

In Tokyo, 4 public truck terminals have contributed to solving some environmental problems in the Tokyo metropolitan area by their transshipment function. However, their transshipment function caused new environmental problems. One of the typical problems was the increase of the number of abandonment pallets. The public truck terminals needed to dispose of their abandonment pallets in low cost and low environmental impact. In this paper, we focus attention on the abandonment pallet transportations from the 4 public truck terminals to a disposal trader. We propose a new transportation plan led by the IBM VSP method. The new plan is effective to reduce transportation costs and CO2 emissions.

INTRODUCTION

In Japan, the decrease of load efficiencies on freight trucking services is a serious problem because of a large amount of small goods for delivery. Therefore, the small goods are often gathered and transshipped into large trucks at truck terminals.

Around the Tokyo metropolitan area, there are 4 huge public truck terminals at which many transportation companies work together. These terminals have contributed to solving some environmental problems in the Tokyo metropolitan area. However, their transshipment function caused new environmental problems. One of the typical problems was the increase of the number of abandonment pallets. The public truck terminals needed to dispose of their abandonment pallets in low cost and low environmental impact.

The 4 public truck terminals in Tokyo developed a cooperative recycling system for pallet disposal. The system was effective to reduce disposal costs and CO2 emissions in the grounds of the terminals (Fujita et al., 2007). Moreover, we confirmed the feasibility of developing a similar system in Osaka (Fujita et al., 2008).

In this paper, we focus attention on abandonment pallet transportations from the 4 public truck terminals to a disposal trader. We propose a new transportation plan led by the IBM VSP method. After that, we examine the effect of the new transportation plan.

CURRENT TRANSPORTATION PLAN

The Keihin terminal, the Kasai terminal, the Adati terminal and the Itabashi terminal have been built around the Tokyo metropolitan area. Each one works as the public truck terminal. These 4 terminals transport their abandonment pallets to one disposal trader. In a current transportation plan, a 10t truck starts from the disposal trader and shuttles between the disposal trader and each terminal. Figure 1 shows the geographical coverage of the current transportation plan.

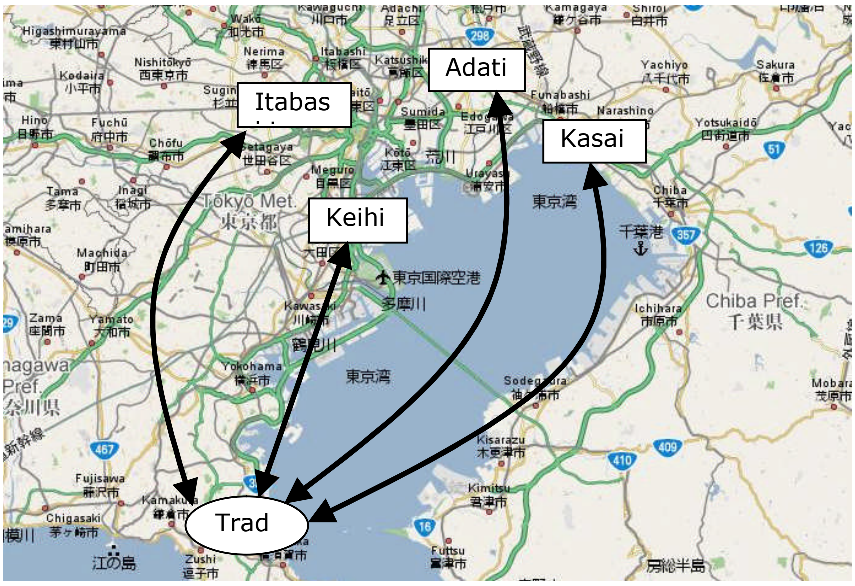


Figure 1: Geographical coverage of current plan

Table1 shows the shuttle transportation frequencies in 2007, and Table2 shows the record of the transportation in 2007.

Month	Keihin	Kasa i	Adati	Itabashi	Total
January	11	5	3	3	22
February	11	4	2	3	20
March	12	4	3	2	21
April	10	4	4	2	20
May	8	3	3	3	17
June	10	2	3	2	17
July	10	4	3	2	19
August	8	3	3	4	18
September	6	3	4	3	16
October	8	5	3	5	21
November	7	5	4	3	19
December	8	5	4	4	21
Total	109	47	39	36	231

Table 1: Monthly transportation frequency in 2007

Total number of pallets	68,249
Total weight of pallets [t]	1,251
Total truck travel distance [km]	22,280
Total freight ton-kilometer [tkm]	60,437

Table 2: Record of transportation in 2007

NEW TRANSPORTATION PLAN

If the total travel distance of trucks can be reduced, the reduction of CO_2 emissions and transportation costs can be expected. Therefore, we make the new transportation plan according to the following policies.

1) The transportation is done by using a 15t truck.
2) Transportation routes are led by the IBM VSP method, and one route includes more than one terminal.
3) The transportation is done regularly, and the 15t truck visits all terminals at the same frequency.

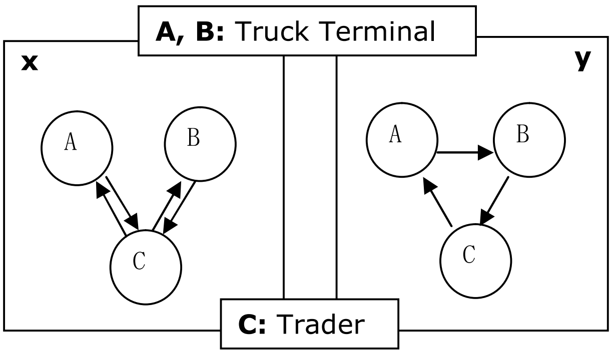
[1] Transportation Frequency

Table 1 shows that the Keihin terminal, the Kasai terminal, the Adati terminal and the Itabashi terminal have respective minimum transportation frequencies of 6/month, 2/month, 2/month and 2/month in 2007. The transportation frequency should be low to reduce the total travel distance of the trucks. However, the frequency less than 6/month probably cause heavy accumulations of the abandonment pallets at the Keihin terminal. Therefore, the transportation frequency is determined to be 6/month under the new transportation plan.

[2] Transportation route

The transportation routes under the new transportation plan are obtained by integrating current shuttling routes using the IBM VSP method.

Specifically, a saving value of the route integration for each pair of terminals is calculated as illustrated in Figure 2, and the route integration is examined one by one from the largest saving value.



Travel distance of x: 2d (C, A)+2d(C, B)

Travel distance of y: d (C, A)+d(A, B)+d(C, B)

Saving value:
s(A, B) = d(C, A)+d(C, B) - d(A, B)

Figure 2: Saving value

When the whole weight of the abandonment pallets on the route doesn't exceed the maximum capacity loading of the truck, the route integration is done. In the other case, the route integration is not done, and other route integration is examined. The transportation routes with a little travel distance are made by repeating this process.

We need the weight of the abandonment pallets at each track terminal for this process. Therefore, we calculate the average weight per transportation unit at each terminal where the truck transports the pallets 6 times a month. Table3 shows the calculation from the record of the transportation in 2007

Month	Keihin	Kasai	Adati	Itabashi
January	10,420	4,674	2,625	2,950
February	10,113	3,450	1,533	2,957
March	10,535	2,532	1,820	1,963
April	9,055	3,695	3,642	2,050
May	7,585	2,750	2,733	2,822
June	9,127	1,900	2,605	2,040
July	9,363	3,770	2,662	1,963
August	7,162	2,890	2,593	3,932
September	4,713	2,713	3,672	3,023
October	7,693	4,905	2,602	4,842
November	6,298	3,010	3,493	2,812
December	6,738	4,907	3,465	3,755

Table 3: Monthly weight per transportation unit [kg]

Table 3 shows that the Keihin terminal, the Kasai terminal, the Adati terminal and the Itabashi terminal have maximum monthly weights per transportation unit of 10,535 kg, 4,907 kg, 3,672 kg and 4,842 kg, respectively. The current shuttling routes are integrated by the VSP method based on these maximum values. In this way, we can obtain the new transportation routes that not vary with changes in the monthly transportation weight.

Figure 3 shows the image of the new transportation routes finally determined.

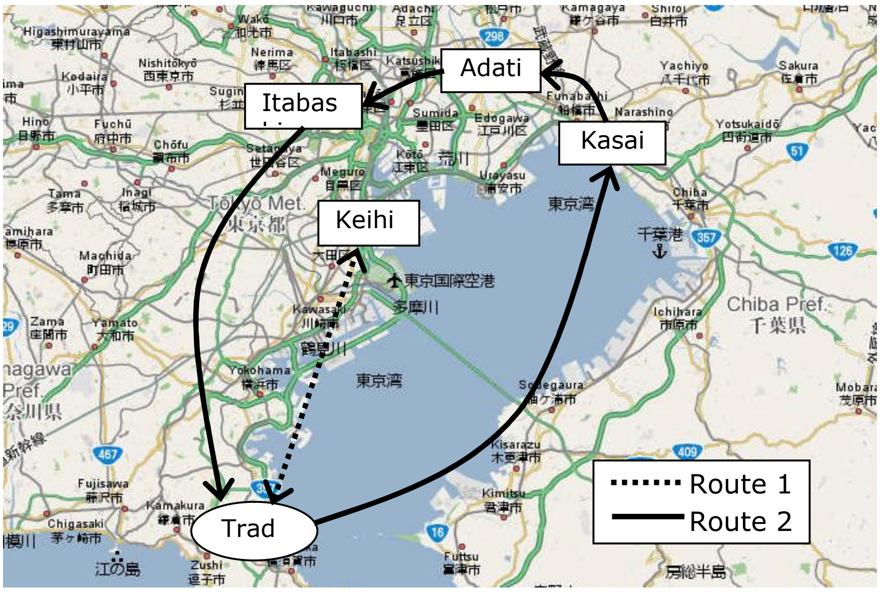


Figure 3: Image of new transportation route

EFFECT OF NEW TRANSPORTATION PLAN

[1] Transportation cost
The public truck terminals have to pay freight charges for trucks as transportation costs. In many cases, the freight charge varies only with an actual haul distance of the truck.

In the Report on Actual Freight Charges, average freight charges of the 10t truck and 15t truck in February 2008 were determined by the following Table 4 (Editorial Department of LOGI-BIZ, 2008).

Actual haul distance [km]	Charge (10t) [yen]	Charge (15t) [yen]
0< and =<20	21,004	22,939
20< and =<50	26,043	28,820
50< and =<100	33,723	38,490
100< and =<150	39,933	45,165
150< and =<200	45,526	52,981
200< and =<300	56,288	64,957
300< and =<400	67,333	77,064
400< and =<500	79,141	89,343

Table 4: Freight charge of truck

To confirm the effect of transportation costs reduction, we calculate the annual actual haul distances and freight charges of the trucks based on the record of the transportation in 2007 and Table 4. Table 5 shows the calculation under the current transportation plan, and Table 6 shows the calculation under the new transportation plan.

Route	Actual haul distance [km]	Freight charge [yen]	Frequency / year	Actual haul distance / year[km]	Freight charge / year [yen]
Trader - Keihin - Trader	37	26,043	109	4,033	2,838,687
Trader - Kasai - Trader	53	33,723	47	2,491	1,584,981
Trader - Adati - Trader	63	33,723	39	2,457	1,315,197
Trader - Itabashi - Trader	68	33,723	36	2,448	1,214,028
Total	-	-	231	11,429	6,952,893

Table 5: Actual haul distance and freight charge (Current plan: 10t truck)

Route	Actual haul distance [km]	Freight charge [yen]	Frequency / year	Actual haul distance / year[km]	Freight charge / year [yen]
Trader - Keihin - Trader	37	28,820	72	2,664	2,075,040
Trader - Kasai - Adati - Itabashi - Trader	112	45,165	72	8,064	3,251,880
Total	149	73,985	144	10,728	5,326,920

Table 6: Actual haul distance and freight charge (New plan: 15t truck)

From Table 5 and Table 6, we confirm that the effect of the transportation costs reduction under the new transportation plan is totally about 1,600,000 yen.

[2] CO2 emission

To confirm the effect of CO2 emissions reduction, we calculate the annual travel distances and CO2 emissions of the trucks based on the record of the transportation in 2007. The calculation of the CO2 emissions follows the mileage method presented by the Japan Institute of Logistics Systems (Japan Institute of Logistics Systems, 2006). The mileages of the 10t truck and 15t truck are assumed to be 3.5 km/l and 2.7 km/l, respectively. A CO2 emission coefficient is assumed to be 2.62 kg-CO2/l.

Table 7 shows the calculation under the current transportation plan and new transportation plan.

Item	Current plan (10t truck)	New plan (15t truck)	Difference
Travel distance/year[km]	22,280	16,836	5,444
CO2 emission/year [kg-CO2]	16,678	16,338	340

Table 7: Travel distance and CO2 emission

From Table 7, we confirm that the effect of travel distances reduction is totally 5,444 km, and the effect of the CO2 emissions reduction is totally 340 kg-CO2 under the new transportation plan. In Japan, many transportation companies pay attention to their CO2 emissions per unit of freight ton-kilometer as an environmental target. For example, the Japan Trucking Association announced the target that the average CO2 emissions per unit of freight ton-kilometer should be reduced at least 0.011 kg/tkm by 2010 (Japan Trucking Association, 2007). Under the circumstances, we calculate monthly CO2 emissions per unit of freight ton-kilometer based on the record of the transportation in 2007.

Table 8 shows the calculation under the current transportation plan and new transportation plan.

Month	Current plan (10t truck)	New plan (15t truck)	Difference
January	0.266	0.174	0.092
February	0.277	0.212	0.065
March	0.317	0.242	0.075
April	0.269	0.193	0.076
May	0.268	0.229	0.039
June	0.270	0.255	0.015
July	0.267	0.205	0.062
August	0.269	0.215	0.054
Septembe r	0.276	0.232	0.044
October	0.262	0.167	0.095
November	0.304	0.218	0.086
December	0.275	0.171	0.104
Average	0.27667	0.20942	0.06725

Table 8: Monthly CO2 emission per unit of freight ton-kilometer

To confirm the statistically significant difference of the averages in Table 8, we execute the paired t-test with aids of SPSS 11.5 (Hoel, 1981). Table 9 shows this result.

Pair	Average of difference	Std. error	t-value	Degree of freedom	Significance Probability
Current plan - New plan	0.06725**	0.00753 7	8.923	11	< 0.01

Table 9: Paired t-test (CO2 emission per unit of Freight ton-kilometer)

From Table 8 and Table 9, we confirm that the new transportation plan is effective to reduce the CO2 emissions per unit of freight ton-kilometer, and to achieve the target of the Japan Trucking Association.

CONCLUSIONS

In this paper, we focused attention on the abandonment pallet transportations from the 4 public truck terminals to the disposal trader. We proposed the new transportation plan led by the IBM VSP method. Moreover, we examined the effect of the new transportation plan according to the record of the transportation in 2007.

As a result, we confirmed the following points.

1) The effect of the transportation costs reduction under the new transportation plan is totally about 1,600,000 yen in a year.
2) The effect of the travel distances reduction under the new transportation plan is totally 5,444 km in a year.
3) The effect of the CO2 emissions reduction under the new transportation plan is totally 340 kg-CO2 in a year.
4) The new transportation plan is effective to reduce the CO2 emissions per unit of freight ton-kilometer, and to achieve the target of the Japan Trucking Association.

