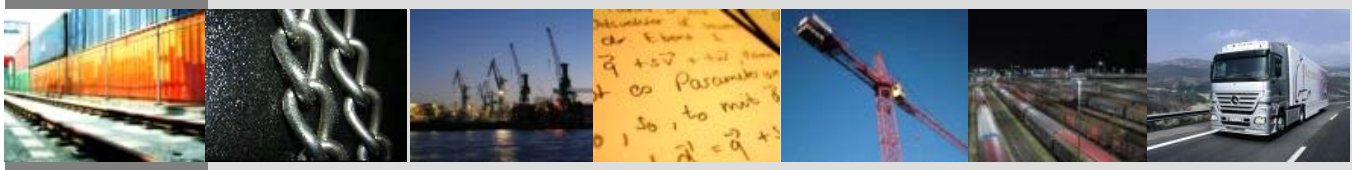

The 8th CEMS Research Seminar on

SUPPLY CHAIN MANAGEMENT

Supply Chain Management – Recent Trends and Future Perspectives

Organized by:

Pierre Semal

and

Werner Delfmann

Haus Bergkranz

Riezlern, AUSTRIA

26.–30.01.2011

Contents

1. Foreword

Dear Conference Participants,

We are happy to welcome you to the 8th CEMS Research Seminar on Supply Chain Management from January 26 to 30, 2011 in Riezlern. We would like to thank you again for submitting a wide variety of abstracts and papers which, we are sure, will serve as the basis for interesting and lively discussions during the seminar.

The seminar is the yearly event of the CEMS Faculty Group Logistics. Its objective is threefold:

- It aims at providing the young PhD students with a stage for the presentation, discussion and guidance of their own current research project.
- It aims at providing all participants with a global overview of the various research subjects and types that are undergone in the field of supply chain management.
- Finally, it also aims at providing all participants with a network of colleagues and friends on which collaborations of various forms (joint research, courses, exchanges, …) are being designed and implemented.

This 8th edition of our seminar will follow the same objectives with more than 20 research presentations and more than 35 professors and researchers from the CEMS community and from its close friend schools.

We wish you a pleasant and safe journey and are looking forward to meeting you in Riezlern! Should you have any further questions please do not hesitate to contact Ralph Müßig or Tobias Lukowitz at muessig@wiso.uni-koeln.de or +49 221 470 3897 and lukowitz@wiso.uni-koeln.de or +49 221 470 6663 respectively.

Pierre Semal & Werner Delfmann

Louvain-la-Neuve and Cologne, January 2011

2. GENERAL INFORMATION

This booklet contains all submissions that were selected and will be presented during the seminar. You are invited to browse through these contributions and thus, get a rough idea of the contents and topics covered. Second, we have included useful organizational information with regard to venue, agenda and participants.

Specifically, we would like to direct your attention to the following aspects:

- All registered participants are welcome to have dinner at Haus Bergkranz on Wednesday evening at 18:00h as indicated in the schedule (January 26).
- At 19:15h the official welcome and formal opening is held by the organizers in the seminar room in Haus Bergkranz (January 26).
- A notebook computer and video projector will be available for the presentations. Therefore, please bring your presentation in digital form on CD or USB Drive. Of course you are also welcome to bring your own computer.
- Dresscode is casual.
- For information about weather and skiing conditions refer to www.kleinwalstertal.com. Skiing equipment can be rented in Riezlern.

For those of you staying at *Haus Bergkranz* please additionally note the following:

- When you plan your journey to Riezlern please take into account that the rooms are only available after 16:00h.
- The individual room assignment will be sent via email before the seminar.
- **Linens will be provided. Please bring your own towels.**

3. LIST OF PARTICIPANTS

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4. VENUE AND TRAVEL DIRECTIONS

The seminar will be held at "Haus Bergkranz", Riezlern Austria. For contact information see below:

Haus Bergkranz
Schwarzwassertalstr. 14
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For further information please refer to http://www.kleinwalsertal.de and: http://www.uni-frankfurt.de/HausBergkranz.

Travel directions:

For those of you arriving *by air*, fly to Munich airport. From there, train services are available to Oberstdorf (train travel time is about 3h30min). For information on train connections check out the internet service of Deutsche Bahn German Railways at www.bahn.de (service in English available).
If you travel by *train*, take a train to Oberstdorf and take a taxi to Haus Bergkranz (costs about €20).
If you come *by car* take the Autobahn Frankfurt - Karlsruhe - Stuttgart - Ulm - Kempten or Autobahn Frankfurt - Würzburg - Ulm - Kempten. From Kempten follow B19 to Oberstdorf - Riezlern/Kleinwalsertal. Drive through Riezlern until you reach Breitach Bridge (Breitachbrücke). Turn right into Schwarzwassertalstrasse until you reach No. 14 on your right hand side (opposite the Hotel Montana).

5. ABSTRACTS (ALPHABETICAL ORDER)

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management –
Recent Trends and Future Perspectives"

Investment Incentives and Coordination for Supply Chain shared Resources under asymmetric information*

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ABSTRACT. Supply chain management challenges in practice the conventional intuition on organization

and organizational interfaces between chain members. On the one hand, the requirements on cost efficiency and lead-time performance force supply chains to coordinate more closely through the exchange of information, arbitration of planning decisions or the utilization of joint resources in production, inventory and distribution. On the other hand, shortened product and process life cycles, leading to short and relatively risky production generations, make classical solutions to implement such coordination schemes, e.g. vertical integration or full commitment contracts, less attractive or unfeasible. In practice, such as in the highly leveraged IT or telecommunications sectors, the coordinating OEMs (original equipment manufacturers) frequently delegate to contract manufacturers (CM) to interact with upstreams suppliers as to coordinate the manufacturing of modules, packaging, testing standards etc. The arrangement can be justified as efficient if the CM is better informed about certain costs and consequences of an investment at upstream suppliers. However, other streams of literature (Agrell et al. 2005) have found support for distortions in the inventory coordination from delegated control using frequently used contracts under asymmetric information in a three-level setting. In this paper, we investigate a dimension that has received less

attention in the supply chain coordination literature, namely the centralization or delegation of investment decisions in shared resources. The particular problem we study is the organizational and contractural choice of a supply chain coordinator (say an OEM) to either control or delegate the investment decision of some shared resource (say dedicated machines, information or product standards etc) to a contract manufacturer (CM) or to an upstream supplier in a three-stage supply chain.

We present a formal model to investigate three prevalent scenarios; the full integration CMsupplier, a decentralized scenario where the OEM provides an incentive scheme to the CM to invest on behalf of the chain, possibly with subsequent outsourcing of the investment to the supplier from the CM, and a centralized scenario with parallel regulation of both CM and supplier substitute investments. For each scenario, we determine optimal investment policies for the profit-maximizing CM and supplier under control or incentives. The evaluation criterion is the generated supply chain surplus, measured as the proportion of coordination increasing investments that are undertaken. The findings suggest that optimal coordination can be designed as a menu of contracts, which supports anecdotal evidence in the electronics industry that usually has been explained using arguments related to asymmetric information and mitigation of market power. The paper ends with some managerial conclusions for the scenario and suggestions for future research in the area.

KEYWORDS Supply chain, coordination, investments, contracts, organization.

* Paper for the *CEMS Research Seminar on Supply Chain Management*, Riezlern, Austria, Jan 26-30, 2011.

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Comparing Organizational Forms in the Trucking Industry"

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Abstract

Transportation is an essential activity in the logistics for a supply chain, which typically consist of several tiers of firms. Grocery retailers, such as WalMart, Carrefour, and Tesco, rely on frequent transports to distribute their goods throughout the world. The grocery retailing industry has an especially rapidly pace, which has led to several supply chain developments over the years (Fernie and Sparks, 2009). In order to reduce transportation costs, a common approach is to consolidate shipments using a central warehouse. When grocery retailers transport goods from these warehouse to their retail stores, they typically use truck transports, which they either can service using a private fleet or by contracting an external firm offering trucking services. Typically, these operations involve a large number of trucks, which perform fairly standardized operations that can be considered as a commodity service with low added-value.

In EU and the U.S., over 70% of the total volume of freight was transported on truck in 2007 (U.S. Department of Transportation and EUROSTAT). Despite a very large demand for trucking services, firms operating in this industry suffer from a highly fragmented structure and low profit margins (Arrunada et al. 2004). At the same time, a large number of shippers demand these services, which further increase the inefficiencies in truck transportation. In such a setting, coordination among

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shippers, forwarders, and carriers for exploiting synergies that might exist among shipments becomes a necessity. Previous work by Baker and Hubbard (2003) points out that efficiency in the trucking industry depends crucially on how efficiently the carriers' supply and the shippers' demand are matched. In our case, the grocery retailers act as shippers and the truck owners act as carriers. The coordination between these is done by a forwarder, which either is a function vertically integrated with the carrier or a separate firm. It is the grocery retailer's choice between these options that we intend to explore in this paper, where we address the alignment of incentives between the forwarder and the carriers.

To explore this issue, we consider a simplified business scenario. Based on the grocery retailer's demand, the forwarder offers a contract describing the trucking service with an associated price to a pool of carriers. The carriers decided on whether or not to accept the contract and if they do, they invest in the proper capacity needed to deliver the service. We simplify this world to have a single contract period, which represents a certain number of years. Assuming that there occurs changes in supply and demand on the market during this period, the benefit of considering several periods is low. Also, the simple-period assumption is primarily made to focus attention on the key aspects of the interaction between the grocery retailer, the forwarder, and the carriers and not to confound the issue with multiperiod effects. Demand for the acquired service is price sensitive and deterministic, which in this case means that the grocery retailer is prepared to pay a certain price for a specific level of service. This simple scenario captures the carriers' capacity planning, the forwarder's coordination of these carriers, and the grocery retailer's procurement of trucking services from the forwarder. The grocery retailer has the objective to maximize the level of service with lowest possible price, whereas the forwarder and the carriers have the objective to maximize their respective profits. The purpose of this paper is to address procurement and coordination issues in such an environment.

