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IMPROVING THE POTENTIALS OF LOGISTICS PROCESSES: IDENTIFICATION AND SOLUTIONS

Tieteellisiä julkaisuja
Research papers 69

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ABSTRACT

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The importance of logistics for companies is a well known and justified issue. Today, enterprises are developing their logistics processes in order to match their products and services to the requirements of the most important customers. Therefore there is a need for developing analysing tools for logistics and especially for analysing the significance of various customer service elements.

The aim of this paper is to propose analytic tools for supporting strategic level logistics decision making by emphasizing service level elements on two levels: (1) to introduce and propose approaches to categorize the developing efforts of logistics and (2) to introduce and/or propose approaches for solving some customer service related strategic level logistics problems.

This study consists of two parts. In the first part an overview of the work is presented, and the second part comprises eight research papers on the topic of the study. The overview includes an introduction, where strategic and tactical level logistics problems are discussed and the relation of logistics to marketing and customer service issues is presented. In the first part of the study the objectives, the structure, the research strategy and the contribution of the research are described, and the challenges for future research are discussed. In the second part the three first papers deal with the identification of developing objectives for logistics while the remaining five papers concentrate on solving customer service related strategic level logistics problems.

ACKNOWLEDGEMENTS

The main part of this thesis for the degree of Doctor of Technology has been carried out during the years 1995 and 1998 at Lappeenranta University of Technology, where the writer has worked as a senior researcher and a graduate school student.

It is not possible to thank here all of the people who have contributed to this work and helped me to complete it. My supervisor professor Anita Lukka has patiently read my manuscripts and papers and she has given many valuable comments and ideas for improving them, therefore I am deeply grateful for her. The co-authors of my papers Dr. Tech. Jukka Korpela, professor Markku Tuominen, professor Kalevi Kyläheiko and Mr. Janne Huiskonen have all contributed not only to the work itself, but in addition, also to my way of thinking and doing scientific work. I appreciate this very much. There are several colleagues at LUT who have encouraged, supported and contributed to my work during the research, whom I like to thank collectively. It was also a pleasure in the early stages of my career to get a lot of valuable ideas from Mr. Jorma Lehtonen and Dr.Tech. Antero Janhunen, who also encouraged me to prepare a doctoral thesis in the field of logistics. Last but not least, best thanks also to my wife Pirjo who has heroically taken care of our home and our children Eero, Riikka and Martti during many evenings, weekends and holidays when I was preparing this work. I hope that I will have more time for you in the near future.

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Lappeenranta, September 1998

CONTENTS

Improving the Potentials of Logistics Processes: Identification and Solutions Part 1

1. INTRODUCTION

1.1 Defining logistics as a strategic function

Logistics has gained respectability and importance for companies in almost all industries and markets. The growing awareness of the critical impact of supply chain management on a company's competitiveness, profitability and strategic advantage has made logistics a truly strategic issue with increased emphasis [1][2]. The focus of logistics organizations has expanded from improving the details of operative issues towards the implementation of strategic and tactical level means of logistics into practice. In fact the strategic scope of one company is not enough, because it is not just companies that compete with each other. More and more often it is value chains formed by different companies that are in competition [3].

Historically, the three fundamental stages of the supply chain, procurement, production and distribution, have been managed independently and buffered by large inventories [4]. This policy has changed, especially manufacturers have increasingly given their attention to the management of logistics issues, in the pursuit of strategies that will give them competitive advantage [5]. It is a well known fact that it is possible to gain even more advantage by improving the logistics chain instead of improving the performance of one player in the chain. Therefore, the

area of logistics research is nowadays not solely restricted to the production process itself but has spread into a wide range of subjects relating to the entire material flow into, within, and out of the organization [6].