Therefore, we think that the IBM VSP method is valuable to make transportation plans for abandonment pallets.

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INTERMODAL COST-TIME TRADE-OFFS

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ABSTRACT
In this paper, we develop a system to tackle a multi-criteria dynamic shortest path problem. The problem was solved using a combination of constraint propagation and Dijkstra's algorithm. An interactive user interface was developed to advise the user on the most effective path and schedule based on the multiple preferences of cost and urgency. Results obtained confirmed that cost-averse user's requirements lead to longer shipping times and lower utilization of airports. We were able to find alternative solutions which were in principle better than the lowest cost and shortest time alternatives.

Keywords: Intermodal, Cost-time

INTRODUCTION

For a cost effective supply chain, it is important to transport goods by the cheapest means while ensuring timely deliveries. However in practice accurate and complete information is rarely known in advance. The dynamism of the supply chain is contributed by various factors and ranges from production delays to changes in delivery requirements. Changes in production schedules can result in either the earliness or tardiness of goods available for shipment. The need to maintain overall schedule consistency downstream in a supply chain can be seen as a further constraint on the availability of choices. Besides, there may not be complete information about the shipping schedule via air or sea well in advance and it may depend on a fixed schedule from a certain service provider.

Besides the need to depart from the origin and arrive at the destination, within specified time windows, the criterion of cost also plays a role on the shipment decision. To cope with the earliness and tardiness of production cycles, when faced with earliness of production, the shipper can choose the lowest cost route to achieve consistent schedule downstream to destination as well as to decrease the on-hand inventory because goods will travel for a longer total transit time to reach the destination. Instead, when a production delay happens, the fastest route (shortest total transit time) can be chosen to maintain a consistent schedule downstream. This helps to reduce the impact of a production delay. Not all optimal decisions are however based on the lowest cost or fastest route and there tends to be choices which are a balance of both.

Thus, the shipper needs a tool which can decide on the shipping route and shipping dates. Given different starting delivery dates at a node to an identical destination node, the tool may result in different shipping routes, depending on the available connecting schedule on that date. Given the goods' arrival time at a certain node, the objective is (i) to provide a solution to deliver the goods as fast as possible, (ii) to deliver the goods at the lowest cost possible, and (iii) to deliver the goods in the given time window and/or cost window.

This paper seeks to simulate the twin effects of lowest cost and shortest time routing for air / sea transportation. The challenge was to reduce the cost without a disproportionate increase in transit time.

LITERATURE REVIEW

Looking at shipping collectively from the perspective of a multimodal nature has been analyzed for various aspects of the supply chain. Kozan (2000) looks at container transfers in multimodal terminals. A mathematical model is proposed to minimize the handling time in a multimodal facility. Kozan & Preston (1999) use a genetic algorithm approach to solve the same problem to obtain near-optimal solutions in reasonable time.

Boardman et al. (1997) considers the cost of changing the mode of transportation in the intermodal routing problem. A K-shortest path algorithm is used to determine the least costly path to be takes. Bookbinder and Fox (1998) focus on intermodal routing between Canada and Mexico and use a shortest path algorithm to define hypothetical services which would add value to shippers. Chang (2007) proposes a mathematical model for the problem which is modeled as a multiobjective multimodal multicommodity flow problem (MMMFP) with time windows and concave costs. A combination of decomposition and relaxation methods which include lagrangian relaxation and heuristics are used to solve the problem, followed by a re-optimization approach to manage infeasible solutions.

Multi modal transportation problems have been identified and solved in a variety of applications. Kim (1999) solves a service network design problem for express package delivery involving land and air transportation. Mathematical programming is used with decomposition methods and heuristics to optimize the service network for package delivery utilizing available air and land transport resources.

One of the more popular problems in the literature on multi-modal transportation is the Travel Planning Problem. Route planning is one form of travel planning in the literature. This involves minimizing cost travelling from a given origin to a destination with time constraints on departures and arrivals. Horn (2003) and Chiu et. al. (2005) apply it to utilization of public transport services within an urban context. Horn (2003) uses a Dijkstra based algorithm to minimize generalized-cost. Chiu et. al. (2005) also use a Dijkstra based algorithm to model a route advisory system and elaborate on the agent-based architecture used to collect information and interface with users.

Travel itinerary planning is another aspect of travelling planning found in the Literature. For itinerary planning the intermediate nodes are of importance. In Berube et. al. (2006) and Konstantinos and Konstantinos(2009) the sequence of travel through these intermediate nodes is fixed and each node has its own time constraints to be satisfied.

PROBLEM FORMULATION

The problem discussed here involves optimizing the routing and scheduling of J jobs defined as graph $G= (N, A)$ where N denotes a set of n nodes and A denotes a set of m arcs among the multimodal transportation nodes.

Let the variable $TT_{i,j}$ represent the total transit time from node i to node j. $TT_{i,j}$ is a summation of the total travel time $ST_{i,j}$ and the total waiting time $W_{i,j}$, while $ST_{i,j}$ is a summation of the total terminal handling time at departure port THT_i, travel time $\Delta t_{i,j}$ and terminal handling time at the destination port THT_j. Thus,

$$TT_{i,j} = W_{i,j} + ST_{i,j} \qquad \textbf{(1)}$$
$$ST_{i,j} = THT_i + \Delta t_{i,j} + THT_j$$

$TT_{i,j}$ calculation starts from goods arrival at origin node i at time $t_{i'}$ until the goods arrive at destination node j at time $t_{j'} + THT_j$.

In general, $\Delta t_{i,j}$ in a multimodal transportation network is time-dependent and stochastic. In this paper, $\Delta t_{i,j}$ is assumed deterministic and dependent on the departure time at origin node.

$ST_{i,j}$ calculation above is only valid when the solution route consists of only 2 nodes. If the solution route consists of more than 2 nodes in sequence, let say *p* nodes, $ST_{i,j}$ is calculated as following.

$$ST_{i,j} = (\sum_{m=1}^{p-1} THT_m + \Delta t_{m,m+1}) + THT_j \quad \textbf{(2)}$$

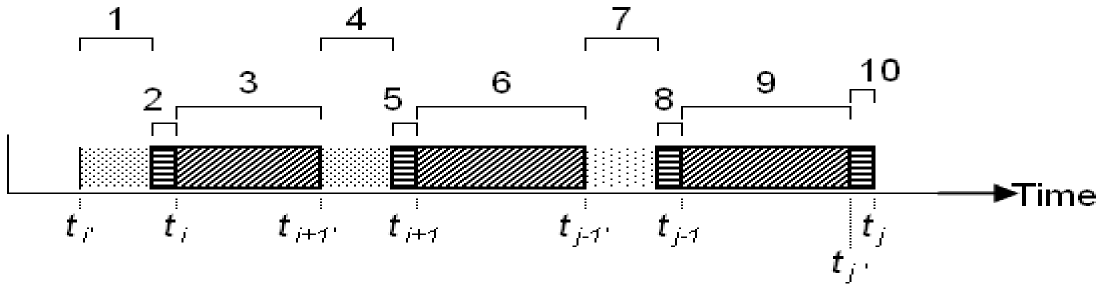


Figure 1. Shipping process through 2 intermediate nodes

Figure 1 shows that goods arrive at node *i* in time $t_{i'}$. Since the departure schedule from the original node is at time t_i and terminal handling time [2] is shorter $t_i - t_{i'}$, waiting time [1] occurs. The goods arrive at first intermediate node after $\Delta t_{i,i+1}$ [3] at time $t_{i+1'}$. At this node, waiting time [4] occurs because $t_{i+1'}$ is much earlier than t_{i+1} – terminal handling time [5]. In summary, the whole shipping process is repeated until the goods arrive at destination node *j* in time [10]. Overall, $TT_{i,j}$ for the complete shipping process is summation of [1] to [10], while $ST_{i,j}$ is summation of [2], [3], [5], [6], [8], [9] and [10].

Now we discuss some cost factors that are associated with each arc and each node. Costs associated with each arc represent the resources consumption needed to travel from node *i* to node *j* while costs associated with each node represent the resources consumption needed such as documentation and terminal handling charges.

Let $CT_{i,j}$ denote the total cost associated with transporting goods from origin node *i* to destination node *j* per TEU. It is a summation of arcs and nodes costs along the route. In general, $CT_{i,j}$ calculation includes total ocean freight cost *(OFC)*, total air freight cost *(AFC)* and total trucking *(TRK)* (land transportation) cost.

$$CT_{i,\,j} = OFC + AFC + TRK \quad \textbf{(3)}$$

However, in practice, $CT_{i,j}$ depends on the transportation modes taken by the solution routes since the solution routes are not necessary a complete combination of *OFC*, *AFC* and *TRK*.

TRK for every schedule is assumed to be a fixed amount, while AFC is assumed as the lowest total ocean freight cost (*min(OFC)*) from and to the two corresponding seaports departing at April 1st, 2008 multiplied by 2.

OFC is a summation of Terminals Handling Charges *(THC)* and total Ocean Freight Charge *(OC)*.

$$OFC_{i,j} = THC_{i,j} + OC_{i,j} \quad \textbf{(4)}$$

THC consists of Document Fee and Handling Charge at origin node and destination node. Thus, *THC* can be formulated as summation of Origin Document Fee *(ODF)*, Origin Handling Charge *(OHC)*, Destination Document Fee *(DDF)*, and Destination Handling Charge *(DHC)*.

$$THC_{i,\,j} = ODF_i + OHC_i + DDF_j + DHC_j \quad \textbf{(5)}$$

When a route goes through intermediate node(s), *ODF* and *OHC* are levied only at the first departure node (node *i*) while *DDF* and *DHC* are levied only at the last arrival node (node *j)*. Document Fee and Handling Charge at intermediate node(s) are not included in the calculation. But, if a solution route results at least 4 seaport nodes and the nodes are not in a consecutive order, *ODF* and *OHC* are levied at each first departure node while *DDF* and *DHC* are levied at each last arrival node.

OC is a summation of Ocean Freight Basic Charge (BAS), Bunker Adjustment Factor (BAF), Emergency Bunker Surcharge (EBS) and Security Charge (SER).

$$OC_{i,j} = BAS_{i,j} + BAF_{i,j} + EBS_{i,j} + SER_{i,j}$$

So, OC calculation for *p* seaports in sequence:

$$OC_{i,j} = \sum_{m=1}^{p-1} BAS_{m,\, m+1} + BAF_{m,\, m+1} + EBS_{m,\, m+1} + SER_{m,\, m+1} \qquad \textbf{(6)}$$

where if $m = 1$, it means that the node is first departure node (node *i*), and if $m + 1 = p$, it means that the node is the last arrival node (node *j*).

Basing on the calculation above, we can generalize OFC as following:

$$OFC_{i,j} = THC_{i,j} + \sum_{m=1}^{p-1} OC_{m,\, m+1} \qquad \textbf{(7)}$$

Now, we discuss the route selection scheme. Let a scheduled link from node i_m to node i_{m+1} through a transportation service $s \in$ S = {Land, Ocean, Air} at an earliest possible departure time t_m is represented by (i_m, i_{m+1}, s_m, t_m). In this context, any route itinerary $I_{i,j}^{t,p}$ from node *i* at time t_i to node *j* can be represented by a sequence of schedule links:

$$I_{i,j}^{t,p} = \{(i_i, i_{i+1}, s_i, t_i), (i_{i+1}, i_{i+2}, s_{i+1}, t_{i+1}), \ldots \ldots \ldots, (i_{j-1}, i_j, s_j, t_{j-1})\}$$

which satisfies the constraint:

$$t_m \geq t_{m-1} + \Delta t_{m-1,\, m} + THT_m$$

Note that arrival time at destination node *j* is equal to:

$$t_j = t_{j-1} + ST_{j-1,j} + THT_j$$

A set of itineraries is denoted by $I_{i,j}$ and the route of an itinerary is denoted by $R(I_{i,j})$. For each itinerary $I_{i,j}^{t,p} \in I_{i,j}$, it is associated with a total transit time function $TT(I_{i,j}^{t,p})$ and a total cost function $CT(I_{i,j}^{t,p})$. $TT(I_{i,j}^{t,p})$ and $CT(I_{i,j}^{t,p})$ notations are also simplified as $TT_{i,j}$ and $CT_{i,j}$

As mentioned earlier, the purpose of this system is to find routes or itineraries with the lowest total transit time $min(TT(I_{i,j}^{t,p}))$ and the lowest total cost $min(CT(I_{i,j}^{t,p}))$.
Thus,

$$STR_{i,j} = R(min(TT(I_{i,j}^{t,p}))) \qquad \textbf{(8)}$$

$$LCR_{i,j} = R(min(CT(I_{i,j}^{t,p}))) \qquad \textbf{(9)}$$

$LCR_{i,j}$ denotes the lowest cost route while $STR_{i,j}$ denotes the shortest transit time route.

If a certain time window (T_w) and a cost value (C_w) are given as a constraint then the intermediate solution route (ISR) will be:

$$ISR = R(I_{i,j}^{t,p}),\ \text{satisfying the constraints}$$

$$TT(I_{i,j}^{t,p}) \leq T_w \text{ and } CT(I_{i,j}^{t,p}) \leq C_w \quad \textbf{(10)}$$

Finally, when the system finds routes with have the same $CT_{i,j}$, then solution result will be the route with the shortest $TT_{i,j}$. The similar decision will be made when the system finds routes with the same $TT_{i,j}$, the solution result will be the route with the lowest $CT_{i,j}$.

ALGORITHM

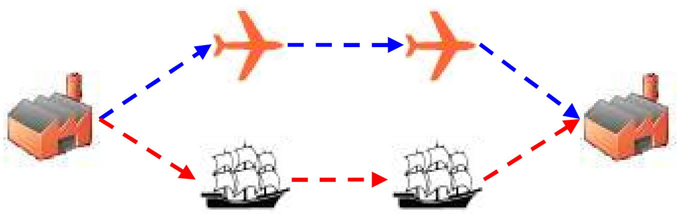
Based on equations (1) – (10) in problem formulation, it is clear that the problem discussed here is a Dynamic Shortest Path Problem *(DSPP)*, where the solutions are LCR and STR with dual cost variables, destination arrival time and destination shipping cost. It is also a single source shortest path problem that can be solved using a graph search algorithm. In this paper, Dijkstra's algorithm is used.

Solutions for the problem are routes that encompass the connecting arcs between ports. The connecting arcs exist only when transportation schedules between ports are available, thus not every transportation schedule to a particular port at any point of time could be connected to every transportation schedule from that particular port to any other ports. This unique property then puts a scheduling constraint into the problem.

Dijkstra's algorithm could solve this problem, but it requires the creation of new connecting arcs for every possible connecting schedule. Given the period of schedule being used in this system, this process will result a huge static dataset. This does not comply with the dynamic requirements of the problem. Thus, a slight modification to Dijkstra's algorithm, which involves the use of constraint propagation, is performed. The purpose of the constraint propagation is to search for the earliest possible connecting schedule between two ports.

CONSISTENT SCHEDULE DOWNSTREAM AND COST – TIME TRADE-OFFS

To deliver cargo, a company can choose a single transportation mode. The solution for this mode is either a solution with the shortest total transit time and a high total transportation cost (extremely fast and solely via air freight) or a solution with the lowest total transportation cost and longer travelling time (extremely low cost and solely via ocean freight).The solution illustration and its graph are shown in Figure 2.