In practice, we find that the relation between a forwarder and a carrier take different organizational forms. The most obvious case is perhaps that the forwarder and carrier are vertically integrated, which means that they behave like single firm. Next, we find independent investor-owned forwarder (IOF) that contracts carriers using a linear transfer price for their trucking services. Less frequently, carriers go together and form a cooperative that act as a forwarder. We refer to this organizational form as a carrier-cooperative forwarder, where carriers are compensated for their trucking services by sharing profits generated at the forwarder. A common approach is to share profits among carriers according their respectively contributed workload. A

question the grocery retailer have is whether one of the organizational forms lead to poor coordination and creates misaligned incentives, and if so, what the consequences of this might be. The answer to this question can help the grocery retailer to improve its procurement strategy and attain a higher level of service in its outsourced trucking operations.

Keywords: Industry analysis; Supply chain competition; Nash-Cournot modeling; Service supply chain; Game pricing

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

A Single Measure for Supply Chain Integration?

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One of the most debated Supply Chain Collaboration concepts is Supply Chain Integration (SCI). This area of research is quite fertile in recent years in terms of empirical papers (Frochlich-Westbrook, 2001, Vickery et al., 2004, Bagchi et al., 2005, just to name a few), which provided evidence for a connection between SCI strategies and firm performace (Flynn et al., 2010). These authors have used different methods on different subsamples, and all of them proved the existence of a positive connection. There is also at least one paper that focuses on the critical review of survey based SCI findings (Van der Vaart T. et al., 2008). **The research question** arises, if the construction of a single valid measure for SCI is possible.

We are not about to build such a measure, but after testing the findings of Frochlich and Westbrook (2001) through replication we faced questions about generalization (e.g., what kind of generalization is possible from a limited sample of companies?) and validity (e.g., are the measurement constructs valid and to what extent?).

Even though the paper which we are going to replicate focuses on manufacturing companies, we will try to use different subsamples, which will give us further information on what would happen if these measures were applied to the service sector. We cannot disregard services,

since in many cases even manufactured consumer products are used as platforms to sell services (ex. iPod, iPad).

Our **research methodology** will be both quantitative empirical – similar to that used by Frochlich and Westbrook- and qualitative in nature, because we believe that besides empirical findings a more general view of the problem is needed, which we will try to achieve through a systems perspective suggested by Kornai (1999).

In our attempt to find a general measure for SCI our starting point is the existing literature, from which we will try to include all the relevant constructs used by others. We will make a synthesis of their findings and use it as guidance during the replication of Frochlich and Westbrook (2001). We think that replication is a primary test for scientific methods, since, if conducted properly, it gives us the possibility of falsification, which is a must for every valid theory, or model.

Peer reviews, as demonstrated numerous times, are not only unreliable quality control mechanisms but the reviewers cannot be expected to check all the calculations in the paper. Also, peer reviews cannot detect the amount of data mining that took place in the paper (Lowell, 1983). Only replications and, especially replications with extensions can move a field forward. "A replication is a substantial duplication of a previously published empirical research project that is chiefly concerned with increasing the internal validity of the research design. A replication focuses on determining whether the initial results are reproducible… A replication with extension is a duplication of a previously published empirical research project that is primarily concerned with increasing the external validity, or generalizability of previous research findings." (Hubbard et al., 1998)

The well-known Hawthorne study provides guidelines in this regard: "The analytical procedures employed in the present study suggest feasibility of examining closely the building blocks of our disciplines, especially when quantitative information is available. This has long been done in the physical sciences, where development routinely includes the process of critical scientific review, secondary analysis, and replication of important studies. There appears great need as well as opportunity for such activities in the social sciences." (Franke and Kaul, 1978: 638)

As a result of our research, we will try to reach a conclusion over the existence of one general and appropriate measure of Supply Chain Integration and the contribution it has to firm performance. If all the features of integration cannot be included in one construct alone, than we will name those main features, which are necessary both in services and manufacturing industries. Our replication of the Frochlich and Westbrook (2001) will be a falsification test for one of the most

cited papers in SCI and the results will enhance the current beliefs or stir skepticism from the scientific community.

We expect that the validity of the measure used for SCI by Frochlich and Westbrook, and through this the proven connection with firm viability will be questioned, because the sample they used for building the model is not a solid foundation. Our paper will be a contribution not only to Supply Chain Management, but also to Open Innovation theory, because our answers will lead researchers closer to a solution of how to measure the effectiveness of Outside-In Open Innovation (Chesbrough and Garman, 2009).

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Multi-objective Stochastic Approaches for Designing Supply Chains under Uncertainty

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A crucial component of the planning activities of a manufacturing firm is the efficient design and operation of its supply chain. Strategic level supply chain planning involves deciding the configuration of the network, i.e., the number, location, capacity and technology of the facilities. The tactical level planning of supply chain operations involves deciding the aggregate quantities and material flows for purchasing, processing and distribution of products. The strategic configuration of the supply chain is a key factor influencing efficient tactical operations, and therefore has a long lasting impact on the firm. Furthermore, the fact that the supply chain configuration involves the commitment of substantial capital resources over long periods of time makes the supply chain design problem an extremely important one.

Many attempts have been made to model and optimize supply chain design, most of which are based on deterministic approaches, see for example Bok et al. (2000), Timpe and Kallrath (2000), Gjerdrum et al. (2000) and many others. However, most real supply chain design problems are characterized by numerous sources of technical and commercial uncertainty, and so the assumption that all model parameters, such as cost coefficients, supplies, demand, etc., are known with certainty is not realistic.

In order to take into account the effects of the uncertainty in the production scenario, a two-stage stochastic model is proposed in this research. Decision variables which characterize the network

configuration, namely those binary variables which represent the existence and the location of plants and warehouses of the supply chain are considered as first-stage variables -- it is assumed that they have to be taken at the design stage before the realization of the uncertainty. On the other hand, decision variables related to the amount of products to be produced and stored in the nodes of the supply chain and the flows of materials transported among the entities of the network are considered as second-stage variables, corresponding to decisions taken after the uncertain parameters have been revealed.

There are a few research works addressing comprehensive design of supply chain networks using two-stage stochastic models. MirHassani et al. (2000) considered a two-stage model for multi-period capacity planning of supply chain networks. Tsiakis et al. (2001) also considered a two-stage stochastic model for supply chain network design under demand uncertainty. They developed a large-scale mixed-integer linear programming model for this problem. Alonso-Ayuso et al. (2003) proposed a branch-and-fix heuristic for solving two-stage stochastic supply chain design problems. Santoso et al. (2005) integrated a sampling strategy with an accelerated Benders decomposition to solve supply chain design problems. However, the robustness of decision to uncertain parameters is not considered in these studies.

Azaron et al. (2008) developed a multi-objective stochastic programming approach, by using goal attainment technique, to design robust supply chains. Azaron et al. (2010) also developed interactive multi-objective techniques to solve this problem. However, these are single-period models. Moreover, the designed supply chains are not responsible and the role of unreliable suppliers has not been taken into account.

In this research, a multi-objective multi-period two-stage stochastic model is developed for supply chain design under uncertainty while addressing issues such as risk management and responsiveness of supply chains. This is a comprehensive model, which includes both the strategic and tactical levels.

The responsiveness of supply chains includes factors such as response time to customers, availability of products, variability of products, etc. It is a challenge to consider all these elements in our proposed quantitative model, since most of them are qualitative factors.

It is also assumed that suppliers are unreliable with time-dependent lifetime distributions. The role of unreliable suppliers is very important in real-world applications. This is another novelty of this research, since reliability issues have not been paid enough attention during the strategic planning phase, see Melo et al. (2009).

In our problem, the uncertainty associated to demands, supplies, cost coefficients, etc., is represented by a set of scenarios with given probability of occurrence. Such scenarios together with their associated probabilities must be provided as input data into the model.

In case the uncertain parameters follow specific types of continuous distributions, this will be discretized using Monte Carlo sampling, thus generating a set of explicit scenarios. In this case, a sampling strategy with Benders decomposition algorithm (also known as L-shaped decomposition method in the stochastic programming literature, see Birge and Louveaux (1997)) will be integrated to solve the supply chain design problem, see Tsiakis et al. (2001) and Santoso et al. (2005).

We then develop a multi-period supply chain design model considering the associated production, transportation and especially inventory-holding costs at different time intervals.

The first objective function of the proposed model is to minimize the sum of first-stage investment costs and the expected second-stage processing, handling, inventory-holding, transportation and shortage costs.

Risk issues, reflected by the variance of the total costs and the financial risk, see Azaron et al. (2008) and Azaron et al. (2010), and also responsiveness cannot be clearly viewed as related to economical issues. Therefore, considering a unique scalar objective resulting from the weighted sum of the proposed objective functions is not a proper way to deal with the problem. So, it is needed to set up a multi-objective design problem whose solution will be a set of Pareto-optimal possible design alternatives representing the trade-off among the different objectives rather than a unique solution.

Then, different simple and interactive multi-objective techniques such as goal programming, goal attainment, surrogate worth trade-off (SWT) and STEM methods, see Hwang and Masud (1979), are used to solve the proposed multi-objective model.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management:

"Supply Chain Management –
Recent Trends and Future Perspectives"

The internationalization process involving outsourcing: A comparative case study

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Outsourcing, especially outsourcing to a low cost country, has attracted a huge interest in academia and a stream of research investigates the phenomena for better understanding of imperatives (Clegg, Burdon, and Nikolova 2005; Warburton 2000), of business model reconfiguration (Borgström and Hertz 2010), of consequences both related to organizational capabilities and related to supply network performance (Agndal and Nordin 2009; Gadde and Jonsson 2007; Kotabe and Murray 2004; Laios and Moschuris 2006), of the role of interactions (Gadde and Hulthén 2009), strategic a well as of operational issues (Harland, Knight, Lamming, and Walker 2005; Moses 2009; Nordigården 2007), of outsourcing as an umbrella term that includes a range of sourcing options that are external to the firm (Sanders, Locke, Moore, and Autry 2007), among others. Outsourcing to other countries is related to learning of international business

The theme we are interested in relates to a firm's internationalization that is described as a process of combined outsourcing and marketing (Agndal 2004), in order to create synergies between the two (Borgström, Cui, and Hertz 2008). Both upstream and downstream internationalization effect acquisition of market and technological knowledge (Naldi and Zahra 2007). It is proposed on the one hand that such international expansion might provide firms with additional knowledge, on the other hand, internationalization might spread a limited resource base and create internal coordination problems (Naldi 2008). A research project, 2006-2008, was initiated in order to investigate the upstream and downstream internationalization process of five purposefully chosen firms, in addition to a survey. In this paper we aim to compare the rich case studies of two firms with substantially different paths of internationalization.