Correspondingly, the focus of logistics is increasingly turning towards providing better services for customers instead of minimizing the total logistics costs or the costs of one logistics sector or maximizing company's profits. Furthermore, logistics managers put more emphasis on controlling the whole logistics chain than concentrating on the problems of one echelon in the logistics process. One result of this is that there has been a growing interest on partnership and customer satisfaction issues. Firms are moving from a decoupled decision making process towards a more coordinated and integrated design and control of their supply chain to provide goods and services to the customer at low cost and high service levels [4]. Companies must also be able to efficiently respond to changes and reconfigure their resources to be able to compete and create profit by taking advantage of the opportunities occurring in the market place [7]. Nowadays logistics can be seen as a value-adding process that directly supports the primary goal of the enterprise which is to be competitive in terms of high level customer service, competitive price and quality, and flexibility in responding to market demands [8]. Furthermore, according to Ross [9], forward looking companies perceive logistics as a strategic, cross-functional management activity whose mission is to plan and coordinate all activities necessary, not only to achieve delivered service and quality at the lowest cost but also to enable today's enterprise to realize new opportunities for competitive advantage.

An example on one logistics chain from vendors to customers is presented in figure 1 [10]. By attaching suppliers and customers to a company's logistics chain we end up with the integrated logistics concept which Bowersow has defined as the process of managing all activities required to strategically move and store materials, parts,

and finished inventory from suppliers, between enterprise facilities, and to customers [11]. According to Copazino [12] many companies have ignored or only partially adopted the integrated logistics concept through ignorance, tradition, or marketing-dominated decision making. Furthermore, Copazino assumes that in today's service-sensitive environment, these companies will not be able to defer opportunities to both reduce costs and improve customer service performance for long.

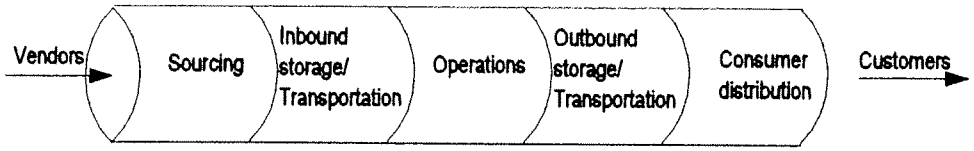

Figure 1.Logistics chain from vendors to customers

The earlier definitions of supply chain management (SCM) and logistics operations management were nearly equal, since their focus was on the effective performance of the day-to-day activities associated with the optimization of distribution and manufacturing and accelerating the flow of inventory and information through the channel system [9]. Therefore, many writers have used the words logistics and supply chain management (SCM) as synonyms. For example, Thomas and Griffin have defined SCM as the management of material and information flows both in and between facilities, such as vendors, manufacturing and assembly plants and distribution centers [4]. This definition is also appropriate for logistics, but according to Cooper et al. [13], however, SCM goes beyond logistics in some given definitions. They have found from the literature that some writers have included in SCM issues like new product development, finance for funding, and marketing concepts. These are the clearest examples of the differences between SCM and logistics which Cooper et al. have found in the literature. Despite of this, they have

proposed that the word logistics should not be replaced by SCM, because it would create more confusion in a still emerging field and detract from the need to achieve a much broader level of integration of firms.

Because rapid changes are occurring in nearly all markets, deliverers must be flexible enough to restructure their logistics network within short time. Therefore, Business Process Reengineering (BPR) has gained a position among important approaches when restructuring or improving such processes as logistics and its sub processes (see figure 1). According to a survey of European Logistics Association the necessity for permanent re-engineering of logistics processes has been accepted by Europe's logistics leaders and also other manufacturers will follow the trend in the future [14]. Indeed, the main driver behind the BPR philosophy has been the search for more time-effective ways of managing the supply chain [15]. Principally, in BPR dramatic improvements are achieved by fundamental rethinking or radical redesign of the business process. The universal purposes of BPR are to cut costs as quickly as possible and to develop innovative ways of doing things that result in higher customer satisfaction [16]. Because of these objects BPR has been a popular topic with many researchers [17][18], Ph.D. students [19], as well as a topic in several text books [20][21]. For example, the main objective in the Ph.D. dissertation of Tinnilä [19] was to develop frameworks and concepts for analyzing service and business processes within BPR framework.

The time and place utilities accomplished by the logistics process also add value by improving customer satisfaction. (cf. Gattorna and Walters [22] or Emerson and Grimm [23]). Figure 2 presents the process by which time and place, possession and form values are added to a product [22].