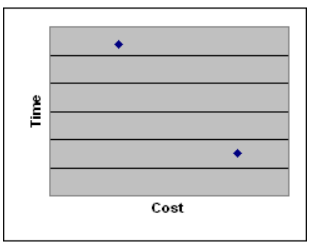


Figure 2. Shipping route without involving hub and its solution space

However, if the requirement is to expedite the goods in a certain time or cost window due to certain reasons and constraints, such as the non existence of either seaport or airport at a certain location, expediting the goods in time speedily can be achieved by using intermodal transportation. In this case, a hub that makes transporting goods between different transportation modes possible is involved in the solution. By involving a hub, the number of alternative solutions is increased. Thus, maintaining a consistent schedule downstream is achievable.

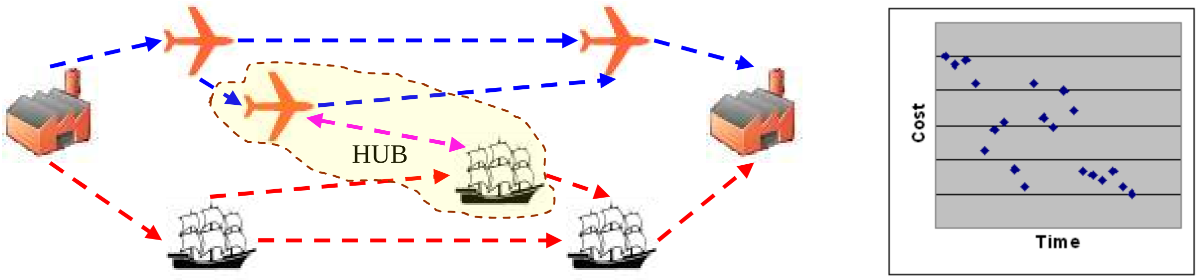


Figure 3. Involving a hub into shipping route and its solution space

The following example shows the intermodal cost – time trade offs between intermodal transportation modes. Suppose that a carrier is to deliver its order from Manufacturing Branch in Qingdao, China denoted by (QDOMF) to Mumbai Manufacturing Branch, India denoted by (BMBMF), on April 1st, 2008. The data used were from various sources. The Flight schedules were retrieved from Singapore Airlines regular flight schedules from April 1, 2008 to May 31, 2008. The Vessel Schedules were retrieved from Maersk's vessels' schedules from April 1, 2008 to May 27, 2008. The Ocean Freight charges were retrieved from Maersk's website. The following are solutions for the above problem using the respective port calls of PVG, SIN etc where the term PVG, SIN etc are name in the Appendix.

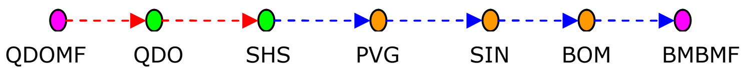


Figure 4. STR$_{QDOMF,\ BMBMF}$

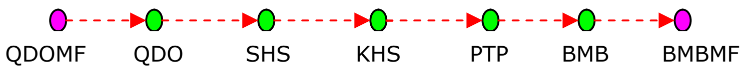


Figure 5. LCR$_{QDOMF,\ BMBMF}$

LCR$_{QDOMF,\ BMBMF}$ costs USD2,374.96 and will arrive at *BMBMF* at April 13th, 2008, 5.00pm, while STR$_{QDOMF,\ BMBMF}$ costs USD5,145.96 and will arrive to destination at April 3rd, 2008, 5.40am. If the company is to deliver its order in between the time and the cost windows of STR and LCR, April 10, 2008, 9am for instance, the solution route could be found through intermodal transportation. The hub, for this example, is located at Singapore. So, the available alternatives could be one of following routes.

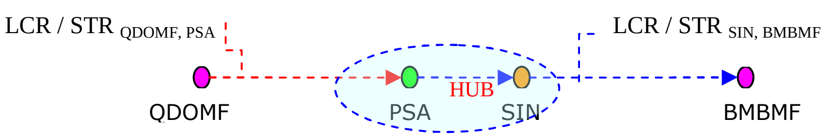


Figure 6. Alternative solutions involving Intermodal transportation 1

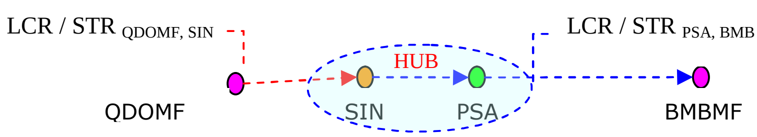


Figure 7. Alternative solutions involving intermodal transportation 2

The solution for the given time window is to travel through $STR_{QDOMF,PSA}$ then continued by $LCR_{SIN,BMBMF}$. Total transportation cost involved for this route is USD4,462.3 and goods will arrive at destination at April 9th, 2008 12pm.

USER INTERFACE

The application is windows based. A map with 26 airport nodes, 41 seaport nodes, 52 arcs connecting airports and 170 arcs connecting seaports is located at the upper left of the main application window. On the right side, several tabs are located. General node information is put in the “General” tab, node’s ranking is put in “Rankings” tab, while facility to search for optimal route/solution is put under “Optimal Route” tab.

A screenshot to show the STR from Dalian, China, to Jakarta, Indonesia, generated from the application is shown as following.

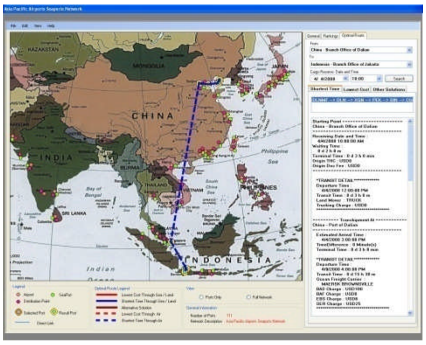


Figure 8. User Interface screenshot

CONCLUSION

The system we have developed deals with a multi-criteria dynamic shortest path problem. The problem was solved using a combination of constraint propagation and the Dijkstra’s algorithm. An interactive user interface was developed to advise the user on the most effective path and schedule based on multiple preferences of cost and urgency. The results obtained were consistent, with a cost-averse user’s requirements leading to longer shipping times and lower utilization of airports. We were able to find alternative solutions which were in principle better than the lowest cost and shortest time alternatives.

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APPENDIX

Ports List

Port ID	Port Country, Port Type, Port Name
BOM	India, Airport, Chhatarpati Shivaji Airport
PVG	China, Airport, Shanghai Pudong Airport
SIN	Singapore, Airport, Changi International Airport
BMB	India, Seaport, Port of Jawaharlal Nehru
KHS	Taiwan, Seaport, Port of KaohSiung
PSA	Singapore, Seaport, Port of Singapore
PTP	Malaysia, Seaport, Port of Tanjung Pelepas
QDO	China, Seaport, Port of Qingdao
SHS	China, Seaport, Port of Shanghai

DEFINING 'EXTRA DISTANCE' AS A MEASURE TO EVALUATE ROAD TRANSPORT PERFORMANCE

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ABSTRACT
In logistics research, there has been a focus on measuring the absolute performance of road transport operations. However, there have not been any studies assessing the marginal impact of supply chain disturbances on the economic and environmental performance of such operations. Starting with the assumption that any unnecessary distance run creates a proportional additional cost and output of carbon dioxide, the aim of this paper is to introduce the concept of 'extra distance' as a means of assessing the marginal impact that deviations from the transport plan have on the economic and environmental performance of road transport. An inductive research approach has been adopted, including the empirical application of the concept within two supply chains. From this, five types of 'extra distance' are identified and linked back to the concept of uncertainty within transport operations. Therefore, 'extra distance' can be considered a novel diagnostic measure that can be used to evaluate the causes and consequences of uncertainty within distribution networks.

INTRODUCTION
In logistics research, there has been a focus on measuring the absolute and/or average performance of road transport operations (Fowkes et al 2004, McKinnon & Ge 2004). One aspect of performance measurement that appears to be under-researched is the impact of unexpected events upon transport performance. In effect, the marginal impacts of supply chain uncertainty on freight transport performance at an operational level. There is evidence of performance measures detailing the number of incidents that occur, and also macro-level measures of planned versus actual distance travelled. However, there have not been any studies that have assessed the impact of supply chain disturbances and disruptions in terms of the extra movements required within the transport network. Starting with the assumption that any unnecessary distance run creates a proportional additional cost and output of carbon dioxide, the aim of this paper is to introduce the concept of 'extra distance' as a means of assessing the marginal impact that deviations from the transport plan have on the economic and environmental performance of road freight transport operations.

The paper begins by presenting a brief section on supply chain uncertainty in transport operations, highlighting why the 'extra distance' concept needs to be developed. An inductive approach is then taken to develop and refine a tool for evaluating 'extra distance'. Finally, 'extra distance' as a principle is defined and the findings are presented. During the research, absolute levels of additional cost and carbon dioxide output were evaluated, but these are not reported for reasons of commercial confidentiality.

SUPPLY CHAIN UNCERTAINTY IN TRANSPORT OPERATIONS
According to Van der Vorst & Beulens (2002), "Supply chain uncertainty refers to decision making situations in the supply chain in which the decision maker does not know definitely what to decide as he is indistinct about the objectives; lacks information about its environment or the supply chain; lacks information processing capacity; is unable to accurately predict the impact of possible control actions on supply chain behaviour; or, lacks effective control actions". According to Davis (1993) sources of supply chain uncertainty may be categorised as coming from suppliers, manufacturing, and customers. Mason-Jones and Towill (1998) develop the uncertainty circle model adding an additional source of uncertainty, the control system. Most recently, Peck et al (2003) add exogenous events as a new dimension to supply chain uncertainty.

In order to extend the previous literature, a transport-focussed uncertainty model has been derived from the Uncertainty Circle (Sanchez Rodrigues et al., 2007, 2008). The model includes five uncertainty sources that can affect transport operations: shipper, customer, carrier, control systems and external uncertainty. From empirical research, major causes of uncertainty include supply chain delays, variable demand and/or inaccurate forecasts, lack of supply chain coordination and delivery restrictions.

There is scope for extending the above research further by quantifying the consequences of these uncertainty causes within transport operations. Sector level surveys in the UK do highlight the frequency of occurrence of different events and their impact in terms of time (for example, Department for Transport, 2007). However, this may not translate into a financial cost if there is flexibility in the delivery network to absorb the delays. There is a need to understand more fully the marginal distance, 'extra distance', that occurs due to uncertainty, as this will have a direct financial and environmental cost.

METHOD

Due to the lack of research into the marginal impact of transport uncertainty, an inductive research approach has been adopted. The first stage was to make the direct link between miles run, output of carbon dioxide (environmental performance) and cost, and from this, the concept of 'extra distance' was developed and defined in a brainstorming session involving all the authors. Consideration was then given as to the different ways in which additional transport may be required in response to the causes of uncertainty identified in Sanchez Rodrigues et al. (2008). From this, five types of 'extra distance' were identified, with discussions with industry confirming their likely existence.

After developing the concept, a measure was created and tested with two third party logistics providers, one in the UK and the other in South Africa. Data was collected on the nature of unexpected events and their impact on the total number of miles travelled. In the UK, this information was obtained through observation of the 'live' transport planning process while archival data was used in South Africa. The number of extra miles in both cases was calculated from route planning software. A cause-and-effect exercise was undertaken to determine the causes of 'extra distance' found. The causes of 'extra distance' collected were categorised in an Excel spreadsheet. In this spreadsheet, their frequency and impact, in terms of cost and carbon dioxide output, was calculated.

The above process was used to confirm the accuracy of the conceptual model and refine it as appropriate. The final stage in the inductive process was to then relate this back to the published literature, reflecting upon the learning gained in data collection.

INITIAL DEFINITION OF 'EXTRA DISTANCE'

From the initial brainstorming session, the following definition of 'extra distance' was developed:

Any additional transport movements that are a consequence of unforeseen changes in the delivery process e.g. due to congestion and/or late changes in customer requirements.

With this definition, it was assumed that the original transport plan produced is an optimum given the constraints imposed. From this, five types of 'extra distance' were identified, in response to uncertain events within the delivery operations. These are described in the following sections and summarised in Table 1.

Extra distance due to optimal route diversion

This type of 'extra distance' can occur when there is unplanned road congestion along the optimal route initially planned for the trip, so the vehicle is required to be diverted. When the driver is informed of a traffic jam that will delay the vehicle, a decision may be taken to use an alternative route so as to minimise the delay. If that occurs, the vehicle runs a greater distance within the trip due to the use of a non-optimal route.

Type of 'extra distance'	Description	Uncertainty cause from literature
Extra distance due to optimal route diversion	Extra distance needs to be run to minimise the delay to the trip.	Unplanned road congestion (Boughton 2003)
Extra distance/ trips due to delays	Extra or diverted trips are required due to the fact that the vehicle original assigned to the trip could not arrive on time.	Loading delays at shippers (Sanchez Rodrigues at al 2007)
		Unload time uncertainty (Esper and Williams 2003)
Extra distance/ trips due to load more than advised	Extra or diverted trips are caused because there is not enough time to find the most economical way to move the extra volume.	Demand variability and forecast inaccuracy (Mason-Jones and Towill 1998)
Extra distance/ trips due to load less than advised	There is unexpected extra space in the vehicle, so the transport plan is suboptimal and unnecessary trips are operated.	Inaccurate demand forecast (Mason-Jones and Towill, 1998); Warehouse inefficiencies (van der Vorst and Beulens 2002)
Extra distance/ trips due to inappropriate vehicle size	A smaller vehicle than planned is provided, requiring additional trip to deliver all products.	Transport delays due to internal reasons e.g. defective vehicle or lack of driver (Mason et al., 2003)

Table 1: Types of 'extra distance' and potential causes

Extra distance/trips due to delays
Occasionally delays can occur within the delivery process, such as production and/or loading delays at shippers (Esper and Williams 2003, Sanchez-Rodrigues et al 2007), unloading delays at customers (Geary et al 2003) and unplanned road congestion (Boughton 2003). The consequence of each is that the vehicle will be late for the next load in its schedule, so a different vehicle may be needed to operate that movement, either as an additional trip, or a diversion of an existing trip; in either case it is likely to be less efficient and involve more miles being run as a consequence of the earlier delay.

Extra distance/trips due to load more than advised
Inaccurate and/or variable volume forecasts can lead to the short notice requirement to move additional product volumes. Whilst there may be spare capacity to absorb small increases, there may be the need for additional movements to ensure delivery on time and in full. These result in 'extra distance'. From a carrier perspective, this type of 'extra distance' is difficult to control since it is generated by the carrier's supply chain partners. Also, if the carrier can charge its customer for the 'extra distance' run, there is less commercial incentive for the carrier to mitigate it. However, from a supply chain perspective, volume forecast inaccuracy and/or variability can have a negative environmental impact in terms of extra cost and carbon dioxide emissions.

Extra distance/trips due to load less than advised
Equally, inaccurate forecasts can mean the load to be moved is smaller than originally planned. This would result in unexpected space in the vehicle but insufficient time to re-plan the network to utilise this empty space. From a different perspective, this means that the actual volume to be moved could have been moved more efficiently, either on less trips or truncated trips, which in turn means that 'extra distance' has been run.

Extra distance/ trips due to inappropriate vehicle size
Planning of transport movements is based on specified vehicle capacities within the transport planning system. If the correct vehicle is not available when required for loading, due to a

planning failure or technical issue with the vehicle, additional trips can be required in order to complete the delivery of the load.