The choice of companies for comparision was made on the basis to identify exciting differences between the two. Ikea has an approach to downstream internationalization that tends to be seen as structured and planned while VSM has an emergent approach. Ikeas supply in terms of goods is highly standardized in order to facilitate the manufacturability. VSM's goods is make up a technically advanced machine. Ikea's internationalization process tends to be integrated while VSM's process shows up and downs.

Learning and development of smoothing practices for coordination seem to be important to the internationalization process. The co-development of sourcing and marketing (Borgström et al. 2008) tends to have yet other dimensions when a supply chain is studied. Tentative results indicate that a the one that initiate supply chain internationalization (upstream and downstream) strongly encourage major suppliers to co-develop their international production that in turn are likely to seek new customers in the new market. The supply chain characteristics is likely to change characteristics in the process. The industrial network approach to internationalization proposes the internationalization variables extension, penetration and integration to be useful in order to explain explored differences from the case studies. Supply chain management literature has focused on the role of integration in international supply chains and will facilitate from knowledge of the interrelationship with extension and penetration of markets to integration of activities.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Lean Innovation from A Flow System Perspective

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In order to overcome the current downturn in many industries and services, innovation and R&D efforts are key. However, as all sorts of resources are not abundantly available, these resources have to be employed efficiently and effectively to preserve a proper and sustainable project flow through the processes of the R&D system. We show how typical insights from supply chain modeling can be extended and applied to analyze R&D systems.

The consolidated literature on R&D/Innovation systems typically boils down to a three pillar constitute:

- Technological issues such as the system aspects of flow (e.g. lead time) and resources (e.g. capacity), operational performance and technological factuals
- Financial issues such as monetary aspects of flow (e.g. expenses) and resources (e.g. investments), financial performance and monetary factuals
- Human issues such as value aspects of flows (e.g. sustainability) and resources (e.g. ethical employment of labor), human performance and non-monetary factuals

We rely on Flow Theory, known in supply chain management, to framework and found the idea of Lean Innovation (see Schuh 2008) and expose the relationship between operational performance

metrics such as R&D project throughput time, time-to-market reliability, the number of R&D projects in the pipeline and the output of the R&D system (the number of projects per time unit).We extend this technological pillar with both a financial and a human pillar. From the financial performance metrics point of view, return on innovation, increased growth rate from innovations and the like come into the picture. On the human pillar performance metric side, market acceptance, reputation and preference are examples. It will be shown that this three pillared R&D process/system is basically people and market oriented, connecting technological and financial opportunities with customer perceived value and customer willingness to pay, in order to lead to more successful innovations (see von Hippel, 1986). At the same time, Lean Innovation constitutes a delicate balance between either the obese or the anorectic state of the R&D system in this three pillar setting.

On top of this exogenous, end-user orientation, the Lean Innovation concept is a dynamic one in all its dimensions, which is urged to be monitored permanently. Each of its constituents are subject to fluctuations induced by (i) technological evolutions and disruptions, (ii) global and local financial developments as well as (iii) shifts in trend-sensitive human perception, changing market situation, product lifecycle, etc.

R&D people are typically output and result driven but as part of a larger organization, the R&D department has to take care about the financial flows too. Therefore, we extend the operational flow model with a financial flow layer taking into account the economic and monetary aspects of the R&D process, an approach already applied in other industrial engineering contexts (e.g. Perdu and Vandaele, 2010). The three layered framework of contemporary R&D processes - technological, financial and human centered - has important operational foundations. We see analogous aspects in three layers, both in terms of modeling the R&D process as a flow system as well as in the respective metrics.

By doing this, the three major pillars of modern innovation and design thinking (see Brown, 2008) come into the analytic picture: both the technological, the financial as well as the human dimension are met. The latter involves interpretation and valuation of human factors and emotional drivers. Performance evaluation of the three dimensional R&D concepts and R&D portfolio will be tackled

with a multi-criteria decision model. Along the same lines, incremental as well as radical innovations can be considered (see Verganti, 2008).

The flow theoretic approach has proven to be very useful in manufacturing, industrial engineering and service contexts. It has been used and implemented for planning purposes (see Vandaele and De Boeck, 2003 for some general ideas) as well as for detailed decision support (see for instance Vandaele et al., 2008). We strongly believe that this approach can offer valuable insights and applications to plan, monitor and enhance the R&D process. We conclude and illustrate this approach with a real life example.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management –
Recent Trends and Future Perspectives"

European Logistics Trends revisited: An exploratory case study

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This paper revisits the trends of European logistics in the light of a potentially new era with particular emphasis on sustainability issues. Where focus has hitherto been on increasing consumption particularly in Western industrialized countries, climate change and environmental issues may pose a new agenda for European logistics. We explore such potential changes with a small case study and conclude that intensified collaboration in and across supply chains based on intensified use of supply chain information systems will be the future trend.

Keywords*:* Logistics trends; European logistics; fourth party logistics; sustainability; supply chain collaboration

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Predicting Churn in the Deregulated Commercial Electricity Markets with Social Network Analysis

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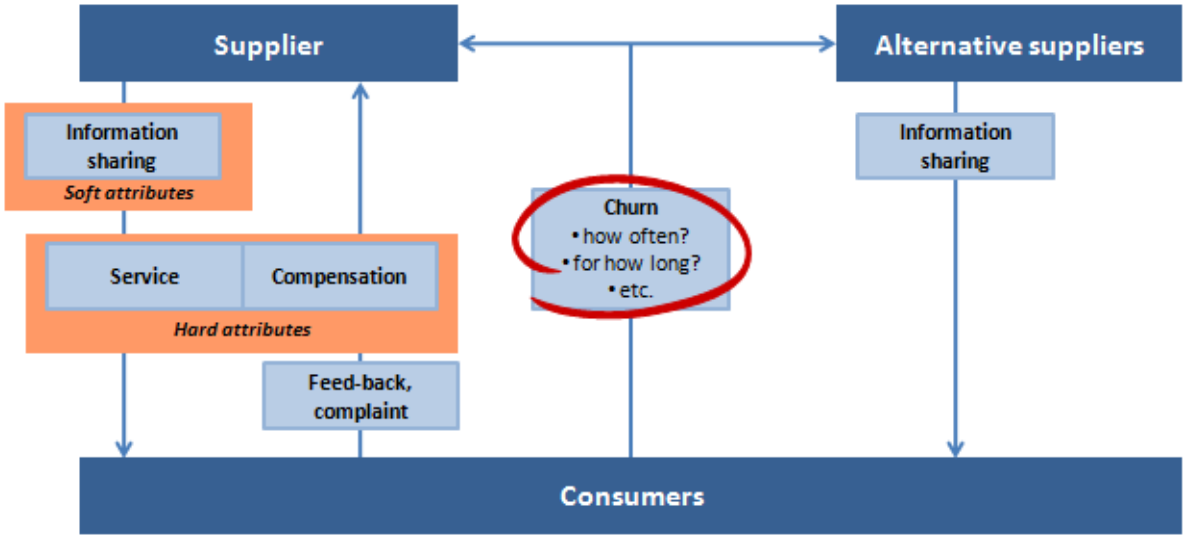
The electricity sector undergoes major changes. Traditionally, this sector has been a regulated monopoly but the perceived benefits from increased economic competition provided arguments for deregulation. The European Union supported deregulation because market liberalization and competition can lead to more efficient allocation of resources. Hungary, with a well-established regulatory system in place, also emphasized deregulation. Deregulated markets, however, assume cooperation in information exchanges among actors to achieve efficient resource allocation. In the Hungarian practice though, it is quite fuzzy (or even murky) what pieces of information are exchanged between whom and through what channels. Also, electricity is a special commodity, and that must be taken into account when a player's social network is mapped.

Social network analysis is a technique used to study relationships between actors, such as people or organizations. It differs from other methods in that it analyzes relational data (data on the connections or ties between actors) rather than attribute data (data on the individual qualities of an actor, such as age). Social network analysis is a useful technique when there is a need to identify areas for improvement within networks. Doing a social network analysis on a Hungarian energy company's network can help to improve customer service (through measuring information and knowledge flows), to improve (through evaluating existing products – e.g. tariff schemes) and develop new products and tariffs (though discover customer needs).

Already existing databases - e.g. a customer relationship management system – is crucial to be able to measure flows. However, measuring informal ties can be sometimes indefinite and therefore, new, generated database may be required. In deciding whether to use an existing database or to generate a new one, or using some combination of the two is required, depends on the company's data management. Since the energy companies are utilities, therefore, many common elements exist in their operation compared to other network-based companies (like telecommunication companies). They do have extended databases, therefore it becomes important to define the boundary of the utilizing network size as well (e.g. corporate level, business unit level, sales unit



level etc.).

In case of energy companies, because of their large network size, both soft (e.g. information sharing) and hard attributes (e.g. electricity, money, complaint flows) should be considered, as well as their relations to each other. The proposed measurement of the SNA can be based on different types of transactions (in case of power generation, the product itself – e.g. electricity in kWh - or in case of customers, the data connected to the transactions). When measuring the information flows inside the organization of the energy company, the information channels and decision-making process are the basis, which social network should examine. In deciding what combination of hard and soft attributes should be used (among others, to identify the density of the network), both the inside information flows (inside the legal entities of the company), and outside information flows

(between company and the market (TSO, customers, regulators, other suppliers) shall be analyzed (see table below).