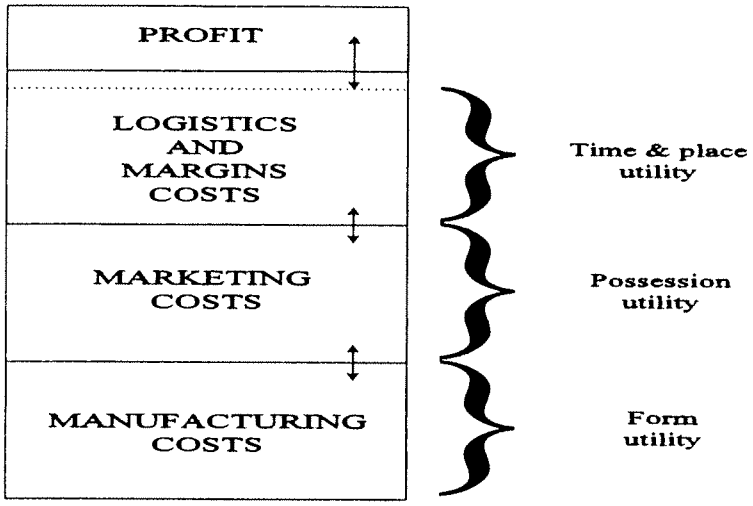

Figure 2. Adding value to improve customer satisfaction.

According to Gattorna and Walters *form utility* originates when manufacturing combines labor and raw material to create the product. Marketing activities add *possession utility*, e.g. by creating awareness of the product and of its characteristics. Finally, *time and place utility* are added by the logistics operations if a product is available at the right place, at the time the customer wants it, and in undamaged condition.

According to Schary, logistics is one of the six major planning processes that determine the direction of the organization [24]: the strategic plan, the production plan, the marketing plan, the financial plan, the manpower plan and the logistics plan. Together these six plans define the need for logistics support and the requirements of the logistics system and, on the other hand, are influenced by the constraints of logistics system capacity [24]:

1. The corporate plan establishes general strategic direction including the choice of markets and major sources of supply. The choice of markets influences the distribution, product and material requirements. The corporate plan lays down the course for the logistics plan.

2. The marketing plan supplements information on the requirements of the product life cycle, customer locations and requirements, and the timing of actions, all of which also influence logistics requirements. On the other hand, logistics serves the marketing plan through the cost and capacity of service, e.g. transit time and availability of products.

3. The production plan determines what facilities will be used to produce the products for each market area. The production plan determines capacity utilization, scheduling practices, and product movement requirements.

4. The financial plan establishes requirements and sources for capital. Well-managed logistics serves a potential to release capital from raw materials, intermediates, and products.

5. Manpower planning for logistics emphasizes technical and economical analyzing and planning skills. Managers should have a breadth of understanding of both the internal and external operations in their organizations.

6. The logistics plan determines the physical connection of material and product flow for the organization. Logistics limits other activities by deciding on the resources available for other plans.

1.2 Strategic and tactical level logistics problems

We need strategies to crystallize the ideas of where we want to go and how we want to get there. However, using logistics as a strategic tool is not a typical starting point for an organization. Firms that use logistics strategically seek to exploit their unique competencies to gain and maintain competitive advantage. Strategic logistics management focuses corporate resources in a manner that achieves maximum value-added customer benefits [25]. The potential for exploiting strategic logistics depends on a firm's ability to successfully integrate basic operational processes and generate a differentiated product or service [25]. Logistics strategy is directly linked to the company's strategy and therefore, the task of logistics

strategy is to support a company's strategy for achieving competitive advantage through cost leadership, service differentiation or both, and to perform value-added activity [26].

By strategic problems we understand problems where the influence of the decision carries over years and is remarkable. On tactical level the scope of the problems is about a year. On the strategic level of the logistics decision making process we establish a logistics structure including the location of facilities, e.g., the location of production capacity, warehouses and harbours, and, on the other hand, we determine the customer service level decisions from logistics point of view. It is important to understand that facility decisions have influence on service level and vice versa. Therefore, these two decisions have to be made simultaneously and on the strategic level.