EMPIRICAL TESTING OF THE 'EXTRA DISTANCE' MEASURE

In this section, the application of the 'extra distance' measure in two different case studies – a primary distribution network from the UK and a secondary distribution network in South Africa – is described. As shown in Table 2, demand forecast inaccuracy and variable volumes were the main source of 'extra distance' identified. Demand forecast inaccuracy and/or variability originating from the customer represented about 40% of the 'extra distance' found. Thus, in order to reduce the level of unnecessary 'extra distance' travelled, a key imperative is an improvement in the accuracy of volume forecast provided to the two logistics providers. There are significant differences between the two cases as well. 'physical load smaller than planned' represents 36% of the 'extra distance' identified in the UK primary distribution network whereas this issue only caused 6% of the 'extra distance' in the South Africa secondary distribution network. Equally, product not loaded at the shipper caused 50% of the 'extra distance' in the South Africa secondary distribution network but only 3% in the UK primary distribution network. The only type of 'extra distance' not found in either case was route diversions. This may be because the data collected did not include telematics reports from the vehicles themselves, and there is scope for refinement of the 'extra distance' measure to capture this.

A key point of understanding from the research was that it is not possible to establish certain types of 'extra distance' by comparing planned v actual distance as practiced by logistics operators. This is best explained by way of an example, whereby an additional movement is demanded at short notice, where none was planned, and has to be resourced by a dedicated vehicle running out full and returning empty. In this case, the 'plan v actual' comparison would return the full return trip distance as the variance. However, the load had to be moved - it was just that there was no time to plan to move the load efficiently, such as on a one way sub-contract movement. If the latter would have been possible with sufficient notification, then the 'extra distance' would only be the empty return leg of the trip – which is half that of the plan v actual variance. As a result of this new insight, a revised definition of 'extra distance' was developed:

Any non value-added or unnecessary distance run within a distribution network due to supply chain uncertainty, and defined as the difference between the distance vehicles actually ran, and the distance they would have needed to have run if:

- *the transport operation had received accurate and timely information on the volumes to be moved, and/or*
- *there had been no unexpected delays at loading or unloading points and/or*
- *there had been no operational failures within the distribution network and/or*
- *there had been no congestion on the journey that could not have been foreseen*

The results have also led to a slight refinement of the types of 'extra distance' observed, based on the case study evidence and also feedback from the companies involved. In particular, a new category of 'Extra distance/trips due to distribution network failures' has been created. This encompasses a number of operational type issues that can occur during the physical delivery process:

- Planning failures, such a required movement not being planned, or certain situations where product is rejected by the customer, leading to inefficient use of resources to deliver the product at short notice or re-deliver it at a later time
- Product not loaded, either at shipper or distribution centre, due to late running or error, leading to additional trips/distance to deliver the product left behind
- Product mis-loaded, at either shipper or distribution centre, leading to additional movements to subsequently correct the error
- Technical failure, causing a smaller than planned vehicle to be presented for loading, leading to additional trips/distance to move the product that would not carry.

Such specifics were not considered in the original brainstorming, highlighting the value of empirical framework testing.

<table>
<tr><th rowspan="2">Initial type of 'extra distance'</th><th rowspan="2">Causes identified</th><th colspan="2">% of incidents</th><th colspan="2">% of 'extra distance'</th><th rowspan="2">Revised type of 'extra distance'</th></tr>
<tr><th>UK</th><th>South Africa</th><th>UK</th><th>South Africa</th></tr>
<tr><td>Extra distance due to optimal route diversion</td><td>Unplanned road congestion</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Extra distance due to optimal route diversion</td></tr>
<tr><td rowspan="2">Extra distance/ trips due to delays</td><td>Loading delays at shippers</td><td>6</td><td>0</td><td>7</td><td>0</td><td rowspan="2">Extra distance/ trips due to delays</td></tr>
<tr><td>Unplanned road congestion</td><td>5</td><td>0</td><td>4</td><td>0</td></tr>
<tr><td>Extra distance/ trips due to load more than advised</td><td>Late notification of extra volume to be moved</td><td>55</td><td>43</td><td>39</td><td>40</td><td>Extra distance/ trips due to load more than advised</td></tr>
<tr><td>Extra distance/ trips due to load less than advised</td><td>Physical load smaller than advised</td><td>20</td><td>8</td><td>36</td><td>6</td><td>Extra distance/ trips due to load less than advised</td></tr>
<tr><td>Extra distance/ trips due to inappropriate vehicle size</td><td>Technical failure</td><td>0</td><td>0</td><td>0</td><td>0</td><td rowspan="4">Extra distance/ trips due to distribution network failures</td></tr>
<tr><td rowspan="3">Not considered</td><td>Planning failure</td><td>12</td><td>8</td><td>8</td><td>4</td></tr>
<tr><td>Product not loaded</td><td>1</td><td>41</td><td>3</td><td>50</td></tr>
<tr><td>Product mis-loaded</td><td>1</td><td>0</td><td>3</td><td>0</td></tr>
</table>

Table 2: Types and causes of 'extra distance' found in the two case studies

LINKING 'EXTRA DISTANCE' AND UNCERTAINTY

In this section of the paper, the link between supply chain uncertainty and 'extra distance' is explicitly drawn to connect cause and effect. The types of uncertainty actually observed in the case studies have been categorised according to the framework presented in Sanchez-Rodrigues et al. (2008). In some instances, the uncertainty arises from more than one source. These are then mapped against the types of 'extra distance' observed in the research. The results can be seen in Table 3.

What can be seen is that the research suggests that operational issues tend to arise from the shipper and carrier. Late notification of extra volume is recorded as a shipper, customer and control issue as, in this research, the exact location of delays in the information flow varied within and between the networks studied. However, other issues relating to the size of load are more focused upon the customer and control systems within the supply chain, reflecting the roles of both of these in generating transport demand. The research has currently failed to identify any links to route diversion although this is likely to be due to the data collection approach which did not track each and every individual trip.

Type of uncertainty		Optimal route Diversion	Delays	Load more than advised	Load less than advised	Distribution network failures
Shipper	Late notification of extra volume to be moved			✓		
	Physical load smaller than advised				✓	
	Loading delays at shipper		✓			
	Product not loaded					✓
	Product mis-loaded					✓
Carrier	Planning failure					✓
	Product not loaded					✓
	Technical failure					✓
Customer	Late notification of extra volume to be moved			✓		
	Physical load smaller than advised				✓	
Control	Late notification of extra volume to be moved			✓		
	Physical load smaller than advised				✓	
External	Unplanned road congestion		✓			

Table 3: Linking transport uncertainty to 'extra distance'

'EXTRA DISTANCE' AND VALUE-ADDING TRANSPORT

The final stage of the research was to link the 'extra distance' concept back to the literature. Through the feedback process, it became apparent that the approach adopted is similar to the identification of waste within lean production systems. Therefore, a literature search was carried out to see how the two concepts relate.

The concept of value adding activities has its origins in the Toyota Production System, in particular the principles of identification and elimination of waste. According to Shingo (1989), waste is any activity that does not contribute to an operation. Also, Taiichi Ohno defined seven common forms of waste, activities that add cost but no value to the operation: production of goods not yet ordered; waiting; rectification of mistakes; excess processing; excess movement; excess transport; and excess stock (Japan Management Association, 1985).

A number of authors have tried to apply the seven wastes defined by Ohno to logistics. At a conceptual level, Sutherland and Bennett (2007) developed a framework for logistics operations, with seven wastes:

- Overproduction due to inaccurate demand forecast
- Delays and waiting in loading and unloading bays
- Unnecessary transport movements due to lack of backhaul consolidation
- Unnecessary motions within a warehouse because of unsuitable warehouse design
- Warehouse space available inefficiently utilised due to non-standardised pallet sizes
- Excessive inventory
- Manufacturing errors that caused product rework

Simons et al. (2004) developed a new measure called Overall Vehicle Effectiveness (OVE). OVE is the result of combining three attributes: availability, performance and quality. OVE is affected by four transport wastes: driver breaks, excess load time, fill losses and speed losses. These five transport wastes have an impact on the performance of transport operations in terms of time. However, the OVE measure does not include the distance dimension of transport performance, which can have a direct transport cost.

The concept of ‘extra miles’ can thus be seen to link directly into the that of ‘excess transport’ proposed by Taiichi Ohno, and more specifically into that of ‘unnecessary transport due to lack of backhaul consolidation’ proposed by Sutherland and Bennett (2007). However the latter appear to propose the ‘lack of backhaul consolidation’, for which we can read ‘lack of schedule optimization’, as a direct cause of waste in itself; this research develops the concept by demonstrating situations where the lack of consolidation is actually an effect, with a series of root causes related to uncertainty creating it. In particular, the other six supply chain wastes can create extra trips at the operational level. For example, delays at shippers and/or customers can lead to a vehicle arriving late back at a distribution centre, so the consignment fails to make a scheduled transhipment, leading to an unplanned additional trip being generated within the transport network, Alternatively warehouse problems can lead to excessive queues at distribution centres, generating delays that later result in ‘extra distance’.

The research presented in this paper makes a strong contribution to the literature by focusing upon the causes and consequences of waste within transport operations. In doing so, it considers transport as part of the wider supply chain, recognising the interaction between these functions. This contrasts with Sutherland et al. (2007) who treat transport as a subset of logistics. Equally, ‘extra distance’ considers waste throughout the whole transport process, from initial planning to the physical delivery of products. This contrasts with Simons et al. (2004), who focus more upon the scheduling of vehicles.

CONCLUSION

Through an inductive approach, this paper has presented a novel approach for assessing the waste caused by uncertainty within freight transport operations. The concept of ‘extra distance’ has been defined, and through the development and application of a measure to test and refine the concept, five causes of ‘extra distance’ have been identified within two empirical settings in the FMCG sector. These have also been linked back to the concept of uncertainty, to provide a clear relationship between cause and effect. Both case studies have identified that a major cause of additional distance is short notice variations in load size which prevents efficient planning. This results in the sub-optimal use of the vehicle fleet with a consequent financial and environmental impact.

The green logistics research agenda has tended to focus upon developments that change behaviours and structures within supply chains. However, this paper looks instead at the impact of disruptions. ‘Extra distance’ has the potential to become a useful measure for both academia and industry, and in the case of the former, it builds on the existing ‘lean thinking’ literature and applies it to a new domain. For industry, the diagnostic approach enables areas for future business improvement to be identified, both internally within a business and externally with other members of the logistics triad.

Future research will see the ‘extra distance’ measure further tested in other transport operations and industrial sectors. ‘Extra distance’ due to optimal route diversion was not identified within the case studies, and this is a potential weakness in the case research. It may be possible to address this by accessing telematics data from vehicles to compare the planned and actual routes. From this, route diversions can be identified and causes analysed, although care will need to be taken to ensure that route diversion due to uncertainty is identified as a subset of plan v actual variance. The collection and analysis of such data will form part of a future case study. Finally, how information on the efficiency of transport operations is recorded and archived varies from company to company. Thus before applying the ‘extra distance’ measure in other logistics operations, it will be necessary to review the transport performance information available, and whether any audit trail actually shows where advised shipment volumes have been increased or decreased within the planning timeline, so that data can be gathered in the most effective way.

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EFFECTIVE MEASURES FOR LOGISTICS SERVICE PROVIDERS TO RESPOND TO INCREASED OIL PRICES

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ABSTRACT

The rapid increase in oil prices worldwide since April 2004 has considerably affected the trucking industry in Japan. The trucking companies have been facing a marked increase in fuel cost, which seriously damaged their management. So, the increase in fuel cost has become the most important problem for trucking companies. They had to deal with it intensely and carried out several measures in order to survive. In this paper, by utilizing questionnaire surveys and an interview survey, we are going to make clear what kinds of measures were adopted by trucking companies and which measures were more effective in coping with fuel cost increase. The purpose of this study is to examine the effectiveness of those measures. Now the problem of fuel cost seems to have been dissolved, because oil prices have decreased rapidly since August 2008. However, analyzing the measures against fuel cost increase remains quite valuable even now because there is a possibility that the increase in oil prices will occur again in the near, and those measures are also effective in order to reduce CO2 emissions causing global warming.

INTRODUCTION

In Japan, the trucking industry is the largest sector of all logistics service providers: it transports more than 52% of total domestic cargo on a ton-km base and consists of more than 62,000 companies and about 1.3 million employees. Thus, it is no exaggeration to say that the trucking industry is a main player within the transport division of Japanese logistics. Shippers have increasingly depended on the trucking industry because trucking companies are able to provide Just-in-Time delivery services.

Skyrocketing oil prices have hit the trucking industry directly. Crude oil prices were stabilized at about 30 dollars per barrel in 2003; thereafter they started to increase and finally reached 145 dollars per barrel at peak period in July 2008. As the crude oil price increased, the price of light oil for diesel engines also increased rapidly in Japan; it became almost double at peak period. That brought the enormous increase of the fuel cost to trucking companies.

This is a crisis for trucking companies because there is a possibility that increased fuel costs could lead to a serious decline in the profit margins of trucking companies. Some of them might have to retire from business or go bankrupt. Trucking companies have been facing a severely difficult situation.

The main purpose of this analysis is to focus on how trucking companies as logistics service providers were able to respond to the severe risks that developed from rapid increases in oil prices. In spite of a difficult management situation caused by rapid increases in fuel cost, Japanese trucking companies have tried positively to overcome such risks. We are going to estimate what kinds of measures adopted by trucking companies are effective in this severe situation.

Worldwide depression has prevailed since autumn 2008, and crude oil prices have returned to a low level. It seems now that the problem of fuel price increase has dissolved. However, it is clear that oil resources will deplete in the near future and another increase in oil prices will be inevitable[1]. Therefore it is valuable that measures against fuel cost increase in this time are analyzed and their effectiveness accurately estimated.

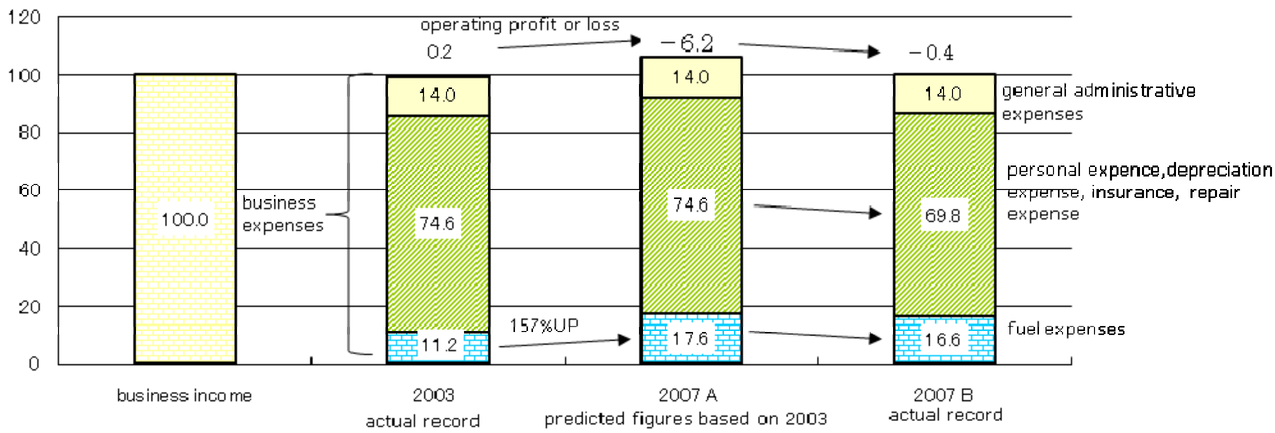
[1] Gilbert and Perl (2008), pp. 127-136.