The size of a network is determined by the number of agents. Size gives an idea of how the network is built up. In the terms of a large, multinational company, the size of the network and the number of the participants can be measured through charts, which also gives an idea of the ties' types (e.g. continuous, discrete). As a hard attribute, the density of a network is defined as the proportion of all ties that could be present that actually are. To indentify the density, the most convenient is to analyze the samples of the commercial contracts usually concluded between the energy company and its customers, which map the company's ties to the outside and show their density. Besides, these gave the necessary information to calculate the centrality, the network distance and the geodesic distance as well.

To sum it up, during the recent years the Hungarian power market has gone through radical changes. Since the electricity is a special commodity and the power market also requires different approach. When measuring the information flows between the energy company and its partners, the communication and cooperation channels between the company and the market are the basis which social network should examine. Researching the social network of an energy company enables to clarify the key nodes and links, just as the bottlenecks of the value chain and it helps to improve service, but it is essential to find the proper measures.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Recapturing the Trends in the Application of Postponement in Retail Supply Chain Management

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The retail industry faces major challenges, with fierce competition, rapid changes and innovations in the business and social environment (Christopher, 2007), customer requirements (Garman and Magazine, 2006), and in retail business models (Ganesan et al., 2009). Moreover, the role of retailers in supply chains has shifted dramatically from being passive recipients of products from manufacturers to being dynamic co-creators of value (see Fernie and Sparks, 2004). In aiming to properly meet the demands and outperforming rivals without incurring higher inventory holding costs, the "twin" principle of postponement / speculation has long maintained a front page position for supply chain scholars and practitioners (e.g., Dapiran, 1992, Feitzinger and Lee, 1997, Bowesox et al., 1999, van Hoek, 2001, Rahiminia and Moghadasian, 2010). With retailers becoming more and more involved in production and value creation, now seems to be a productive to revisit the conventional interpretation of the model, broadening its scope to include the potential in the new business organization.

The purpose of this article is to provide a framework for the underlying developments in the literature on postponement in supply chain management, and to identify contemporary postponement and speculation practices in retailing. The study starts off by a systematic review of the literature (see Denyer and Tranfield, 2009). The review clearly reveals that there has

been a clearly increasing trend in papers addressing postponement in peer-reviewed journal articles. The database of reviewed journal articles contains 253 individual papers, out of almost three times as many identified through an initial evaluation; this is followed by a methodological discussion of the articles along with their corresponding journals. Moreover, a typological analysis identifies 12 main classes of postponement; namely, Form, Time, Place, Financial, Purchasing (Procurement), Purchasing (Consumer), Identity, Information, Process, Transportation Mode, Service, and Pricing. Finally, by discussing the theoretical gaps in the existing themes in the literature, a model is presented to capture the contemporary and emerging themes in the postponement literature; namely, Manufacturing, Logistics, and Marketing. It is argued that the role of services has been underdeveloped in the existing theory; therefore, by recapturing the latent marketing perspective on postponement and speculation, the model aims to shed light on the role of services in the deployment of postponement and speculation in retailing.

Later, by means of three case studies of major European retailers in electronics, furniture, and grocery sectors respectively, a cross-case analysis of the taxonomy of postponement and speculation is provided. The results show that there is a growing tendency towards postponement based strategies, and away from speculation based strategies. However, the results are not clear-cut, and also show an incidence of highly successful speculations based retail strategies. Also, the study highlights that efficient postponement in retailing requires a high level of supply chain integration.

The contribution of the paper lies on the one hand in that it is the first systematic review of literature in the area of postponement. It provides valuable insights into the existing literature, including notable gaps and hence contributes to the existing literature. The study shows that there is a need for revisiting postponement as a theoretical concept, and in particular the role of services seems to be underdeveloped in literature. As regards the empirical results, based on an analysis of the empirical results of the review, the paper provides direction for further research in the area. Whereas the potential for postponement is traditionally viewed as ending with the point of purchase, our results indicate to the potential for using postponement even after the point of purchase, through the use of after sales services and upgrades that effectively postpone the finalisation of the product until even after purchase. This use of post sale postponement efforts also indicates the potential usefulness of the postponement concept in

relationship building. Finally, the results highlight the role of perspective in the postponement analysis, and the potential business strategic opportunities from inherent in shifting the perspective. For example, a clear-cut speculation strategy on the part of a retailer ordering a one-time batch of campaign goods corresponds to a postponement strategy from the perspective of the manufacturer who does not begin production until the customer order is in place. The results are useful to researchers and other wishing to familiarize themselves with the area of postponement in literature and in pointing out important directions for future research.

Keywords: Retailing, Postponement, Speculation, Marketing, Services, Distribution, Logistics

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Mixed Contracts in the Newsvendor Model

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In this paper we investigate the effect of using mixed contracts in a Newsvendor ordering context. We consider a Newsvendor model with real options and a contract consisting of a mix of ordinary orders and options. Hence the retailer is ordering q units of the item and Q options of the same item. We provide a closed form solution for this mixed contract when the demand is discrete and study some of its properties. In particular we demonstrate that a mixed contract may be superior to a pure real options contract when the manufacturer has a bound on how much variance she is willing to accept.

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Intermodal Freight Transportation: Australia and the European Union Port Administration

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Purpose of the paper

The economic and geographical structures in Australia and the European Union (EU) represent an interesting point of comparison of transport systems, including intermodal freight. Both areas involve the distribution of a high volume of inputs and outputs within large boundaries, yet the infrastructure, physical constraints, regulatory frameworks and decision-making structures are distinct. In light of these similarities and differences, a research program centring on a series of interviews with freight industry representatives in Australia was developed. The goal of these interviews is to identify current experiences and potential strategies that may be used to improve intermodal freight transport efficiency in EU, and to compare this with the corresponding situation in Australia.

Key words Intermodal Transportation, Port Governance, Authority and Policy.

Introduction

In recent decades the maritime sector in the European Union (EU) and Australia has been undertaken reforms concerning ports and transport policy, especially in the field of management of public port authorities and their objectives. In general, the goal of state

authorities is to take measures supporting the long-run efficiency and competitiveness of ports as key elements of intermodal transport chains. This goal is not simple to achieve because maritime and intermodal transport is a complex industry, in which it is difficult to measure both objective factors for port performance and port efficiency, which requires targeted quantitative research, and subjective factors for port effectiveness, which requires sufficient qualitative methods for measuring intangible factors such as customer satisfaction. To create an effective business sector, effective legislation has to be implemented, determining the structure of organisations within the port industry, ensuring accountability and responsibility (Everett et al. 2006; Everett 2007).

Linking port governance and performance is highly difficult, and only a few scholars have conducted research in this field leading to significant outputs (Brooks et al. 2007; 2008). A critical missing element is a gap in our understanding of how the efficiency of external factors such as the geographical location of ports, their physical constraints (e.g., tides, depth) and historical infrastructure development patterns, impact the performance of ports and intermodal transport, in general.

Methodology

To be able to obtain the data necessary for an informed analysis, regional, Australian and European bodies and research authorities responsible for transport policy planning or evaluation were selected as data resources (Bureau of Infrastructure, Transport and Regional Economics; Department of Infrastructure, Transport, Regional Development and Local Government; European Commission; European Executive Agency for Competitiveness and Innovation; European Sea Ports Organization; Institute of Transport and Maritime Management Antwerp; Trans-European Transport Network Executive Agency). Qualitative research based on a soft data approach (Baird 2009) has been conducted via a questionnaire designed for port authorities' representatives. The resulting data will be evaluated for the 10 ports with container terminals surveyed (Hamburg, Bremerhaven, Rotterdam, Antwerp and Koper for EU; Sydney, Melbourne, Brisbane, Fremantle and Adelaide for Australia). The results will be made available when the analysis is concluded in the following months. The research issues are based on the fact that maritime policy of public authorities, contrary to the private sector, must always take into account a variety of different and contradictory objectives such as an efficient pricing

system, cost efficiency, distributive goals, development of short sea shipping or improvement of environmental protection and safety (Trujillo et al. 2005).

Society contribution

This paper compares regulatory systems, constraints and issues for efficiency in intermodal transport through seaports in Australia (Pettitt 2007) and the European Union. Implications for domestic and European policy makers and stakeholders will be offered, highlighting common concerns and opportunities for both areas to learn from one another's efforts.

The key objective of ongoing research is to perform a new evaluation of port samples for two different economic entities (Australia and the EU) and provide a bottom-up analysis. This paper sets the context for this research by comparing policy and decision-making structures, and the role of supply chain members in the evolution of port development strategies in Australia and the EU. Due to limitations in the spatial scope of research in the area, it is important to establish information links amongst scholars in different regions; this holds especially in Central-Eastern European Countries (CEE), in which research tends to be fairly isolated and the level of international cooperation in the field is fragmented.

Anticipated results

Ultimately, there are several similarities concerning maritime and port policy in Australia and the EU, but even more differences. The role of ports as key intermodal transport chain nodes is still neglected in both areas, but in the EU some progress in increasing port performance and utilisation has been achieved, due to the identification of strategic goals. On the other hand, in Australia private sector and customer-oriented needs tend to shape the development of port policy objectives. This commercial and customer focus represents an interesting contrast to the higher involvement of state and regional authorities in port business in Australia compared to the EU.