The establishment of logistics network structure is an essential part of the location problem, which also is a well known mathematical problem. One of the first theoretically oriented and widely quoted location problem papers was written by Hakimi in 1964 [27]. After him, according to Hakimi and Kuo [28] it was Geoffrion and Grawes, who first included production in the facility location models. These models are called capacited production location problems. The first location-production-allocation problem with price-sensitive demands was given by Wagner and Falkson [29] [30]. Since then several topics have been added to this base locating theory. The basic case is that facilities are to be established to meet fixed market demand by minimising the total cost of location, operation and transportation. [28][30]

There are also many papers that deal with the plant location theory, see e.g. [31]. This paper presents the standard division of the plant location models:

- simple plant location problem (SPLP)
- plant location under uncertainty (SPLPU)
- international plant location problem (IPLP)

SPLP provides two types of decisions simultaneously [31]: locational and allocations decisions. The SPLP model simply satisfies the market demands with minimal costs. According to Sridharan [32] the SPLP problem can also be called uncapacited plant location problem when each potential plant does not have an upper bound capacity on the amount of demand that it can serve. The SPLPU problem has a profit maximization objective, and the IPLP problem is stochastic in nature due to randomness in price and exchange range movements.

Using optimization to design distribution systems became technically feasible a little more than two decades ago, and development has occurred at a rapid rate ever since [33], making modelling approaches and techniques for analyzing logistics structure popular subjects for researchers. Also academic dissertations and publications related to the modelling issue have been published (cf. [34][35]). The development of optimizing systems for complicated logistics systems has continued, because companies' capabilities and resources to utilize mathematical models have increased, as well as their desires and needs. On the other hand, the development of information and hardware systems has enhanced fast development in optimizing techniques and approaches.

The traditional quantitative framework for the optimization of logistics network is the cost minimization approach, see for example Lee [36], Hansen et al. [37] or Tyagi and Das [38]. According to Lee [36] these models simultaneously locate a set of facilities and satisfy the demands of a given set of customers to minimize the total cost of location, operation and transportation. However, the problem of the cost

minimization framework is that it focuses the problem on the deliverer's point of view, and excludes the profitability to the customers. The focus of a more advanced distribution network design framework is on profit maximization, see for example Hakimi and Kuo [28]. In the profit maximization framework the costs of the distribution network are deducted from the customer's profits. No attention is paid to the customer's wishes, however, and therefore they are not satisfied. In several papers, for example Meshkat and Ballou [39] and Canel and Khumawala [40], customer service elements have been included in the distribution design problem, in addition to cost and profit information. Typically this, the so-called service sensitive framework, includes elements like product availability, delivery time requirements and delivery frequencies.

One possibility to use qualitative elements among quantitative in distribution network design is to utilize the Analytic Hierarchy Process. This approach has been used e.g. by Korpela [41] in his Ph. D. dissertation. The AHP approach can be expanded as a tool for analysing logistics networks by using it together with linear programming. This enables taking physical and political restrictions related to the supply chain, deliverer, and service providers into account when designing the distribution network. The AHP and linear programming have previously been used together for logistics network design by e.g. Korpela and Tuominen [42], Lehmusvaara and Korpela (paper 6), Korpela et al. [43] and Korpela et al. (paper 7). However, the logistics network design problem is approached in the publications mentioned above either by analysing the overall logistics chain as a whole or by concentrating on just one node or link of the overall logistics network. Furthermore, according to Korpela et al. (paper 8) the focus of the problem firstly enables a customer-oriented evaluation of each alternative link and node in the logistics network and, secondly, optimises the overall customer service capability of the network.

According to Gopal and Cypress [44] the primary components of logistics strategy are: configuration/network, coordination/organization, customer service, integrated inventory, information technology and transportation. The components of logistics strategy are divided further by Gopal and Cypress as follows. The elements of configuration/network are process staging, time/proximity, market/preferences, and total network cost. Coordination is defined by them as "the linking of like activities along the value chain," while the organization structure defines the roles, responsibilities, and culture necessary to manage the supply chain effectively. Customer service includes measures for distribution like order fill rate, order accuracy, on-time delivery performance, response to emergency customer requirements and response to customer complaints. Gopal and Cypress emphasize that customer service elements are measurable and product superiority is no longer enough for any company. Furthermore, inventory deployment and safety stock management are necessary and viable strategies for maintaining high levels of customer satisfaction, because the stockouts can be high in terms of lost sales and goodwill. According to Gopal and Cypress the role of information technology is to link supply chain together, and it can even differentiate successful companies from less successful ones.