INFLUENCE OF OIL PRICES INCREASE

The increase in oil prices is considered to have great influence on the balance of payment of trucking companies in Japan, because it necessarily generates the increase of cost. So, at first, it is necessary to estimate the influence of the oil price increase on the management of trucking companies. By using the management data of trucking companies collected by the Japan Trucking Association (JTA), it is possible to do a trial calculation on the degree of this influence[2].

In this trail calculation, the data on balance of payment in 2003 is selected first, because this is the last year in which oil prices were stabilized. As shown in Figure 1, the fuel cost in 2003 constitutes 11.2 % of the total operating expenses in the trucking companies and the operating profit is only 0.2%. Subsequently light oil prices increased 57% in 2007 compared with those in 2003. If the increase of oil price in 2003 occurs in 2007, a new business income and expenses based on 2003 will be calculated. The result of this calculation is shown at 2007 A in Figure 1. The component ratio of fuel cost would increase considerably, from 11.2% to 17.6%. This would cause its revenue to deteriorate. The revenue would go 6.2% in deficit. However, the actual count of the balance of payment is shown at 2007 B in Figure 1. The component ratio of fuel cost in 2007 is really 16.6% and the deficit remains at a low of 0.4%.

By analyzing the comparison between the predicted figures and actual count in the balance payment, it is possible to form the hypothesis that trucking companies would in reality suffer less damage than anticipated according to the rapid increase in oil prices. Furthermore, several measures against fuel cost increase carried out by trucking companies would be effective and enable them to minimize their damage. So, in the next stage, it is necessary to make clear what kinds of measures were carried out by trucking companies.



Source: Management Analysis Report 2007(Japan Trucking Association)

Figure1. The balance of payment of trucking companies

MEASURES AGAINST FUEL COST INCREASE

The questionnaire survey was carried out in order to make clear how trucking companies actually responded to the rapid increase in fuel cost, and what kind of measures against fuel cost increase were adopted by trucking companies[3].

The survey findings are shown in Figure 2. In this survey, as a measure against rapid increase in fuel costs, 87% of trucking companies answered that they adopted promotion of fuel-efficient driving among truck drivers. The items surpassing 50 % are usage of expressway toll discounts

[2] JTA has, since 1993, collected its members' management data and released annually the statistics of management as *Report on Management Analysis*. The latest data in 2007 was collected from 2083 trucking companies. These statistics covered a wide range.

[3] Japan Trucking Association (JTA) backed up this survey. The survey period was in September and October 2008. In this survey, the questionnaires were sent to 842 trucking companies which were selected at random nationwide, and 542 trucking companies responded to this survey. The collection rate was 66.4 %.

and cost reductions such as truck repair and maintenance. These are typical measures for cost reductions for trucking companies. It also should be noted that 45% of trucking companies pointed out the increase of freight rates as a measure against fuel cost increase.
According to the results of the survey, it is possible to classify those measures against fuel cost increase into three categories as follows.

1. Reduction of fuel consumption.
2. Cost reductions including fuel price cut.
3. Passing on fuel cost increase on freight rates.

As shown in the results of the questionnaire survey, we will especially focus on two fundamental measures; reduction of fuel consumption and passing on fuel cost increase to freight rates. Although both measures are very difficult for trucking companies to practice, it seems that they would contribute significantly to improving their quite difficult management situation.

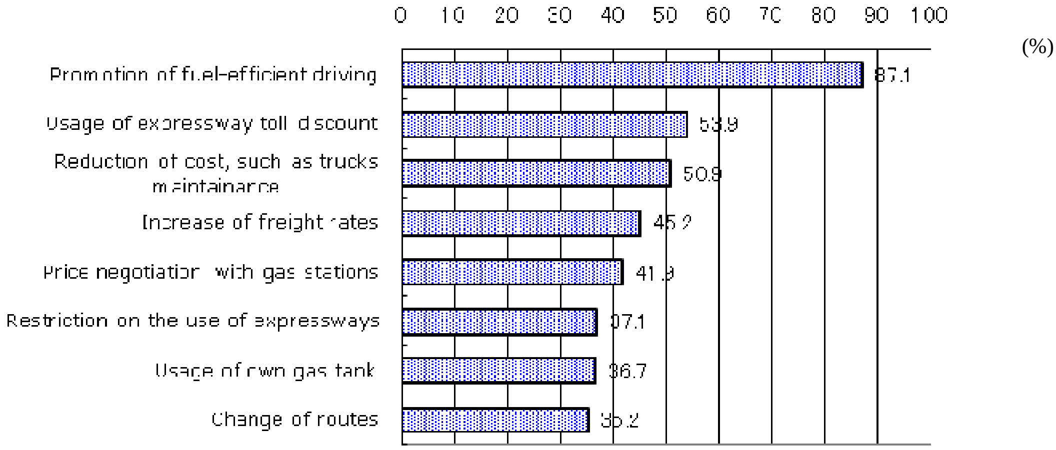


Figure 2. Measures against fuel cost increase

EFFECTIVENESS OF FUEL EFFICIENT DRIVING

As a feasible measure for reducing fuel consumption, the promotion of fuel-efficient driving among truck drivers is very important for ordinary trucking companies. In order to make clear the real situation of promotion of fuel-efficient driving and its effectiveness, it is quite important to use a case study and do an interview survey for it. The following is the result of an interview survey on the promotion of fuel-efficient driving among truck drivers.

The Tokyo Trucking Association, which is constituted by trucking companies mainly doing business in Metropolitan Tokyo, started the "Green Eco Project." The main purposes of this project are both to curb CO2 emissions generated by trucks and to reduce the fuel cost burden imposed by the rapid increase in oil prices. This project is practiced as follows.

1. Truck drivers enter basic data such as running distance and refueling amount in the form whenever they refuel at gas stations.
2. Trucking companies regularly send this data to the project office.
3. The office analyzes it by computer and accumulates a database of fuel consumption.
4. Database on fuel consumption by each truck feedbacks to trucking companies.
5. Trucking companies utilize the database in their training sessions for truck drivers.

This is not complicated but rather simple and easy to practice for participating truck drivers. In this project, it is possible to gradually change truck drivers' attitudes toward daily driving. Filling in the data makes each truck driver acknowledge the real situation of their drive and then compete with each other to get a good result. This change of behaviour will contribute to a good result of fuel-efficient driving.

A more important thing is that participating trucking companies hold regularly-scheduled training sessions for their truck drivers, where the database collected and analyzed in this project is utilized for driver training. In those training sessions, truck drivers are taught the importance of driving without sudden braking and sudden starting, and adhere to the "stop idling" practice. And their efforts are eventually shown in the data on fuel consumption. That also gives them motivation to improve their fuel consumption

This project eventually brought about positive results. Figure 3 shows the accomplishments of the project. Before the project the average running distance per litre of large-sized trucks was 3.49 km, but after the project it increased to 3.82 km. As a result, the average fuel consumption of large-sized trucks increased 9.5 % during the project. It is clear that this project brought a positive result. In addition to this, the project had another advantageous effect. As shown in Figure 2, the number of traffic accidents involving large trucks dramatically decreased by half, from 178 before the project to 91 after the project. Fuel efficient driving that is able to be achieved by preventing excessive speed, sudden acceleration, and sudden braking also contributed to realizing safer driving.

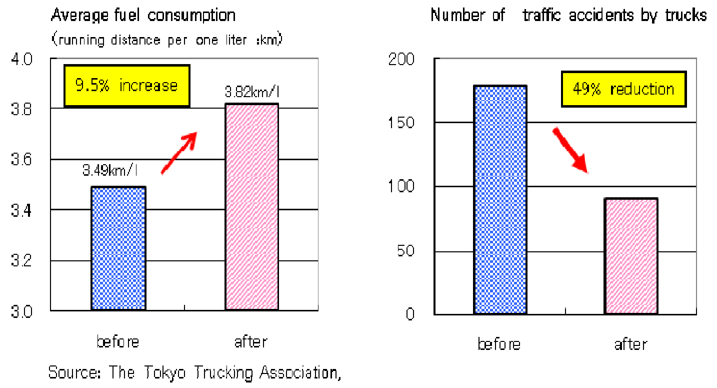


Figure 3. Effectiveness of "Green Eco Project"

THE IMPORTANCE OF IT AND REDUCTION FUEL CONSUMPTION

In relation to this, it is important to point out that a new technology equipped in truck vehicles plays a quite significant role in fuel-efficient driving. Digital tachograph equipped in trucks is able to accurately record the driving situation. By using this data, it is possible to make a daily record of driving quite easily. More importantly, a digital tachograph can automatically estimate driving skill. After arriving at the office, drivers who just finished driving trucks bring out a small memory medium from a terminal equipped in the truck and insert it into a computer. The data of their driving situation is analyzed by computer and the score of their driving skill is shown on screen immediately. If the truck driver tries to drive carefully and avoid excessive speed, sudden acceleration, sudden braking so on, the score will improve gradually according to his effort.

As a result, digital tachograph is able to contribute greatly to both fuel efficient driving and safe driving. This kind of IT equipment is able to greatly assist truck drivers in practicing fuel-efficient driving. Japanese trucking companies have positively introduced such IT equipment that enables them to reduce truck fuel consumption. These actions contribute partially to curbing fuel consumption.

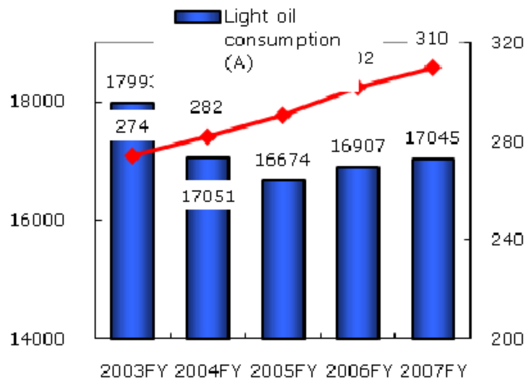


Figure 4. Light oil consumption in the trucking industry

Japanese trucking companies have been making efforts to implement several measures in order to cope with soaring fuel prices. One of their efforts has been devoted to decreasing the fuel consumption of daily operations. The importance of training for truck drivers and the introduction of new trucks equipped with IT have already been explained.

The result of their efforts is shown in the reduction of the total amount of fuel consumption in the trucking industry. According to Figure 4, the annual total

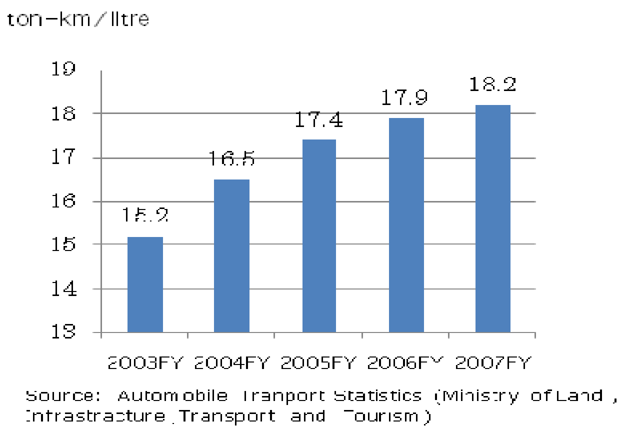


Figure 5. Transport efficiency of the trucking industry

consumption of light oil in the trucking industry decreased from 18 million kilolitres in 2003 to 17 million kilolitres in 2007, although the total transport volume of the trucking industry increased steadily during this period. Other more interesting data is shown in Table 5. Transport volume per litre of oil in the trucking industry increased from 15.2 ton-kilometre in 2003 to 18.2 ton-kilometre in 2007. Those results indicate that trucking companies' measures not only achieve cost reduction, but also contribute substantially to increasing transport energy efficiency and halting global warming by reducing CO2 emission.

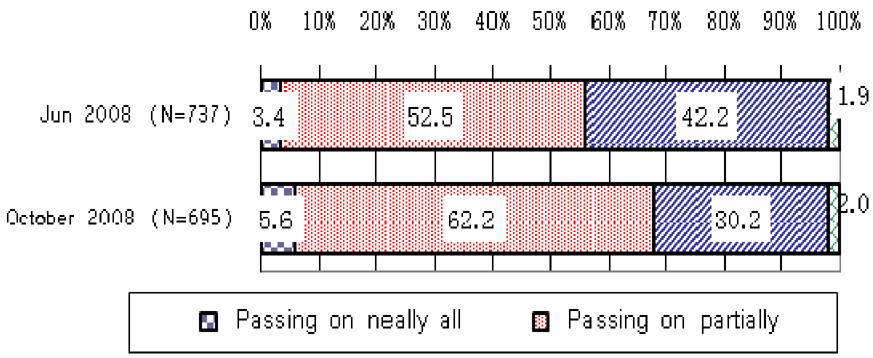
PASSING ON FUEL COST INCREASE TO FREIGHT RATES.

As already pointed, the increase in fuel price was so sharp that most trucking companies could not maintain their profit even if they tried desperately to cut their cost. A remaining measure was to persuade shippers to increase freight rates. In the relationship between trucking companies and shippers, shippers were usually in an enormously strong position. They would not easily accept trucking companies' request that they increase their freight rates according to soaring fuel price.

In this situation, it is quite important to introduce a new method in order to make a breakthrough. That method was the fuel surcharge system. In general, there are two methods of passing on fuel cost increase to freight rate: to increase the freight rate itself, and to introduce a new charge which is added to existing freight rates.

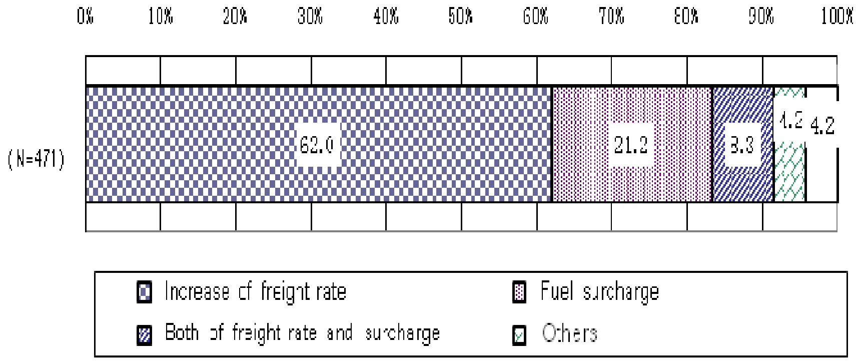
As the management of trucking companies has been getting worse, the chance of introducing a fuel surcharge has been increasing gradually. At last, a new fuel surcharge system was developed for the trucking industry in 2008. If fuel prices increase above a predetermined standard price, an additional charge to be calculated automatically according to fuel cost increase will be demanded by trucking companies to shippers in addition to ordinary freight rates. This fuel surcharge reflects directly the increase of fuel price.