Ongoing research will test the behavioural relationships identified in the literature discussed in this paper. It is difficult to conduct research, evaluate and benchmark implementation of port policy objectives by port authorities for Australia and the EU based on the same quantitative

indicators, but the research involves a balance of empirical tools and data appropriate for the task.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Service Supply Chain Games under Different Product Support Contracts

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After-sales support business is acknowledged as a relevant source of revenue, profit and competitive advantage in most manufacturing industries. The product sustaining activities are running upon the **service supply chain** which focuses on the business processes and resources that support customer relationships throughout the product's life cycle. The contract between the members of the service supply chain can be multiple types. Traditionally, the acquisition and service of products is separated, this *transaction-based contract* can be fixed-price or cost plus, and also may include a warranty period. Recently, the *performance-based contract* has been adopted increasingly in the after-sales business. Instead of selling the parts and repairing activities, the supplier's compensation is based on the product's actual performance (i.e. system availability). Stakeholders may confuse to choose the right contract forms to undertake the after-sales operation. In this paper, we will discuss how the different service contracts influence the relationship of members in the service supply chains; and develop the right incentive schemes of channel coordination by a comparison analysis of the two types of contracts.

Our main method lies in the theory of service parts inventory control and supply chain contracting. Consider a two-echelon service supply chain, consisting of one supplier and one OEM. The OEM buys N identical capital goods from the supplier, which are subject to random breakdowns. In order to implement product support, the supplier has to manufacture the spare parts inventory

together with the products so as to replace the unserviceable parts when system failure occurs. If backorder occurs, in other words, there are no spares on hand whenever the equipment is out of order, the system will become unavailable. Comparing to the retail supply chain, the demand of service supply chain is triggered by the system failure, i.e., the demand of spare parts inventory equals to the number of parts being repaired under our fail-and-replace product support frame. Since the OEM uses the product to generate revenues only if the system is functioning properly, the supply chain members have to trade off between the cost of spare parts inventory and the off production caused by system unavailability. Then a newsvendor game framework can be applied to model this service supply chain relationship. In this paper, we use a game-theoretic method to model the supply chain relationship in two different product service contract settings, the *Transaction-based contract* and *Performance-based contract*. Our model explains the individual and global interests of supply chain, and coordination terms are created by finding the equilibriums of different games. Also, we compare the two types of contracts and show that how the parameters affect the right choice of contract type.

At present, it is not surprising that more and more manufactures will continue developing competitive strategies for their aftermarkets. In the scientific aspect, Most OM literature on the service domain studies the spare parts inventory management, of which the objective is minimizing inventory cost suffering a certain level of service constraint. However, various kinds of service contracts, especially emergence of performance-based contract become the prime consideration of service business operation. Unfortunately, academic literature offers little guidance of this segment, although numerous papers of supply chain contacting focus on the forward manufacturing/retailing field rather than the after-sales service sector. Hence, our research tries to make contributions on this domain. In the practical aspect, our research may give insights to service supply chain practitioners on how to choose the right contract forms according to the supply chain attributes as well as coordinate the service supply chain by aligning the incentives of the members.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management –
Recent Trends and Future Perspectives"

How to find correct distances

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Road databases are becoming more important in transportation planning and computations of distances and routes are important tasks. One obvious reason for this is that payments and invoicing are often based on the driven distance. However, the distance can be hard to agree on because of different features such as length, quality, width, speed limits etc. It is therefore a need to find suitable weights on available features. The Swedish forest industry has a transportation cost of about US 600 million. The transportation is done by many forest companies and transporters and there is a common goal to use a standardized system to establish routes and distances that can be used as a basis for all invoicing.

As a basis we use the Swedish National Road database (NVDB) was developed (starting 1996) in a collaboration between the Swedish National Road Administration, the Central Office of the National Land Survey, the Swedish Association of Local Authorities, and the forest industry. The database contains digital information of all Swedish roads: the state road network, the municipal road and street network, and private road networks. All roads, approximately over 560~000 km, are described geometrically, topologically, and with detailed information about each road segment. For transportation on forest roads, more than 200~000 km, there are also special details about accessibility, special forest roads, preferred routes in cities, turning radius, barriers etc.
We describe an approach to find a set of optimal weights of the features in the road database. An important part is a set of 1,285 detailed "Key routes" where the forest companies and transporters

have agreed on the best route between a set of start and end nodes. Given this set of "Key routes", an optimization model is formulated where the main decision variables are the weights on each feature and their attributes. In our application there are more than 55 weights to be determined. The optimization model which is a critical part is an inverse shortest path problem.

Since 2008, we have established a number of set of weights. The number of features and attributed have increased during the process after that the results have been studied by a national logistic board and evaluators in forest companies and at transporters. For example, we have added features like road width to improve the results. Also, a number of mechanisms to control the route selection have been included. One example is passing routes to avoid traffic in cities. Another example is so-called approach routes to industries. If an industry is situated in a town, there is often a local requirement to follow a particular route. During 2009-2010 a prototype testing has been done and evaluated. Six companies each selected a smaller district to test the system in practice. The result was very good and several companies have decided to run the system for all their operations. We have also compared reported distances used during a period of ten months in 2008 covering more than two million invoiced routes.

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Geographic dispersion and supply chain performance – Empirical evidence from large manufacturing companies

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On one hand, market and product diversification brings economic performance benefits (Rumelt, 1982) and, on the other hand, there are downsides to the increasing complexity of the firm's international business. As the critical internationalisation thresholds are reached, the eroding profit margins imply diminishing levels of economic performance (e.g. Geringer et al., 1989). The physical characteristics of the international network involve uncertainty for material flow that may affect the performance of supply chain operations to a serious degree (Prater et al., 2001; Arvis et al., 2010). Relevantly, Levy (1995, pp. 356) has suggested that relational, not locational factors, "raise the cost of geographically dispersing value chain activities". In our research, geographic dispersion of the supply chain and the resultant complexity, is identified as one potential determinant of supply chain performance.

The purpose of this paper is to find out how the geographic dispersion of the supply chain impacts supply chain performance at the firm level. We limit our scope on individual firms, i.e. not on the total effects in the inter-organisational supply chain, and study the *supply chain performance* among three dimensions: logistics costs, service performance, and asset utilisation. *Supply chain geographic dispersion* included the dispersion of sales, production, and sourcing.

Logistics cost components were classified following Töyli et al. (2008) as transportation cost, warehousing cost, cost of capital tied in the inventory, and logistics administration costs. The costs were measured as percentages from turnover. Service performance was measured through perfect

order fulfilment and order fulfilment cycle time as was done, e.g., in Töyli et al. (2008). Asset utilisation included the cash-to-cash cycle time and its widely used sub-component, inventory days of supply.

Based on a measure of network geographic dispersion by Stock et al. (2000), we use the percentage share of purchases, production capacity, and sales in six geographical areas of the world, in determining *supply chain geographic dispersion* profiles for each respondent. The six areas are: Finland (home), other EU (including Norway, Iceland, and Switzerland), Russia, North and South America, Asia, and Other. This regional configuration was formed from the Finnish foreign trade point of view.

The empirical data analysed in this research consists of a sub-sample of 109 large manufacturing companies from the Finnish logistics survey data of Solakivi et al., (2009). For data analysis we applied generalized linear modelling for both gamma and normally distributed performance variables.

In our analysis the relationship between each performance variable and the three potential geographic dispersion related independent variables was investigated. In the first phase all three independents were included in the model that was then improved with trial-and-error basis by shedding independents that do not demonstrate statistical significance, i.e. p values are below 0.1. Independents were also tested singularly with a dependent variable; however, models with more than one independent were prioritised. We were able to specify fourteen different statistically significant models.

The main findings of the research include the following. Increased geographic dispersion of the upstream and downstream supply chain operations results in higher costs of warehousing, inventory carrying and logistics administration, in the decline of perfect orders, and increase in order fulfilment cycle time. In contrast, geographically dispersed production network enables improved service performance as closer proximity to customers enables shorter order cycle times but, on the other hand, inventory costs tend to increase. Further, geographic dispersion in all tiers of the supply chain affects negatively asset utilisation since both the inventory days of supply and cash-to-cash cycle time increase. As compared to the median performance values from zero-dispersed companies, the above mentioned effects may on average be quite substantial in globally dispersed supply chains. Based on our results, the management of supply chain performance should be high on the agenda in internationalising and global companies.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

An attention-based view of the marketing-logistics interface – Balancing effective demand creation with efficient demand fulfillment

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Strategic issues regarding customer-services as for example the choice and design of product characteristics, sales channels, speed of delivery or after sales services affect marketing and logistics departments simultaneously and, hence, constitute a pivotal area at the marketing-logistics interface within organizations. Whereas marketing departments in the context of customer-services typically aim at an effective demand creation, i.e. trying to influence customer needs in favor of the products or services offered by the firm, logistics departments focus on fulfilling existing demand in the operationally most efficient way, i.e. modifying processes to satisfy existing consumer needs with the most efficient operational performance achievable (Mollenkopf, *et al.* 2000). These two different perspectives, however, constitute a potential source of conflict in decision-making processes: Effective demand creation can, for instance, imply a broadening of the product portfolio, a shortening of delivery times or an immediate supply of spare parts. In contrast, from a logisticians' point of view, such implications are most likely to decrease the efficiency of business processes. At least they might temporarily increase the complexity of tasks logisticians are confronted with. Vice versa, concentrating on the efficiency of logistics processes could result in

marketing related constraints leading to less satisfied customers and a deterioration of competitive position on the market.

This discrepancy of functional perspectives is commonly assumed to be the primary reason for conflicts at the marketing-logistics interface (Lynagh and Poist 1984, Ballou 1992, Murphy and Poist 1996, Mollenkopf*, et al.* 2000, Esper*, et al.* 2010). Proposals on how to dampen this conflict are manifold and have been widely discussed and analyzed conceptually as well as empirically. The predominant logic of the solutions proposed thereby lies within the integration of or at least the cooperation between the two functions in order to balance perspectives (Voorhees*, et al.* 1988, Morash and Droge 1996, Ellinger*, et al.* 2000). However, it seems that the academic discussion still falls short of sufficiently explaining and solving the conflicts arising in organization. The key pitfall of the discussion can thereby be found within the commonly assumed primary reason for conflicts arising between marketing and logistics departments. Complementary to just focusing on discrepancies between functional perspectives, the nature of the conflict must also be viewed in a biased way organizations channel and distribute their overall attention towards strategic issues in the area of customer-services. Such biases may occur, if attention is mainly oriented one-sidedly, that is either market-driven or efficiency-driven. If, for example, an organization is purely market-driven, the attention of top executives will be mainly oriented at competitor-moves or consumer-behavior and less at the efficiency of logistics processes. This in turn will influence the decision-making behavior of executive committees and consequently the proposals made by marketing and logistics departments. Similarly, but looking at a downstream level, activities of operational managers might differ from what marketing and logistics departments have agreed upon, if they are after all overemphasizing demand creation. Hence, it is not only the two functions which must be addressed to solve potential conflicts at the marketing-logistics interface but moreover the distribution and regulation of attention of all decision-makers within an organization.