Bowersox et al. [45] have given a formal definition of logistics strategy classification, using a qualitative research design. They define process, market and channel as follows [45]:

Process: A process-based strategy is concerned with managing a broad group of logistics activities as a value added chain. The emphasis is on achieving efficiency from managing purchasing, manufacturing, scheduling, and physical distribution as an integrated system.

Market: A market-based strategy is concerned with managing a limited group of logistics activities for a multidivision single business unit or across multiple business units. The logistics organization seeks to make joint product shipments to common customers for different product groups and to facilitate sales and logistical

coordination by a single order-invoice.

Channel: A channel-based strategy is concemed with managing logistics activities performed jointly with dealers and distributors. The strategic orientation places a great deal of attention on external control. Significant amounts of finished inventories are typically maintained forward or downstream in the distribution channel.

Bowersox et al. emphasized that the process/market/channel classification is not absolute, but they noted that advanced logistics organizations shared certain characteristics [44][46]. Later, Clinton and Calantone found out in their own study that the use of the process/market/channel typology may not be appropriate outside the North American sector [2]. The survey they made covered Australia, Japan, Korea and some European Union countries.

McGinnis and Kohn [47] have performed several inquires to logistics managers in the United States in order to develop better understanding of logistics strategy as a contributor to time competitiveness, and they have examined the relationship of logistics strategy to the firm's extemal environment. According to these surveys three basic clusters for logistics strategies can be identified [47]:

1. Intense logistics strategy: This cluster emphasizes both process and market strategy to optimize simultaneously two or more business units and coordinate these units to serve common customers. 25 per cent of the studied companies pertained to this group.

2. Balanced logistics strategy: This cluster emphasizes both process strategy and market strategy, but not as deep as strategy 1. This was the biggest cluster representing 61 per cent of the companies.

3. Unfocused strategy: This cluster places the lowest emphasis on process and market strategies and logistics is not considered a source of competitive advantage. It represented 14 per cent of the companies.

The clusters of logistics strategy determined by McKinnis and Kohn are given in figure 3. In this empirical study, 86 per cent of the companies belonged to the first or the second cluster (intense or balanced logistics strategy), where customer service and logistics coordination were high or at least moderate priorities. In these companies the components of customer service, e.g. transport time policy and service level, had a significant role both in operational and strategic level decision-making processes. On the other hand, for the rest of the companies, representing only 14 per cent of the companies, customer service and logistics coordination were low priorities.