It is necessary to examine the effectiveness of introducing this new method of increasing freight rates. The Japan Trucking Association (JTA) has regularly searched nationwide truck freight rates over a long period. According to the survey conducted by the JTA, the percentage of trucking companies that succeeded in both passing on nearly all and passing on partially fuel cost increase to their freight rate reached 67.8% in October 2008 from 55.9% in Jun 2008 (see Figure 6). In this time, the average increase of freight rates was 5.1%. Furthermore, Figure 7 shows the method of passing fuel cost increase to freight rates. According to this data, the increase of ordinary freight rates constitutes 62.0% in the trucking companies that



Source: Survey on fuel surcharge. October 2008(Japan Tracking Association)

Figure 6. Passing on fuel cost increase to freight rate



Source: Survey on fuel surcharge. October 2008(Japan Tracking Association)

Figure 7. Ways of passing on fuel cost increase

succeeded in raising the rates. And the rate increase by introduction of fuel surcharge constitutes 21.2%. Furthermore, the increase of both ordinary freight rates and fuel surcharge constitutes 8.2 %. As a result, nearly 30% of trucking companies were able to realize the introduction of a fuel surcharge and to increase the freight rates. This indicates that fuel surcharge started to prevail among

CONCLUSION

Although skyrocketing oil prices had a negative influence on the trucking industry by increasing fuel costs, many trucking companies tried to positively introduce measures against rising fuel costs. One of the most important measures was the promotion of fuel-efficient driving among truck drivers. From the case study, it became clear that the new project by trucking companies in Tokyo was effective in achieving it. Another important measure was to introduce a fuel surcharge in order to pass the increase in oil price to freight rates. Although shippers in Japan had consistently rejected the increase in truck freight rates, trucking companies managed to realize it by using this new system. Therefore, the introduction of fuel surcharge is a breakthrough for the trucking industry, which was facing a severely difficult situation. The increase in oil prices eventually encouraged trucking companies to positively improve their transport inefficiency and gave them a good opportunity to strengthen their bargaining power with shippers. Although those measures were carried out mainly in order to improve the difficult situation of management within trucking companies, it is also important to point out that measures such as the promotion of fuel-efficient driving were able to contribute steadily to transport efficiency, the environment, and traffic safety.

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INVESTIGATING THE ENABLERS AND BARRIERS FOR INTRODUCING PORT-CENTRIC LOGISTICS WITHIN THE INDIAN LOGISTICS NETWORK

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ABSTRACT
The prevailing lack of transportation, port and intermodal facilities is one of the major hurdles for the development of the Indian Logistics sector and causes congestion at various points in the supply chain. The UK port industry has also been facing many challenges in the recent past. The congestion challenges in UK ports have eased to a certain extent in recent times due to investment and new government and private sector initiatives. One example of this has been the adoption of a "Port-Centric-Logistics" strategy by some UK ports to attract direct callers in these ports. This strategy will try to replace/reduce the feedering that is going on between the continent and UK, and improve the efficiency and productivity in the whole supply chain up to the end user. Teesport has taken the lead in this exercise and set up a fully-fledged distribution centre which provides facilities such as container stripping, storing, repacking at the port already, in collaboration with ASDA. This model is now being considered by other ports such as Hull and Liverpool in order to improve their competitive edge over European ports.

In a previous paper, Galhena, et al (2008) studied the bottlenecks with reference to Indian ports. Considering the issues presented in that paper and with reference to the Port Centric concept, this paper will investigate the possibilities of adopting the "Port Centric Logistics" concept in the container ports of India. Based on the analysis of the literature on Port Centric Logistics and Logistics models within the Indian scenario, this paper will investigate the enablers and barriers for introducing this concept within the Indian Logistics environment. This analysis will be also be coupled with data from a limited number of semi-structured interviews conducted with respondents in the Indian Logistics environment. The research is in its infancy and will present a conceptual model highlighting the factors affecting Port Centric adoption in India for the practitioners.

INTRODUCTION
In the recent times, India's imports and exports in/out of container ports/terminals have been growing at a higher rate, compared with other principal ports. India's main container port, Jawaharlal Nehru (JNP), which handles more than 50% of the country's container volume, recorded a 26.3% growth rate to 3.89 million TEU and 7.5% growth rate to 4.18 million TEU, in 2007 and 2008 respectively (Galhena 2008; Fossey 2009). But, lack of container terminal facilities and the required intermodal facilities to connect the main producing/consuming areas have been a major challenge for the growth of international trade.

Some UK ports had also been in a similar situation in the recent times and the adoption of 'Port-Centric Logistics' (PCL) strategy has helped ports such as Teesport and Felixstowe and their customers including supermarket chains (ASDA Wal-mart and Sainsbury's) to overcome the congestion situations in the intermodal facilities/system. The efficiency of the supply chain between ports and consuming area have increased due to this strategy. Also, this environmental-friendly concept helps to reduce the need for the empty containers to travel and saves a large amount of unproductive road/rail miles.

Although, the 'PCL' concept is not yet a widely accepted/used strategy in the UK, some large supermarket chains such as ASDA/Walmart and Sainsbury's have been benefited by the concept. The following quotations highlight some of the economic and environmental benefits that could be harnessed.

'The actual on-port operation helps reduce the suppliers issues as we have the ability, working with the port authority to manage the flow of imported products at the point of landing, where as without the port centric operation, many decisions were previously taken many days or weeks in advance…' **(BAP Group which provides 'PCL' facilities at Felixstowe, March 2009)**

'The use of a northern port saves unnecessary inland road miles. For ASDA the saving is over two million lorry miles a year.' **(PD Ports, March 2009)**

'ASDA supports the Teesport and the 'PCL' concept. It works well for us. But, Teesport still needs deepsea container handling facilities to implement this concept fully. Due to the feedering requirement into Teesport from ports such as Rotterdam and Felixstowe, the lead time is gone up by two days or so. But, strategically we are better off.' **(ASDA, March 2009)**

'*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)**

PORT CENTRIC LOGISTICS CONCEPT

The 'PCL' concept is explained by Mangan, et al (2008a) as an encouragement to locate distribution centres within port premises which will cut down the empty movement of containers. This allows a faster turn round and savings of road miles. Mangan, et al (2008b) discuss the role of ports and their changing nature within the supply chain and suggest that port-centric logistic activities is a new/potential revenue earner for ports. Van Marle (2008) argues that the shift in global manufacturing patterns and 'PCL' concept has emerged as a result. As the paper stated there are two models; the retailer model (minimum 1 million sq ft) and the 'warehouse in the container yard' (goods stays in containers until the need arises). The author argues the potential of 'PCL' has not yet been exploited. Hailey (2009) has indicated the plans of the Spanish port of Ferrol to offer 'PCL' facilities which is increasingly becoming fashionable.

USAGE OF PORT CENTRIC LOGISTICS STRATEGY IN THE UK

The concept of limiting the maritime container to the sea leg and that the land transportation of cargo should be done in a more environmentally friendly and economical way, is gathering momentum. The UK ports such as Felixstowe and Thamesport (managed by Hutchison) adopted this method and are successfully providing the facilities to companies such as BAP which in turn service customers including Sainsbury's and Somerfield with on-port and off-port de-stuffing, warehousing and storage (Ship2Shore 2007; BAP Website 2009; Mangan et al 2008b). PD Ports (2007) states that 'PCL' is an opportunity to reduce costs, lead-times and environmental challenges in the logistics industry. The paper argues that the port choice for inbound cargo has been a decision of the freight forwarder without considering the benefit to the retailer. ASDA, as a beneficiary of 'PCL' activity, has reduced road miles drastically and consider strategic business partnerships as key to success. Also this research document recognises the benefits to the retail sector in general.

CONTAINER PORTS/TERMINALS: INDIA RELATED ISSUES

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. 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 has been discussed by Bennett (1995). Bennett also argues the need to progress on privatisation of the ports on an urgent basis irrespective of national consensus on labour issues in order to get optimum benefits from investments. Venkiteswaran (1995) explains the limitations that were in force in India's legal framework in respect of privatisation. The paper deals with the decision made to privatise the Nhava Sheva container terminal at Jawaharlal Nehru Port. This was an imperative step to facilitate India's manufacturing boom and growth in international trading opportunities. Baird (2002) argues that especially, for developing countries, such as India, the way forward is only with a higher level of private sector participation. 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).

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 transhipment over ports in another country. The diagnostic work carried out by Raghuram (2006) and Ray (2004) on JNPT, the largest container port in India, recognises the limitations of the port, Intermodal connections (rail and road) and other logistics infrastructure that cause port congestion.

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 and the infrastructure bottlenecks in India. 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 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). 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.

A previous study carried out by the authors (Galhena, et. al. 2008) provided an input in terms of the bottlenecks in India's port interface for this study. The factors that emerged from this study were; port capacity limitations, insufficient investment, bureaucracy and port inefficiency issues. These were revolving around human involvement as a central theme and it was suggested that the human involvement was contributing to the vicious cycle of the said inefficiencies.

Some UK ports have introduced 'PCL' to overcome similar challenges in a few ports with some success. This paper examines the enablers and barriers to introducing this concept in India's container ports as a solution to its acute congestion related bottlenecks.

RESEARCH DESIGN

In the above context the research questions for this study are as follows;

(1) Can 'Port-Centric Logistics' be implemented in India?

(2) What are the enablers and barriers to implement 'PCL' in India?

In order to explore the research questions, a literature review was conducted on port related challenges and issues in India, and on the 'PCL' concept both in general and its application in the UK scenario. However, the academic literature was somewhat limited on the ground level issues. Therefore, in order to obtain a better insight into the factors affecting this study and ground situation, the approach used was that of qualitative research. Interviews were conducted with four senior executives of ports/container terminals and an academic/consultant who has carried out a large number of Indian port-related studies/projects. The interviews were recorded and transcribed, for diagnostic purposes and analysed using grounded theory principles. The analysis was based on the suggested methods by Miles and Huberman (1994) using the early analysis technique following the date sequence of interviews. The clusters which didn't have identified themes were given new titles. Some of the major concepts that emerged, were, as follows: lack of space/land in ports, old existing port infrastructure, congested road/rail networks, high level of bureaucracy, stringent and outdated regulatory and legal regimes and long delays in decision making.

The data which was derived from the relevant literature was also analysed using the same method. These themes were then compared with the interview data and the focus was narrowed down for this research. The new factors that emerged were as follows;

(a) Lack of rational thinking- the human component.
(b) Lack of empowerment
(c) Lack of sensitivity to the need and urgency in the system

RESEARCH MODEL

The research model is depicted in Figure 1. It considers the PCL concept as a central solution (at least partial) to the bottlenecks in India's maritime chain. The outer circle shows the themes that were identified in the study. These are the general bottlenecks in the system (delays, lack of space, old infrastructure, bureaucracy, outdated regulatory/legal systems and congestion) that can have an adverse impact in the implementation process of 'PCL' concept/strategy. Based on the data analysis, three scenarios are identified which will influence the decision of the users (of maritime logistics) to implement 'PCL' as and these are placed with a link to the main circle in the diagram;

Scenario1: The user has adequate space in terms of land and warehouse/ factory and hence does not need to use a service such as 'PCL'. This is identified as 'no go situation' and crossed out in the diagram.
Scenario 2: The user does not have the space on his own but has access to the 'PCL' set up without much hassle. This is identified as a 'go situation' and has been ticked.
Scenario 3: The user can obtain better freight rates for oversized containers (45ft or so) which are not permitted on the road. This is also identified as a 'go situation' and has been ticked.

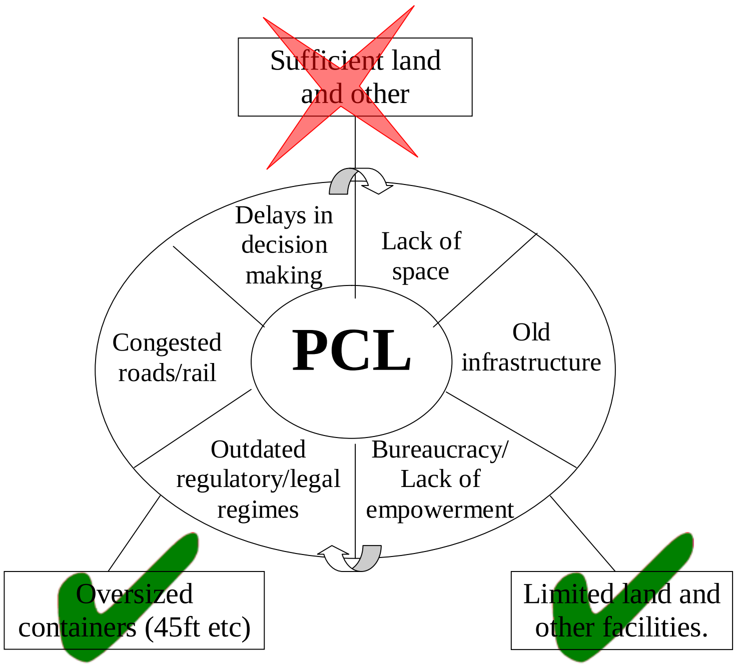

Figure 1: 'PCL' possibilities for India

DISCUSSION & ANALYSIS

The purpose of this study was to ascertain the enablers and barriers for implementation of 'PCL' strategy in India's ports as a solution (atleast partial) to the challenges in the country's maritime logistics environment. The growth of the international trade has temporary slowed down due to the global economic/trading downturn. But the long term prospect still appears to be bright for India. Although the port privatisation process commenced in the 1990s, the main legal framework governing the maritime industry and international trade has not changed adequately to suit the 21st century. For instance, the port trust/governing act and customs ordinance will require changes to implement a 'PCL' strategy successfully, as this will demand somewhat liberal thinking. However, the implementation of privately-run Container Freight Stations (CFS) outside of ports, several years back, for delivery of import cargo can be considered as 'outside of box' thinking. With the increase of import/export volumes, the main ports (mainly at inner-city ports) began to face numerous difficulties as far as container yard capacity/space is concerned. These developments have pushed the authorities to listen to the practitioners and take radical decisions.

The interviews revealed that 'PCL' concept cannot be adopted in every port. The infrastructure and capacity of old ports such as 'Port of Kolkata' is not conducive or give room for this sort of novel ideas. At the same time, the design of new container facilities at Jawaharlal Nehru Port (JNP) which is the largest container port of India (with three container terminals) also does not permit the land-required developments such as this. The Indian situation is somewhat similar to the UK scenario. The Port of Felixstowe, UK has got only limited warehousing facilities on-dock and other warehouses are located outside of the port due to land/space restrictions. The port of Teesport, UK (in north east) has land resources, but does not have deepsea container handling facilities for larger vessels to efficiently connect the Far Eastern producing regions. At JNP, CFSs (about 20 in number) are set up just outside the port to deliver the goods to consignees.

The port dwell time for containers is two to four days on average at JNP and the evacuation of containers from port is critical for the port operations and its productivity. However, the most interviewees agreed that Indian ports can get benefited from 'PCL' strategies depending on circumstances. Mukherjee (2009) has reported that due to the recession, Indian retailers are streamlining logistics to remain profitable, and as an initiative "the retailer plans to reduce the space per distribution centre to lower the cost of real estate and encourage direct supply to stores". These aspirations are quite similar to the current strategy of ASDA to implement 'PCL'. The relatively new ports/container terminals such as Pipavav and Mundra (situated in Gujarat state and privately owned) which are becoming popular as alternatives to JNP should be able to embrace the 'PCL' concept mainly because of the availability of port/adjacent land and relatively better road/rail connections with the north and north west hinterland. However, the operators/owners of the Mundra port have adopted a different concept to that of 'PCL'. They have set up two facilities/warehouses (in 500-700 km from port in Delhi and Rajasthan) with modern facilities to serve the customers being in the close proximity to the customer. In this case, this provider offers a full package from discharging from the ship up to the customers' door-step. The interview with a senior executive of this company revealed that the port stay of containers are costly and it could pose challenges on 'Just-in-Time' concept that most manufactures are adopting. Hence the new extended service will help. Also, this reduces the inventory cost for the users. Similarly, they provide facilities in the reverse direction for exports. This paves the way for the manufacturers to concentrate on their core business while logistics component of the business is taken care of by a strategic partner.