This paper intends to formulate propositions on how situations, rules, resources, and relationships of firms interrelate and affect general strategic behavior as well as concrete strategic decisions in the area of customer services by applying the attention-based view as developed by Ocasio (1997) to the marketing-logistics interface. The attention-based view addresses how organizations behave by explaining how attention of decision-makers is shaped. It thereby links individual and collective information processing as well as behavior with the organizational structure and its environment and by this means analyses how dominant logics provide perceptual filters that influence attention and decision-making behavior (Ocasio 1997, Ocasio and Joseph 2005). Applying this view will

enable a more comprehensive understanding of the causes of interdepartmental conflicts between marketing and losgistics as well as an evaluation of the currently proposed solutions. Based on this, promising but yet incomplete solutions can be enhanced to better solve the conflicts confronted.

By pointing out that the basic problem is not merely to be found within the pure design of decision making process, i.e. the coordination between marketing and logistics, but also and more importantly in the way organizations and their decision makers pay attention to issues regarding customer services, I intend to highlight that the overall solution for conflicts at the marketing-logistics interface will not be exclusively found in cooperation or integration, but moreover in shaping the distribution and regulation of organizational attention. This implies that decision-makers must, in each and every vein, observe and process information regarding customer services in a balanced manner to avoid the formation of one-sided attention and, thus, the breeding ground for conflicts between effective demand creation and efficient demand fulfillment.

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Abstract for

8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Production Network Engineering: An approach to robust capacity allocation to stochastic production processes

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Keywords: Production Network, Dynamics, Robust Capacity Allocation

Introduction

Production networks are shaped by several factors (e.g. technological innovation, logistics services available world-wide) and have become global. These large-scale networks comprise external suppliers, distributed manufacturing plants and transportation assets. In addition to the structural complexity, the underlying procurement, manufacturing and transportation processes are dynamic. Furthermore, the evolution of internal and external parameters that determines structural and dynamic properties of global production networks is not certain. Hence the resulting behaviour of the network is often complex and uncertain. Especially the long-term planning has to anticipate customer demand as well as the dynamics of the production network that have a significant impact on the performance and sustainability of the network. A robust and sustainable production network engineering is given by the capability of the network to cope with several possible future scenarios in an efficient manner. In this context not only locations and transportation links of the

network have to be properly chosen but also production capacities at each location for the processed products.

Methodology

A sustainable creation of value is paramount aim of global production networks and mainly determined by the network engineering. This goal is fostered by Advanced Planning Systems (APS) - applied to such networks. The underlying structure of APSs is illustrated by the Supply Chain Planning Matrix (Rohde et al. (2000)). The matrix comprises modules for the planning tasks that are characterized by time horizon and involved business functions. The degree of detail increases and the planning horizon decreases by shifting from the long-term to the short-term. These consecutive modules allow to handle the complexity of an overall planning process (Fleischmann et al. (2004)). The modules are often based on mathematical programming formulations or heuristics that assume deterministic planning information (Scholl (2001)). However, it can be shown that such approaches fail to cope with a dynamic environment and the considerable uncertainty of the underlying planning information (Landeghem and van Vanmaele (2002)). Stochastic programming and robust optimization address uncertainty of relevant parameters (Mulvey et al. (1995)) and are used for robust planning. They are based on a set of deterministic future scenarios of relevant parameters (Helfrich and Cook (2002)) instead of point estimates. In this context a plan is considered robust as it remains close to a desired solution for each scenario. These approaches are applied to network design problems (Klibi et al. (2010)) and (Pan and Nagi (2010)). Nevertheless, the obtained planning results depend on the arbitrarily chosen scenarios.

In the following we present an approach to production network design that maximizes the robustness of a production network with respect to perturbations of customer demand or production processes. This approach incorporates knowledge about the dynamic behavior of production networks as well as a consideration of uncertainty. The dynamics of such complex networks can be modelled by multiclass queueing networks. A queueing network is said to be stable if the total number of products in the network remains bounded over all time. This means that the long-run input rate of the network equals the longrun output rate. For a precise definition of the stability of multiclass queueing networks see Bramson (2008). Dai (1995) and Bramson (2008) presented an approach to investigate the stability of queueing networks by using a fluid limit model. The fluid approximation model is a continuous deterministic analogue of the discrete stochastic model. The stability of a corresponding fluid limit model implies the stability of the

original queueing network. In comparison to a queueing model the stability of a fluid model can be determined more easily. Since the evolution of relevant external and internal parameters is not known prior we embed a measure for robustness of a fluid model with respect to perturbations of the customer demand and process rates into our approach. The stability radius of a network quantifies the size of perturbations that are guaranteed not to destroy stability. Hence it allows to prepare a network precisely for unexpected events of a certain magnitude. First results and capabilities concerning this measure were presented in Scholz-Reiter et al. (2010). There the concept of the stability radius for dynamical systems (Hinrichsen and Pritchard (2005)) is adapted to the case of fluid network models. During the process of capacity allocation we aim to maximize the robustness of a production network in regard to perturbations of customer demand or production processes. Hence, we seek for a sustainable capacity allocation that enables the network to handle unexpected higher demand or reduced production capacities (e.g. machine breakdown or strike). Based on findings regarding the stability radius we set up a mathematical program that allows to find an optimal capacity allocation to the production processes.

Expected Results

Obtained results concerning the new approach for a robust capacity allocation within dynamic and uncertain production networks present the basis for a forthcoming method to production network engineering that is dedicated to the robustness of the network. In particular the question should be answered how to design the network with respect to the processed products at the locations, such that the robustness of the whole network is maximised. In this context several monetary tradeoffs occur, e.g. the number of product classes processed at a certain location determines fixed costs per location, required production capacity allocation and capacity costs.

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Abstract for

8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Functional scope and organizational design of logistics outsourcing relationships

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The variety of activities that are transferred to Logistics Service Providers (LSP) has expanded enormously over the last decades. Basic logistics functions often are encompassed by value adding services as a result of outsourcing efforts. Alongside to the scope of activities a second decision of huge strategic importance is the organizational mode of the inter-firm relationship between the LSP and its customer. One aspect is the legal form of the cooperation: While in many cases independent joint ventures are founded by the involved partner firms, non-equity based contractual agreements are common in practice as well.

Examples for joint ventures for standard logistics services like transportation as well as joint ventures in the context of complex 3PL-solutions can be observed. On the other hand also contractual agreements are used for both, standardized and highly customized processes at the same time (cf. e.g. Bollig 2009; Helmke 2008; Siegmund 2009). Thus at a first glance the different arrangements can not solely be traced back to the intensity of the relation or its strategic importance.

The mentioned issues basically refer to the fundamental questions of *what* to outsource and *how* to implement this outsourcing undertaking. Existing prescriptive models directly address these two questions and do provide theory based advice. Transaction Cost Theory (TCT) e.g. connects exactly the alternative institutional arrangements with the activities characteristics (cf. Williamson 2008). The also widely recognized Resourced Based View (RBV) assists decisions on outsourcing subjects

from a strategic perspective (cf. Barney 1991). Both theories have been applied to the logistics context many times and build the basis for several outsourcing frameworks (cf. e.g. Bolumole et al. 2007 and Holcomb & Hitt 2006).

Nevertheless, the mentioned examples of joint ventures substantiate doubt on the significance of most of the prescriptive models at least within the logistics context. Moreover critique is already expressed in several literature contributions, describing logistics outsourcing praxis as often intuitive driven, operational oriented or as highly influenced by the decision maker (cf. Mello et al. 2008).

Thus the resulting question is which determinants and drivers actually do influence the scope of logistics outsourcing relationships and affect the organizational design of the underlying interfirm partnership.

Based on first pretest interviews with logistics experts, factors like financial motives, outsourcing experiences in the past and the organizational embedment of the decion maker on side of the outsourcing company are assumed to have a much more prominent influence on the interorganizational relationship than strategic considerations. Conceptualizing these determinants and deriving typical clusters of customers is the declared goal of this project.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

On the Function of Supply Chain Collaboration in Organizations

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Collaboration has been claimed to be an interesting strategy for reducing costs and improving performance (Dyer, 1997). Min et al. (2005), for example, show that organizations committed to their relationships regard collaboration as a key success factor. The growing interest on different types of collaborative relationships is highlighted by Camarinha-Matos and Afsarmanesh (2005), who argue for a specific discipline for the field.

Despite the fact that some initiatives generate real gains, organizations still strive to estimate risks and to achieve the full potential of collaboration. Kampstra et al. (2006) suggest that the reality is still different from the picture drawn in theory. Singh and Mitchell (1996) highlight some interesting risks when developing collaborative initiatives related to partner shutdown and partner changes. Recognizing the difficulties of collaborating, Holweg et al. (2005) suggest some leverage points, based on multi-case studies and Barratt (2004) argues that the lack of a clear understanding of collaboration contributes to the difficulties seen in practice.

Different theories have been developed, which explain the gains of collaboration. Transaction costs theory suggests that firms choose optimal strategies based on the costs of the transactions involved in different strategies (Williamson, 1973, 1981). Dyer (1997) draws on transaction costs literature and shows that collaboration is an effective option for reducing these costs. Although interesting at first sight, transaction costs are difficult to be estimated ex-ante and difficult to be calculated ex-post. The resource based view, developed by Wernerfelt (1984),

suggests that mergers and acquisitions are strategies used to access strategic resources. In this sense, collaboration can also be regarded as a form of accessing resources of other firms and partners should be managed in order to generate an optimal resource base for the company. Dyer and Singh (1998) extended the Resource Based View changing the basic unit of analysis from the firm to its network. In their view, network relations cannot be further divided and are also a source of supernormal profit returns. Madhok and Tallman (1998) suggest that these theories fall short in explaining why collaboration fails and proposes a value based approach. Even though interesting, the term value brings with it the same difficulties of definition and measurement as transaction costs.