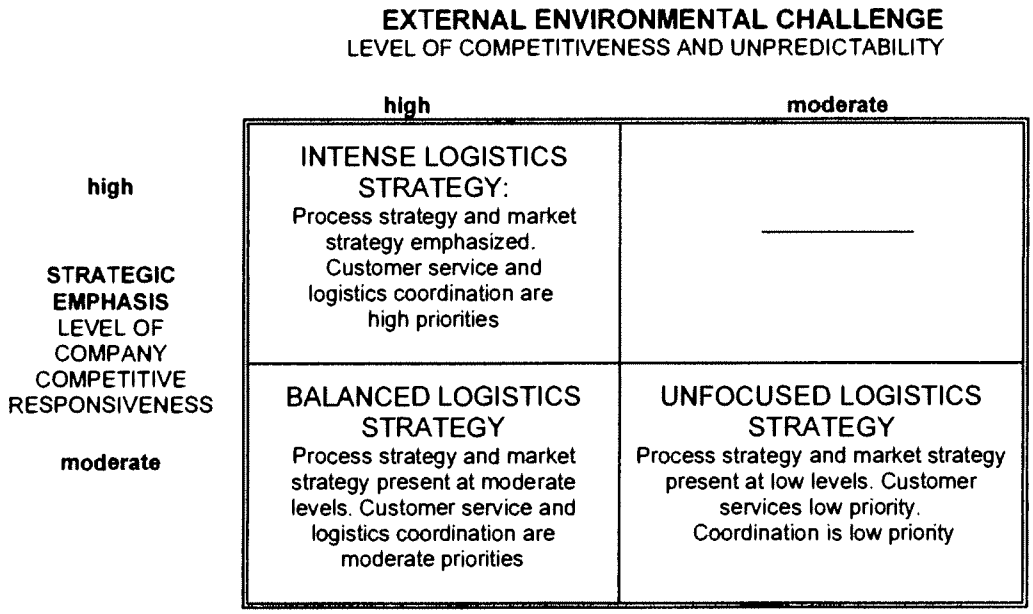

Figure 3. Impacts of external environment and company competitive responsiveness on logistics strategy

In order to manage and monitor logistics strategies efficiently the role of logistics organizations is gaining more emphasis. In many companies the position and power of the logistics organization has improved, because the importance of logistics has been noticed. Therefore, logistics organizations have more possibilities

and power to influence the most important logistics decisions. These are factors which have made logistics organizations and their decision making an important and challenging research area. For example the subject of the Ph.D. work of Juga [48] was to describe and analyze the changing logistics organization within its external and internal contexts.

1.3 The relation of logistics to marketing and customer service

The need for better products and services is emphasized by experts everywhere [49], and the role of logistics in customer service evaluation has been well documented. The connection between logistics and marketing functions is given in figure 4, which depicts the situation where the total objective is to allocate resources to the product, promotion, and place components of the marketing mix in a manner that will lead to the greatest long-run profits [50]. Especially the role of time compression as a performance driver for improving various logistics elements has been emphasized in various articles. Time reduction does not only lead to faster response to customer needs but, just as importantly, can lead to cost reduction and greater flexibility [15]. Towill has made a literature review on the influences of time compression [51]. According to his article, by time compression it is possible to influence also the bottom line performance by reducing the value of work in progress needed to meet customer service levels, by reducing safety stocks, by reaching lower scrap rates, or by reducing obsolescence risk. The focus on speed is beginning to impact directly on three areas of logistical operation, which are, according to Bowersox et al. [52] process, information, and decision making. Time compression influences in most cases the process speed, while the speed of information and decision making depend on the development phase of information systems and the organization's capabilities and resources to make decisions.