CONCLUSION

This study has reported the results of a preliminary qualitative exercise conducted to explore the enablers and barriers for the adoption of a 'PCL' strategy in Indian ports as a solution to some existing bottlenecks in India's maritime logistics chain. However, the study is in its infancy and this is just a basic attempt to obtain the views of the practitioners and their likeability on the concept. This study will require more in-depth data collection to understand the adoptability in an Indian port scenario, which will be conducted in the next phase of the research project.

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PERFORMANCE IMPROVEMENT IN INTERMODAL FREIGHT TRANSPORTATION SYSTEM THROUGH EFFICIENT COLLABORATIVE TRANSPORTATION MANAGEMENT

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ABSTRACT
Information-enabled collaboration between trading partners not only simplifies the processes of planning, execution, monitoring and completion, and also provides cost reduction and value enhancement throughout the logistics chain. Nevertheless it is not easy to perform a transparency due to fact that trading partners are still reluctant to share information, as data sharing is perceived as a competitive threat. Therefore they perform unwilling acts for the collaboration. Moreover the impact of collaborative planning and management often cannot be understood sufficiently by trading partners in theory because of lacking of high safety and reliability levels.

This paper empirically investigates performance outcomes and success factors in intermodal freight transportation system and reveals importance of efficient *Collaborative Transportation Management* (CTM). Survey data from both transport users (e.g. manufacturer) and transport service providers (e.g. carriers, logistics service providers, logistics service intermediaries) was analyzed using techniques from *Partial Least Squares* (PLS), a structural equation modeling method. The study points that successful CTM in intermodal freight transportation system is depending on the communication quality of the shipper-carrier relationship, long-term orientation and satisfaction, the quality of information and communication technology system and the intensity of joint information sharing. Furthermore, the result of the study shows that increased customer service level, increased revenue, improved inventory level and reduced costs are major outcome of the efficient CTM.

Keywords: intermodal transport, collaborative transportation management; CTM, Partial Least Squares; PLS

INTRODUCTION
Increasing global competition, shortened process, longer and more customized transport linkages and the need to cut costs have changed the requirements of freight transportation. Today intermodal freight transportation system has become an important issue in responding to the growing freight traffic and an increasing imbalance in the use of the various transport modes and infrastructure. Intermodal is inherently complicated, expensive and difficult to manage therefore collaborative efforts should be undertaken to set up functionalities to improve transport quality and to reduce management costs within logistics chain.

Collaboration is the touchstone of concurrency in intermodal transport. Some important projects are currently being executed to support intermodal issues in terms of creating a common understanding and contributing standardization for electronic data interchange (EDI) within trading partners which are funded by *EU-Frameworks Programs* and there also exist some approaches that cope with mutual reconciliation of activities, such as *Continuous Replenishment Program* (CRP), *Vendor Managed Inventory* (VMI), *Collaborative Planning, Forecasting and Replenishment* (CPFR) and *Collaborative Development Chain Management* (CDCM) (Barratt, 2004; Kilger & Reuter, 2005).

CPFR process can be seen as an evolution from CRP and VMI, is the most known prolific management initiative of the *Voluntary Inter industry Commerce Standards* Association's that provides collaborative efforts and visibility. One of the recent extensions of this process is CTM which is a concept as a continuation of CPFR process that involves information and process flows for supply chain needs of a group of shippers, receivers and carriers that facilitate transportation (Russell, 2002; Sutherland, 2006).

Although CTM is relatively new process, it has been gaining perceived traction in the last years. CTM was developed as a process code to provide a framework of how to structure such collaborations to maximize effectiveness and manage expectations (Dutton, 2003). A most comprehensive definition of CTM is based on sharing information from ordering through payment. CTM focuses on the combination of strategies and tools to integrate all the entities of transportation management and achieve a common objective. The goal of CTM is mainly to reduce cost, to boost customer service, to increase revenues, to improve efficiencies associated with transportation and delivery through strategic partnerships among trading partners. CTM is a culmination of a series of collaborative measures involving planning, forecasting and replenishment. CTM involves information and process flow whereby receivers and shippers jointly collaborate with carriers to provide effective and efficient shipment delivery (Browning & White, 2000).

In this paper, we are analyzing empirically the impact of CTM process implementation on intermodal transport by developing a path model with the method of PLS. Based on this model, four key collaborative success factors and four key competitive performance outcomes were identified. Key collaborative success factors are namely, shipper-carrier relationship, long-term orientation, ICT quality and information sharing; key competitive performance outcomes are customer service, cost reduction, revenue enhancement and inventory efficiency. Selection of parameters in success factors and performance outcomes for proposed research model are based on a comprehensive literature review of the peer-reviewed journal papers and supplemented with experts and consultants' interviews to identify current challenges in the transportation field. This work is based on an empirical study of customers, shippers and transportation intermediaries from different industries in Europe, which are associated with intermodal transport. The rest of the paper is organized as follows: In the next section, a literature review is given. Then we describe the model and its assumptions and the result of the experiment respectively, and the finally in last section we give the result and summarize implications of our study.

LITERATURE REVIEW

CTM and expected benefits on intermodal freight transportation

The term "collaborative" means according to online Merriam-Webster's Dictionary –"to work jointly with others or together especially in an intellectual endeavor" (Merriam-Webster, 2009). A single member in supply chain cannot do to resolve all problems. Therefore collaboration among partners in a supply chain has become a topic of great interest for many and an essential element of company strategy for others (VICS CTM, 2004). Integration of all trading partners has become an important way for the industry to gain competitive advantages. Collaboration in transportation management represents a business relationship between tree principle parties - a shipper, a carrier and a receiver as well as secondary or tertiary participants. Trading partners collaborate by sharing key information about demand and supply, e.g. forecasts, expected capacity, and assets, where feasible.

Collaboration requires a strategic relationship to enable planning activities and the exchange of expertise-based partner information to create additional value in order to establish long lasting relationship. Figure 1 shows a sample of data flows as well as material flows in triadic collaboration among shipper, carrier and receiver. It mapped out the triangle that exists joining the firms together, based on both the contractual (where relationships are formalized by contracts between shipper and carrier) and the non-contractual relationships (the relationship between carrier and receiver, where there is no contract) (Bask, 2001).

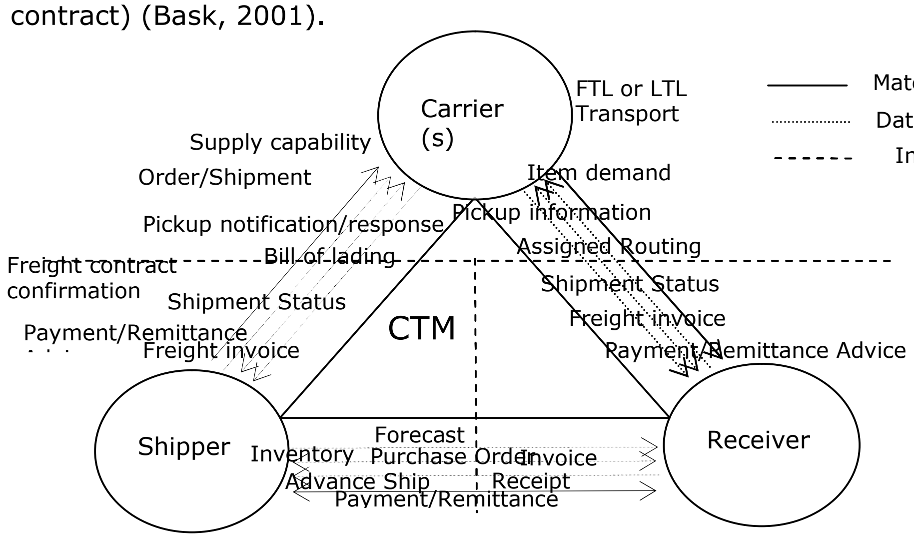

Figure 1 Triadic collaboration among trading partners in intermodal freight transport
* Carrier includes logistics service intermediaries, third-party service providers, logistics service providers and so on

In the literature there are only limited references to conduct on the concept of CTM with analytical experiments, simulations and practical case studies in some industries (Browning & White, 2000; Russel, 2002; Dutton, 2003; Esper & Williams, 2003; Tyan *et al*., 2003, VICS CTM, 2004; Field, 2004; Sutherland, 2006; Feng & Yuan; 2007). CTM is widespread used in food and consumer goods industry like in Wall-Mart, P&G, etc. (Karolefski, 2002). Most of the researches were done on the direct collaboration between carrier and the other trading partners, where discovered that, by implementing CTM could bring about better outcomes and profits for all trading partners. The benefits of CTM in terms of intermodal transport haven't been researched yet, in this paper we want to reveal the expected benefits of CTM with an empirical study.

Intermodal transport combines more than one mode of service to deliver shipments. Typically this involves both rail and truck transportation. To perform efficient intermodal transport chain including any kind of transport modes, coordination is obviously necessary and can be realized by intelligent use of information technology. Hence, CTM will grant intermodal transportation a higher competitiveness by providing better transport logistics control along supply chain, providing higher quality and enhancing visibility, making intermodal chains accessible. In order to achieve the positive results of CTM, the processes between trading partners should be real-time, extendible, automated, and cost-effective. CTM also requires a unique data mapping for each message types between users, otherwise complexity is added when published EDI standards are not consistently applied among trading partners. Moreover creating direct data connections with trading partners using own resources is mostly expensive and time consuming, and with constantly evolving partner relationship.

METHODOLOGY

Research Model and Hypotheses

Collaboration is a process of decision-making among interdependent parties (Stank & House, 2001) which includes shippers, receivers, agents; carriers in intermodal transport, any one of which can significantly alter overall demand and causes considerable changes in the transportation decisions at the strategic, tactical and operational levels (Eatough *et al*., 1998). Figure 2 shows the trading partners of intermodal transport.

In this study we determined 9 factors and subsequently 54 items in order to structure research model (Figure 3). Our research model is based on the conclusion of the studies and findings from literature review and recommendation of consultants/experts. As major building blocks for the path model (structural equation model) four key enablers were determined to enhance successful CTM: the quality level of shipper-carrier relationship, long-term orientation, the quality of information system and intensity of information sharing. We hypothesize:

H_1: The higher the quality of shipper-carrier relationship, the higher the perceived CTM success.
H_2: The higher the quality of long-term orientation, the higher the perceived CTM success.
H_3: The higher the quality of information and communication technology infrastructure, the higher the perceived CTM success.
H_4: The more intensive the quality of information sharing, the higher the perceived CTM success.

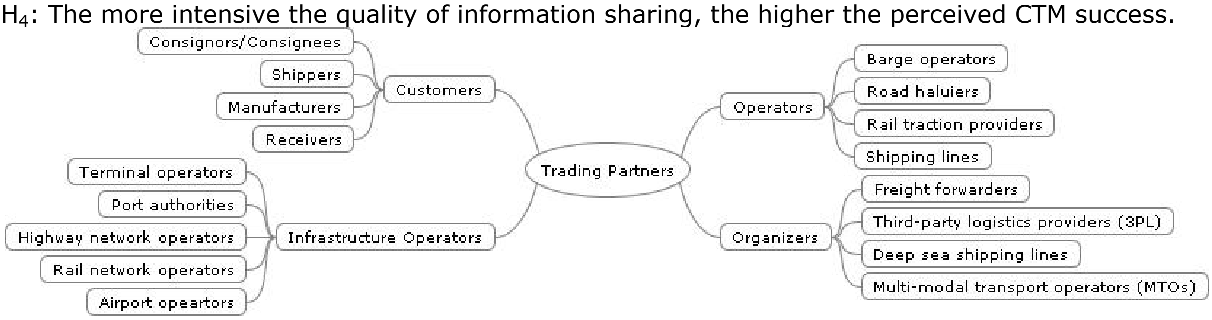

Figure 2 Trading Partners for Intermodal Freight Transportation

Successful CTM implementation in intermodal transport requires strong shipper-carrier relationship (H_1), as companies that communicate effectively and have a closer relationship with carriers, lead to higher levels of on-time delivery performance (Esper & Williams, 2003; Kleijnen & Smits, 2003, Zsidisin, et al. 2007). Long-term orientation (H_2) or continuity with all parties in transportation management has importance to maintain strategic partnership which requires high levels of commitment and effective communication (Kwon & Suh, 2004; Sudeesh, 2006). The quality of information systems (H_3) is becoming a concern of both intermodal users and service providers. According to Simchi-Levi *et al*. (2003) the objectives of IT in SCM and thus CTM are providing information availability and visibility, enabling a single point of contact of data, allowing decision based on total supply chain information and enabling collaboration with supply chain partners. Seamless data integration and track, system to system integration, detailed trading partner implementation plan and project management proven best practices for connectivity. In many of published articles were highlighted that information sharing (H_4) among trading partners is very important in the logistics systems where the use of information system with a timely information availability enables increase long-term efficiency and the visibility (transparency) in supply chain (Zhao & Zhang, 2002; Dutton, 2003).

We define four expected outcomes of CTM based on literature review with combination of exclusive case studies: improved customer service level, reduced cost, increased revenue and efficient inventory. We hypothesize:

H_5: The higher the perceived CTM success, the more improvement in customer service level.
H_6: The higher the perceived CTM success, the more achievement in cost reduction.
H_7: The higher the perceived CTM success, the more achievement in revenue growth.
H_8: The higher the perceived CTM success, the more efficiency in inventory level.

Successful CTM implementation leads customer service (H_5) and cost reduction (H_6) which are very important in terms of enhancing customer satisfaction. CTM enables continuous service quality and cost control for every trading partner. Furthermore, with CTM, companies can maximize revenues and set better pricing strategies (dynamic vs. constant) via monitoring of activities, costs and deadlines etc (H_7). CTM enables automated load tendering which reduces overall lead time and variance to the benefit of the shipper, carrier and receiver (VICS CTM, 2004). Moreover all trading partners can manage and control their inventory as CTM process enables real-time shipment tracking, better forecast accuracy at SKU level; all these boot inventory efficiency (H_8).