All mentioned theories recommend collaboration to be rationally pursued as a potential source of competitive advantages, through cost reduction, differentiation against competitors and value maximization. But they still fail to acknowledge what is the function of collaboration in the organization[2]. This is in accordance Camarinha-Matos and Afsarmanesh (2005), who points out that the sociological grounds of collaborative relationships is still lacking.

Social systems theory breaks with the rationality assumption of the classical organization theory, presenting organizations as only one of different types of systems (Luhmann, 1995, 2006). Modern society is characterized by functional differentiation in which systems emerge to fulfill non-hierarchical societal functions (Luhmann, 1995). In this context, organizations are a specific type of system, which fulfill different functions, among which, the most important is the transformation of an uncertain future in a certain one through the constant (re)production of decisions.

Based on the assumption that firms are a specific type of organization, which strive to produce (in general sense) profitably (Baecker, 2006), we argue that a collaborative relationship can prove its worth, only when collaboration contributes to the fulfillment of the organizational function. Moreover, we argue that the reduction of costs and improvements both in value and performance are all consequences of the specific organizational function fulfilled by collaboration. However, by no means we argue that collaboration is the only form of fulfilling it. Other functional equivalent options represent the most important hindrances to collaborative initiatives.

Drawing on theory of social systems (Luhmann, 1995, 2006) and second order cybernetics (von Foerster, 2003) we investigate how collaboration contributes to the general organizational

[2] Function can regarded as the cybernetic idea of transformation. In Ashby's words, a transformation is *"a set of* [state] *transitions on a set of operands"*, (Ashby, 1956, p.10). Thus, a function of a system describes its *raison d'être*, what the system does, which problem the system contributes to solve, independent of the system specific goals and structure.

function. We argue that collaborative relationships have the specific function of reducing external uncertainty while maintaining internal complexity low, when compared to other organizational structures, such as strict market orientation or vertical integration.

The main contribution of this work is a novel system theoretical functional analysis of collaborative relationships in supply chains. This analysis helps explaining not only the role of collaboration in the organization, but also why in practice many collaborative efforts still fail to reach their goals.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

The Decision how to Decide: The Effects of Group Decision Rules on Sales and Operations Planning Performance

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Introduction

Research in operations management (OM) has remained largely independent from research in organizational behavior (OB) until about the year 2000. Traditionally, OM was concerned with constructing normative mathematical models which "have historically invoked oversimplified models of motivation, learning, creativity, and other such aspects of human behavior that are vital to the success of management policies in practice" (Chopra, Lovejoy & Yano, 2004, p. 13). Drawing from various disciplines, the emerging research field of behavioral operations is a multidisciplinary "study of attributes of human behavior and cognition that impacts the design, management, and improvement of operating systems, and of the interaction between such attributes and operating systems and processes (Gino & Pisano, 2008). The proposed study follows the call of behavioral operations for more research of human behavior in operating environments (Boudreau, Hopp, McClain, & Thomas, 2003). More specifically, by adding new behavioral perspectives, this study aims to make a much needed scientific contribution to team research in operations management.

Decision-making is essential for operations management performance. Literature on the interface of economics, management and psychology has shown that individuals and teams do not make decisions in a perfectly rational manner, but rather according to principles of bounded rationality (Simon, 1957). Bounded rationality causes people to unconsciously use heuristics which limit someone's capacity to learn, act and make decisions. Research about biases in information processing and decision-making has begun to identify behavioral factors that lead decision-makers to deviate from optimal decisions in supply chain management. Schweitzer and Cachon (2000) investigated decision biases in the newsvendor problem and found that decision-makers ordered inventory quantities that were close to a mean demand and thereby ordering too little of high-profit products and too much of low-profit products. This decision pattern illustrates how decision-makers can fall prey to the anchoring and insufficient adjustment bias in inventory ordering decisions.

Decisions in organizations, however, are rarely made by individuals, but rather by teams. Despite the importance of teams in ensuring the profitability and competitive advantage of organizations (De Dreu, Nijstad, & van Knippenberg, 2008), group decision-making in supply chain management has hardly been explored from a behavioral perspective. Groups as information-processing entities (Hinsz, Tindale, & Vollrath, 1997) have to interpret information in order to make good decisions. Furthermore, in a group, individuals are likely to possess different relevant information and consequently different preferences for decision-making. Thus, "an important

aspect of group judgment and decision-making is how group members combine these various resources and preferences to come up with a decision" (De Dreu et al., 2008, p. 24). The effects of different decision rules on negotiated group outcomes have been explored in controlled experimental settings. Two decision rules that are commonly used in groups are the unanimity rule and majority rule. The unanimity rule refers to a decision procedure in which all members of a group have to agree to a solution before it will be implemented. Under a majority rule the agreement of more than 50% of the group is enough to implement a solution even though it may yield unfavorable outcomes for the minority. Thopmson, Mannix and Bazerman (1988) examined the impact of the two group decision-making processes and found that groups that used a unanimous decision procedure achieved higher negotiation outcomes than groups that used a majority outcome. Expanding these findings, Ten Velden, Beersma and De Dreu (2007) showed that the use of a majority rule in group negotiations does not necessarily lead to suboptimal negotiation outcomes. Instead, the interplay between procedural and motivational variables determined whether a negotiation outcome was beneficial or detrimental for the group. Thus, the proposed study seeks to answer the question whether the type of decision-making in a cross-functional Sales and Operations Planning (S&OP) team explains differences in performance.

Hypotheses

Similarly to Ten Velden et al. (2007), we propose that the task context (modeled in a S&OP supply chain business simulation) and decision rule interact to determine group decision-making outcomes. In a highly complex, dynamic and unpredictable environment, the unanimous decision rule might prove unfeasible and unfavorable as the time to reach an agreement in a group is increased. More specifically, we first hypothesize that teams that use either the unanimity or majority rule for decision-making make better decisions (with regard to supplier delivery reliability, forecast accuracy, production reliability and inventory of raw materials) than teams in which one dominant team member made all the decisions or teams that did not have a clear decision rule at all. Furthermore, given the complexity of the task, it is proposed that teams that employed a majority rule as decision-making procedure make better decisions and experience higher performance than teams that adopt a unanimity decision rule.

Methodology

In the current research, we claim that the type of group decision-making can have a positive effect on the performance of four-person teams that participate in the S&OP supply chain business simulation "The Fresh Connection". In this business simulation, a cross-functional team consisting of a VP Purchasing, VP Sales, VP Operations and VP Supply Chain Management considers issues such as its sales and operations plan regarding the purchasing of supplies, capacity planning, production planning and inventory planning. The simulation is divided into seven decision periods of one week each in which the teams have to process a considerable amount of information, make numerous decisions and anticipate and/or react to unforeseen events. Furthermore, teams have to share proprietary information in order to make decisions. The team with the highest return on investment at the end of the simulation will win the game. Besides that, individual roles within the team are assessed based on different key performance indicators.

Contribution

The research has relevant theoretical and practical implications as it aims at improving and ultimately managing group decision-making and performance in operations and supply chain management. Thereby, it adds to the emerging research field of behavioral operations. Furthermore, using a setting that is highly representative for actual work settings, the study provides insights into the human factor in S&OP. Results might point to the usefulness of group process interventions in order to enhance performance in operations tasks, such as forecasting, inventory and capacity planning.

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Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management –
Recent Trends and Future Perspectives"

Anchoring and Regulatory Focus in the Newsvendor Problem: Field Evidence

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Using data from a luxury goods manufacturer, we analyze the order quantity decisions made by individual product managers for a set of high-margin, limited edition products. For new products like these, the decision makers do not know the demand distribution, neither a priori (since all products are unique and one-time), nor a posteriori (since they observe only the sales realization of a product, not the demand realization). We find that if the decision makers use sales data of a comparable product launched in the past (the anchor), they become more conservative; they overstock less and face more stock-outs then when they do not. We also find that the higher the margin, the lower the overstocking rate. These findings are consistent with the so called pull-to-

the-center effect for the newsvendor problem observed in experimental studies. The use of multiple anchors makes decision makers even more conservative, a finding that seems to contradict earlier experimental predictions. We also examined the role of regulatory focus on inventory decision making, a yet uncharted area, and demonstrate a strong relationship between regulatory focus and order quantity. Decision makers with a prevention focus rely more on past sales data in their judgments, and thus are more conservative and face more stock-outs than decision makers with a promotion focus who tend to overstock more.

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Deregulation and the New Economics of European Road Transport Operations

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Even though the 1957 Treaty of Rome had stated that a common transport policy has to be achieved by 1969, and the 1985 decision of the court of Justice confirmed that the EC should act to realise the basis freedoms at time the Common European Market will be established, deregulation in the European road transport sector is indeed a long lasting, ongoing process due to the EU enlargements in 2004 and 2007. This offers in turn diverse opportunities to road transport operators to run international transport operations on a pan-European scale, especially regarding cross-trade (international transports between two countries performed by a haulier which truck is registered in a third country) and cabotage (international transports within a host country performed by hauliers with trucks registered in another country) with truck fleets registered in new EC member states of the last two enlargement rounds of 2004 and 2007. Whereas a long time the impacts of such practices were regarded as rather negligible, recent developments in cross-trade and cabotage operations show, that they get more and more a persistent figure in European road transport operations.

In this contribution, past and present cross-trade and cabotage rules and their consequences for road transport operators are reviewed. Based on a series of surveys among Austrian road transport

operators since 2003, impacts for national hauliers as well as overall economy are quantified and an outlook to further development is given in the case of Austria.