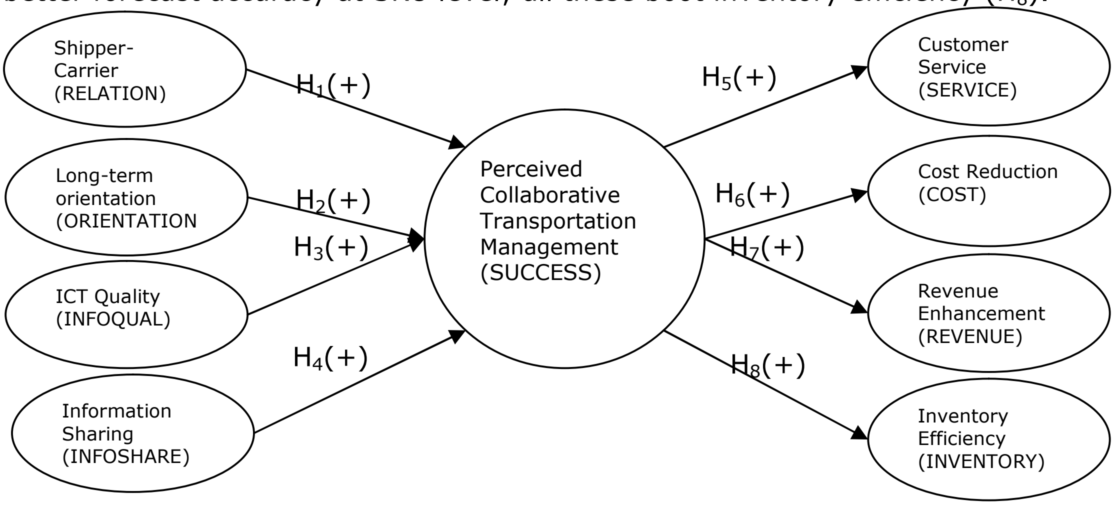

Figure 3 The structural design of the proposed research model

Measures

All items included 54 statements (see Table 1) on the impact of CTM process implementation on intermodal transport in terms of shipper-carrier relationship (7 items), long-term orientation (6 items), ICT Quality (9 items), information sharing (4 items), collaborative transportation management (6 items), customer service (6 items), cost reduction (6 items), revenue enhancement (4 items) and inventory efficiency (6 items). These all applicable statements to the model are derived from literature reviews. The survey were measured on a 7-point Likert scale, where respondents had to indicate the extent to which they agreed with a given statement, ranging from 1 (totally disagree) to 7 (totally agree). A comprehensive survey intended for the logistics managers of different companies was designed for the study; hence nearly sixty-six companies from a variety of industries were identified. We received 40 useable responses from our survey which shows 60% response rate, this is rather limited in size.

Factor and item description	Mean	SD	FL	CR	AVE
Shipper-Carrier relationship (RELATION)				**0,82**	**0,68**
We have an arms'-length relationship with our carriers.	4,13	1,37	0,88		
We make effort to form mutual partnerships with our carriers.	3,73	1,61	0,83		
Our carriers are willing to shift and modify capacity	3,58	1,85	0,76		
Our relationship with carriers is characterized by a high level of trust	4,34	1,32	0,75		
A close relationship is maintained by all levels of the organization.	4,21	1,52	0,87		
Relationship features systematic continuous improvement and some breakthrough thinking*	3,80	1,67	n/a		
We give a consistent direction at management level and changes are well documented.	3,56	1,45	0,82		
Long-term orientation (ORIENTATION)				**0,83**	**0,56**
We frequently are in close contact with customers	4,55	1,62	0,73		
Our customers are actively involved in improving intermodal services	4,23	1,75	0,84		
We respond to market and customer needs promptly and flexibly	3,05	1,88	0,75		
Customers give us feedback on quality and delivery performance.	6,25	1,08	0,92		
Customers frequently share current and future demand information	3,10	2,02	0,77		
We frequently are in close contact with customers	4,51	1,68	0,82		
ICT Quality (INFOQUAL)				**0,95**	**0,73**
CTM process can be applied easily in the existing ICT infrastructure	4,47	1,84	0,89		
Is good to ensure better visibility (transparency)	4,23	1,67	0,82		
CTM contributes to standards development for EDI	3,91	1,20	0,90		
Enables readily access data from all applications involved in project	5,67	1,13	0,87		
We use e-logistics chain approaches for communications and transaction with our carrier and customers.	5,02	1,23	0,81		
Web-services are very easy to use	5,43	1,42	0,89		
Is compatible with trading partner's ICT system*	5,24	1,76	n/a		
Provides accurate and reliable info	5,21	1,68	0,91		

CTM process offers more/better functionality for int. transport	4,23	1,74	0,79		
Information Sharing (INFOSHARE)				**0,85**	**0,61**
We inform our carriers about demand changes	5,24	1,62	0,89		
We exchange information with our carriers which provide us to perform better.	5,81	1,05	0,84		
We share information on actual and forecast sales data to our carriers	5,77	1,38	0,89		
We make inventory data available to our carriers and customers	5,23	1,62	0,84		
CTM (SUCCESS)				**0,94**	**0,75**
Enhances better logistics performance (full truck, vehicle fill, less empty running, less cost)	3,98	1,31	0,88		
Enhanced better demand visibility	3,62	1,67	0,85		
Enhances better logistics planning (materials, production, capacity and transportation)	3,69	1,88	0,70		
Increases the accuracy of sales forecasts*	4,38	1,38	n/a		
The implementation of CTM process in intermodal freight transportation is a good idea.	4,25	1,61	0,82		
Has more advantages to enhance better log. chain efficiency	4,41	1,66	0,87		
Customer Service (SERVICE)				**0,77**	**0,59**
Impact of CTM on provide long-term efficiency in supply chain	5,32	1,42	0,72		
Impact of CTM on replenishment cycle times	4,06	1,27	0,85		
Impact of CTM on reduction the frequency of out-of-stocks	5,34	1,74	0,81		
Impact of CTM on increase the number of delivered on time	4,77	1,82	0,79		
Impact of CTM on stock rates for receiver*	2,67	1,05	n/a		
Impact of CTM on preparation of rush orders.	3,05	1,79	0,86		
Cost Reduction (COST)				**0,73**	**0,61**
Impact of CTM on intermodal transportation costs.	4,93	1,34	0,74		
Impact of CTM on administration costs	3,29	1,71	0,78		
Impact of CTM on material handling costs	4,64	1,64	0,83		
Impact of CTM on transaction costs	5,05	1,52	0,70		
Impact of CTM on operational costs and implementation costs	3,89	1,22	0,82		
Impact of CTM on inventory/holding costs	3,52	0,96	0,84		
Revenue Enhancement (REVENUE)				**0,83**	**0,70**
Impact of CTM on revenue enhancement	5,60	1,62	0,82		
Impact of CTM on pricing strategies	4,23	1,47	0,75		
Impact of CTM on cycle time reduction	4,12	1,59	0,86		
Impact of CTM on provide LTL freight transportation	4,76	1,78	0,77		
Inventory Efficiency (INVENTORY)				**0,85**	**0,68**
Impact of CTM on control of inventory from cycle time reduction	5,07	0,93	0,79		
Impact of CTM on manufacturing and inventory deployment strategy	5,33	1,08	0,82		
Impact of CTM on inventory record information which is real time and 99 percent-plus accurate.	4,84	1,87	0,85		
Impact of CTM on impact on the decline of the bullwhip effect	3,86	1,22	0,77		
Impact of CTM on having better ABC analysis results	3,12	0,95	0,73		
Impact of CTM on forecasting process which has the demand variability integrated with a service-oriented inventory deployment strategy.	5,72	1,45	0,87		

SD: Standard deviation, FL: Factor Loading, CR: Composite reliability, AVE: Average variance extracted

*All scale items were measured using five-point Likert scales. Respondent were asked to what extent they agreed or disagreed with each statement (1: strongly agree and 5: strongly disagree).

* These items were eliminated from the proposed model, as their loading figures were under 0,70.

Table 1 Summary of measurement scales

Data analysis

The proposed research model was tested with PLS (Partial Least Squares) Graph 3.0. PLS is a variance based latent variable structural equations modeling technique. PSM uses an estimation approach that places minimal demands on sample size and residual distributions (Chin, 1998). The evaluation of the proposed model fit was conducted in two stages (Chin, 1998; Hulland, 1999). The measurement model is firstly assessed, in which construct validity and reliability of the measures are assessed and secondly, the structural model with hypotheses is tested.

RESULTS

The measurement model was used to assess discriminant and convergent validity of the constructs that were used in the hypotheses and research questions. All constructs which are modeled using reflective indicators. For reliability analysis, composite reliability (CR) was assessed. CR values vary from 0, 73 to 0,95. After the first test, four items had a factor loading lower than 0,70 which was suggested as a common minimum level (Chin, 1998). These all items were deleted from the model afterwards the model was estimated again. All of the loading figures in the new model were equal or greater than 0,70. (Table 1). To test for discriminant validity, the square root of the average variance extracted (AVE) for each latent variable was compared to the latent variable correlation matrix (Hulland, 1999). To possess adequate discriminant validity, the square-root of the AVE for each latent variable should be considerably greater than its correlation to each of the other latent variables. All constructs satisfy this criterion (Table 2). For each construct, the AVE is at least 0,56, which is above than the recommended minimum (treshold value) AVE, 0,50 (Fornell & Lacker, 1981).

The path loadings between the item and its corresponding factor were all positive and significant at $p < 0{,}01$, and the value of the path loading ranged between 0,727 and 0,915 (Table 2). Composite reliability exceeded 0,70 for all nine factors. AVE exceeds the 0,50 threshold value for all nine factors. These results indicate that construct reliability depends on the measure employed to asses it. Composite reliability and variance extracted present an acceptable picture. The quality of a PLS model can be determined by examining the R^2 values of the endogenous constructs (Hulland, 1999). The model explains 48% of variance in perceived CTM success, 25% of variance in customer service, 12% of variance in cost reduction, 9% of variance in revenue enhancement and 11% of variance in inventory efficiency. Unfortunately we have not earlier studies to compare our findings, but from our findings we can suggest that revenue enhancement is not the most important benefit of CTM process implementation, most of the benefit should be particularly customer service level and cost reduction. Figure 4 shows a graphical representation of the outcomes of the research model.

	R^2	1	2	3	4	5	6	7	8	9
1.RELATION	n/a	**0,727**								
2.ORIENTATION	n/a	0,245	**0,756**							
3.INFOQUAL	n/a	0,615	0,502	**0,873**						
4.INFOSHARE	n/a	0,425	0,325	0,654	**0,850**					
5.SUCCESS	48%	0,490	0,589	0,566	0,376	**0,915**				
6.SERVICE	25%	0,278	0,197	0,214	0,322	0,397	**0,790**			
7.COST	12%	0,178	0,164	0,321	0,279	0,586	0,436	**0,848**		
8.REVENUE	9%	0,067	0,072	0,170	0,281	0,312	0,479	0,276	**0,897**	
9.INVENTORY	11%	0,189	0,243	0,233	0,329	0,242	0,317	0,356	0,362	**0,802**

*For adequate discriminant validity, the square root of average variance extracted (AVE) for each construct on the diagonal should exceed the interconstruct correlations (Fornell & Larcker, 1981). These conditions are satisfied for all constructs.

Table 2 Discriminant and convergent validity of the constructs.

The results of the hypothesis testing are summarized in Table 3. The hypothesis that the shipper-carrier relationship has a positive impact on CTM success which indicates a positive and significant path coefficient of γ=0,28 ($p < 0.01$) between two constructs, thereby providing support for hypothesis H_1. The coefficient of the path between long term orientation and CTM success is not significant which means that the second hypothesis (H_2), The higher the quality of long-term orientation, the higher the perceived CTM success, is not supported by current data as it has no positive effect to support CTM success. The third hypothesis (H_3), ICT Quality, has a positive impact which shows a highly positive path coefficient of γ=0,36. It shows that the quality level of information system is heavily important point for successful CTM process implementation. Information sharing as a fourth hypothesis (H_4) has also positive result on CTM success which shows a positive significant path coefficient of γ=0,29. This indicates that the more extensively information sharing between trading partners in intermodal transport, the more successful CTM process implementation. These all four factors explain 48% of the variance in perceived CTM success in given research model (Figure 4). Perceived CTM process success has a positive and significant effect on the last four factors. CTM results first and foremost to improve customer service and to reduce cost. The results in turn for hypothesis five and six show that customer service (H_5) and cost reduction (H_6) indicate in turn positive coefficients of γ=0,68 and γ=0,62. Revenue enhancement (H_7) and

Inventory efficiency (H_8) show similarly positive results for CTM implementation, which indicates coefficients of γ=0,54 and γ=0,48.

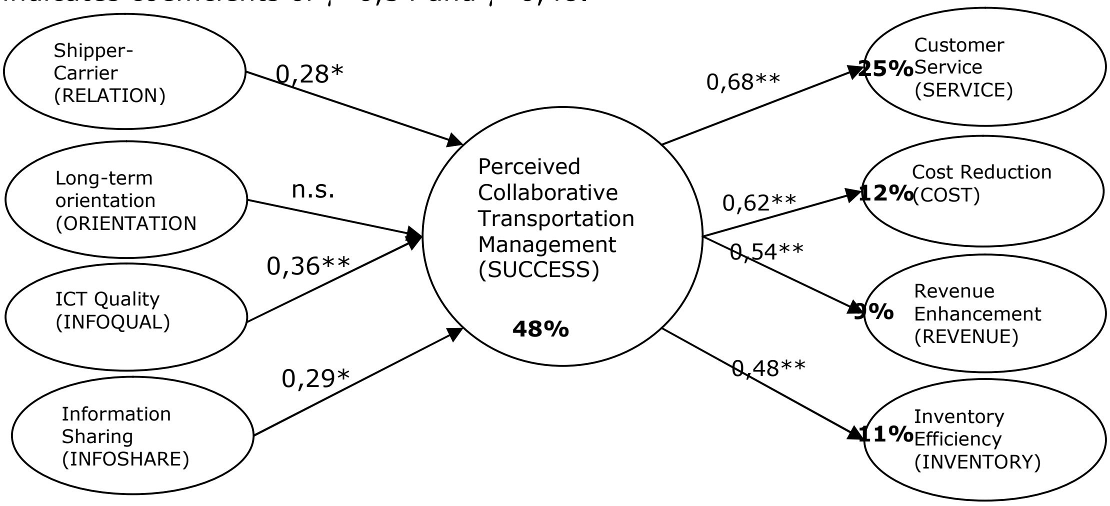

Figure 4 PLS results.
Notes: Variance explained (R^2) between brackets. * Path coefficient significant at the 0,01 level; ** at the 0,001 level.

Hypotheses	Independent variable	Dependent variable	Path coefficient	Sig.	Supported?
H_1 (+)	RELATION	SUCCESS	0,276	p < 0,01	Yes
H_2 (+)	ORIENTATION	SUCCESS	-0,189	n.s.	No
H_3 (+)	INFOQUAL	SUCCESS	0,358	p < 0,01	Yes
H_4 (+)	INFOSHARE	SUCCESS	0,291	p < 0,01	Yes
H_5 (+)	SUCCESS	SERVICE	0,677	p < 0,01	Yes
H_6 (+)	SUCCESS	COST	0,623	p < 0,01	Yes
H_7 (+)	SUCCESS	REVENUE	0,535	p < 0,01	Yes
H_8 (+)	SUCCESS	INVENTORY	0,484	p < 0,01	Yes

Table 3 Summary of findings.

CONCLUSION

CTM is the most recent management initiative as the successful extension of CPFR that provides collaborative efforts and visibility in transportation management. By following CTM, companies can dramatically improve profitability and effectiveness in intermodal transport. Studies show that most companies and industries can benefit from CTM. As more companies move toward supply chain collaboration, this may well result in an optimization of transportation processes and systems.

The objective of this study was empirically to show the impact of CTM process implementation on intermodal freight transportation by developing a path model, as the existing literature relevant to intermodal freight transportation lacks an understanding of the CTM behind the movement of freight. We wanted to show with this study only a way to implement successful CTM process into an organization. The result of the study reveals the significant importance of carrier relationship, ICT quality and information sharing which are important enablers to perceive successful CTM implementation. Moreover this study could help practitioners to understand the potential benefits of CTM in intermodal freight transportation. Most important benefits of CTM implementation was deducted from this study which are customer service, cost reduction, revenue enhancement and inventory efficiency.

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