Cross-trade and cabotage as an outcome of European road transport deregulation and its consequences to national hauliers as well as overall economy is so far not much reflected in literature. Therefore risks and chances for national hauliers arising from present European road transport deregulation through cross-trade and cabotage operations are exemplified taking Austria as an example.

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Abstract for

8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

Optimal configuration in a puzzle-based compact storage system

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Storage facilities, including warehouses, distribution centers and container terminals, can be found everywhere in supply chain networks. They form the key nodes in supply chain networks decoupling demand from supply in time and quantity. Over the past decades, these facilities have evolved towards higher storage density, more automation, and more intelligent control. This development is particularly attractive as (1) land becomes more scarce and expensive in many densely populated areas, like the Netherlands, or when space is scarce, like within ships or aircrafts; (2) costs of technology-based systems are decreasing, and (3) system response times have to be shortened to earn customers. As a result, a new generation of storage systems is emerging: dense, autonomous and intelligent (DAI) storage systems also called puzzle-based compact storage systems. In a puzzle-based compact storage system, every load is accessible and can be moved between storage locations and input/output (I/O) point. Each unit load can move in x- and y-directions as long as an empty slot is available next to it. In such a system, unit loads are stored in a

grid in which at least one location is open, and so the location utilization can reach $(n-1)/n$, where n is the number of storage cells in the grid (Gue and Kim, 2007). Compared to traditional storage facilities where unit loads are stored single deep with many transport aisles, puzzle-based compact storage systems need less space.

In this study, we will derive retrieval time models to estimate the performance of a random storage policy and use these to optimize puzzle-based system dimensions yielding minimum system response times.

The main components of a puzzle-based compact storage system are storage racks, shuttles, a lift, and an I/O-point. Shuttles can move in x- and y- directions while carrying a unit load. A shuttle can move a unit load as long as there is an empty slot next to it. Shuttles move unit loads into the open locations to maneuver the desired unit load to the output at the load's storage level. A lift takes care of movements in the z- direction. At each level, the shuttles can move independently of the lift. We assume the I/O point is located at the lower left corner of the system. When idle, the lift waits at the I/O point.

This paper optimizes dimensions of a puzzle-based compact storage system under random storage policy. In order to do this, we define a mathematical model for the expected retrieval time of a random unit load as a function of system dimension sizes. Figure 1 illustrates a schematic view of a puzzle-based compact storage system with lift.

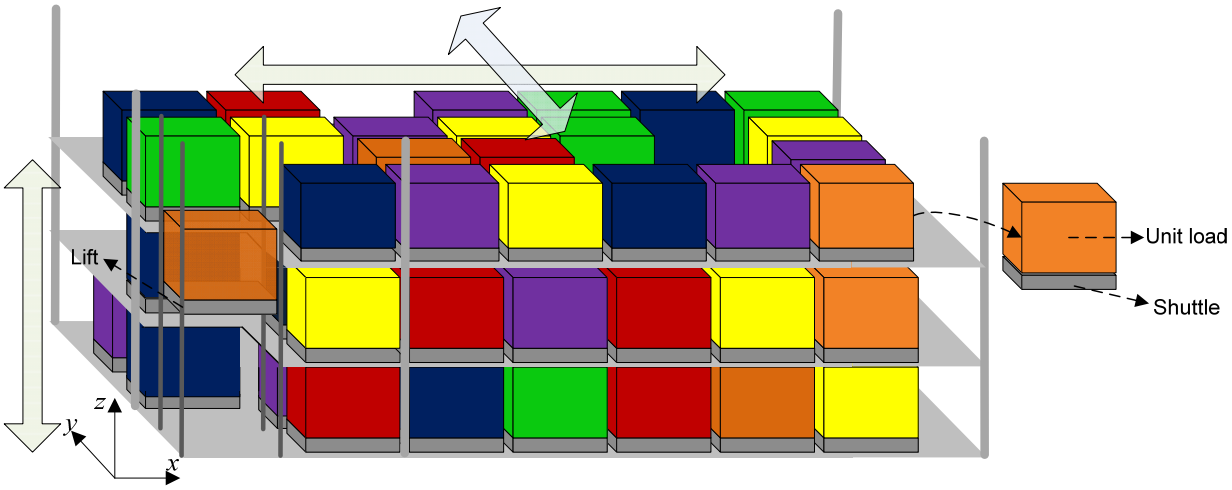

Figure 1. A puzzle-based compact storage system with a lift

A random retrieval location can be denoted by (X, Y, Z) where X, Y and Z refer to coordinates in x-, y- and z- directions respectively. The system capacity is a known positive constant. A random storage policy is assumed. It is also assumed that the utilization of the system cannot exceed

$(V' - \max\{L,W\})/V'$, where *V´*, *L,* and *W* represent the capacity of the system in number of storage locations, the number of columns in each level, and the number of rows in each level, respectively.

Theorem 1. *If there is at least one empty location in each row and each column of each level of a puzzle-based compact storage system (i.e. max utilization* $\leq (V' - \max\{L,W\})/V'$ *), the minimum retrieval time of a random unit load stored at location* (*X, Y, Z*)*, can be estimated by the following equation:*

$$RT(X,Y,Z) = \max\{X+Y, Z\} + Z \quad (1)$$

Proof. Theorem 1 can be proven by using mathematical induction, which is omitted here.

Using this theorem, we obtain the expected retrieval time given by Equation (2) and the mathematical model of the problem as below (Model MGM):

$$\min ERT, \quad (2)$$

subject to:

$$l \times w \times h = V, \quad (3)$$

decision variables: $l > 0, w > 0, h > 0$,

where *l, w,* and *h* (length, width, height of the system) are the decision variables. All the dimensions are expressed in time units. *V* represents the volume of the system in cubic time unit.

Constraint (3) makes sure the given capacity is achieved.

The model is non-linear and mixed integer; however, we can optimally solve it by splitting it into several solvable sub-models and reducing the feasible area of the decision variables without losing the optimal solution.

The following equations define the optimal solutions of Model MGM. For any given volume of the system, a system with the following dimension sizes is the system with minimum expected retrieval time.

$$h^*(V) = \left(-2 + \left(\frac{1}{2}\left(11 + 3\sqrt{13}\right)\right)^{1/3} + \left(2/11 + 3\sqrt{13}\right)^{1/3}\right)^{1/3} V^{1/3} \approx 0.874461V^{1/3} \quad (4)$$

$$w^*(V) = l^*(V) = \left(-2 + \left(\frac{1}{2}\left(11 + 3\sqrt{13}\right)\right)^{1/3} + \left(\frac{2}{11 + 3\sqrt{13}}\right)^{1/3}\right)^{1/3} v^{1/3} \quad (5)$$

$$\approx 1.069374V^{1/3}$$

Reference

1. Gue, K.R., B.S. Kim (2007) Puzzle-based storage systems. Naval Research Logistics 54(5) pp. 556-567.

KEYWORDS

Logistics, warehousing, puzzle-based compact storage system, random storage

Abstract for
8th CEMS Research Seminar on Supply Chain Management

"Supply Chain Management – Recent Trends and Future Perspectives"

The discrete lot splitting problem with attached setup times in the two-machine flow shop

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We address the discrete version of the lot splitting problem in a two-machine flow shop with attached setup times, where the single lot consists of n identical items. The result is only known for the continuous case by Buckhin 2002. We present a procedure based on dynamic programming which provides a strong lower bound and upper bound on minimizing the total flow time. The lower bound and upper bound are much stronger compared to the results in Buckhin 2002, where they tried to provide a lower bound by solving the continuous version.

Lot splitting is a relatively simple and easy to implement technique to reduce manufacturing lead times. The principle is to split up a large lot of n identical items into sublots, and then release a sublot for the next manufacturing stage once it has finished on the current stage. This thus enables the items to flow faster through the work shop than when keeping the lot together. It also enables a faster delivery to the customer. In many manufacturing environments, however, including the semi-conductor industry and discrete parts manufacturing, an attached machine setup is required before the beginning each sublot.

We can then formulate it into a two-machine flow shop scheduling problem with attached setup times. For the continuous version of the problem, Buckhin (2002) presents an efficient heuristic.

They also provide a lower bound and upper bound for the general problem. Even they have listed some cases which can be solved to optimality, their gaps between lower bound and upper bound are still large for other cases.

We deal with the discrete version of the lot splitting problem on a two-machine flow shop with attached setup time. For the objective of minimizing the total completion time, we need to determine the number of sublots that we will use and the number of items in each sublot. We derive a strong lower bound and upper bound through a procedure based on Lagrangian relaxation and dynamic programming. We gave two lower bounds for the problem, one of them relaxed the constraints that the sublots on Machine 2 cannot be started before it is finished on Machine 1. Then we know that there exists an optimal Lagrangian solution in which the sublots on machine 2 are processed contiguously as well, without any idle time in between. For another lower bound, we relaxed the constraints for the capacity conditions of Machine 2. Once these constraints have been relaxed, all sublots on Machine 2 will be processed right after their finishing on Machine 1. We design two dynamic programming algorithms to solve these two Lagrangian problems, and select the better one as our lower bound.

In the Lagrangian relaxation, since we relaxed some constraints, the solution we have may not be a feasible solution. But we can always construct a feasible solution by adding the removed constraints. So, each solution returned by these two Lagrangian problems is a candidate upper bound for our problem. We also design a dynasearch algorithm to search its swap neighbourhood for a better upper bound. We use a best-improve strategy: a dynasearch swap move is equivalent to a best series of independent swaps. To find a best set of independent swaps that can be obtained from a solution, we also employ a dynamic programming algorithm to solve it.

To save the computation time, we give an upper bound for the number of items that can be put into each sublot. So we can know that at least how many sublots that we should use. In the experiment, we tested the total 40 instances which have also been tested for the continuous version in Buckhin's paper. Our procedure is programmed by C++ and can be finished in 5 minutes. The lower bounds are much stronger compared with their results for the continuous case and the gaps are much tighter which is 2.1% in average.