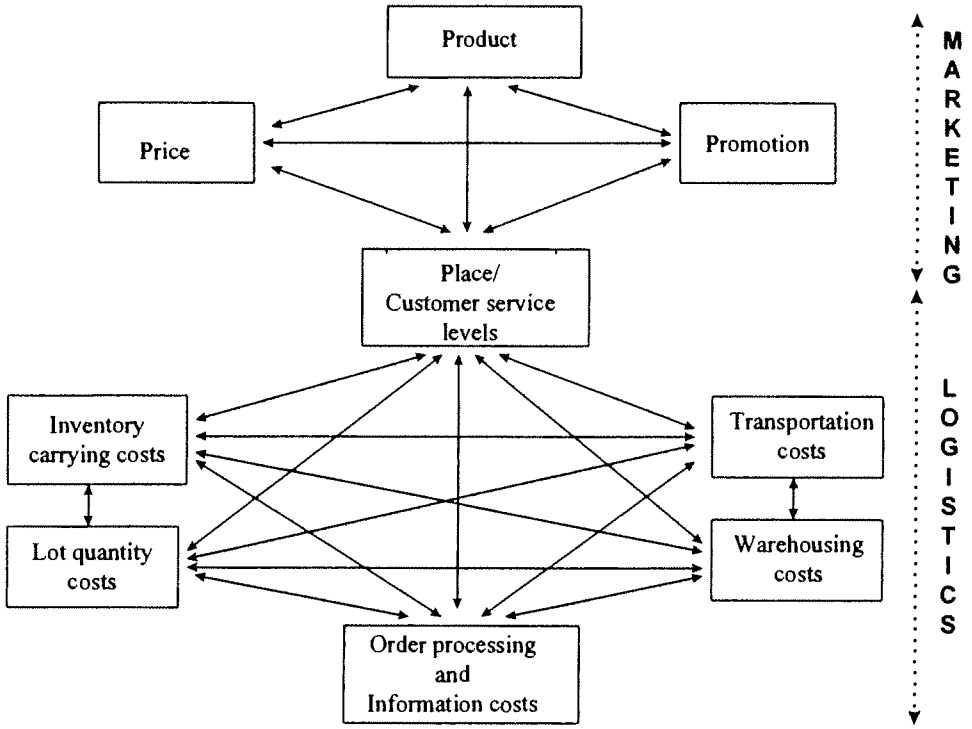

Figure 4.Cost trade-offs required in a logistics system

As logistics customer service elements and their sub elements Emerson and Grimm [23] have presented *availability* (fill rate, minimal backorders and accuracy of orders shipped), *timeliness* (order cycle time consistency, average order cycle time and products always arrive when promised), *delivery quality* (physical condition of goods received, correct product received, dependability of freight carriers and driver co-operation at delivery), and *communication* (projected delivery date information given at order placement, inventory availability given at order placement and provided advance information on cancellations/delays). On the tactical level the intention is to guarantee that the utilization of the given logistics structure is as profitable as possible within the given physical and service restrictions.

One difference between marketing and logistics research according to Mentzer [53]

is that marketing literature has concentrated on measuring the service quality that a distribution channel delivers to the customer, where as logistics research has emphasized more the cost of delivered logistics service and its sales/profit implications.

According to a survey made by the European Logistics Association [14] the ability to meet customers' demands is a crucial and the most important factor in achieving customer satisfaction in Europe. Furthermore, also other factors, such as reliability, delivery time and delivery flexibility are important for European companies today and they are estimated to stay important in the future. In addition, the readiness to give information to the customer will be more important in the future than today. The significance of some customer service components reported by the European Logistics Association is given in figure 5.

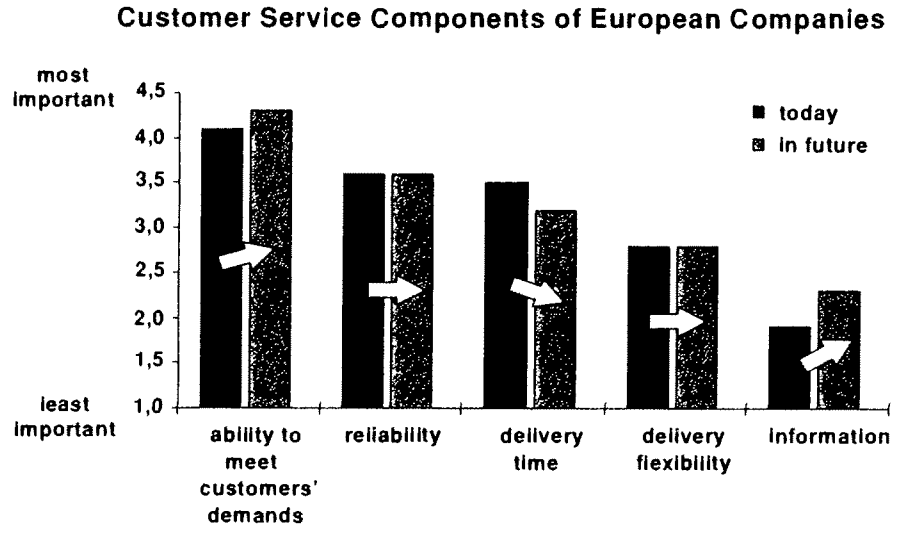

Figure 5.The significance of customer service components of European companies.

2. OBJECTIVES OF THE STUDY

The lack of analytic tools for prioritizing developing efforts of logistics operations of a company or a delivery process is clear to researchers and especially to practitioners. Correspondingly, the lack of analytic tools is obvious if different customer service levels are evaluated when solving strategic level logistics problems. In addition, continuous development of logistics processes and the determination of the right customer service levels belong to the key elements for a successful enterprise. Therefore, it is important for logistics research to support these subjects, and therefore the objectives of this dissertation are to speed up this fast proceeding development, and on the other hand, to propose analytic tools for supporting strategic level logistics decision making by emphasizing service level elements on two levels:

- First, to introduce and propose approaches to categorize the developing efforts of logistics

- Second, to introduce and/or propose approaches for solving some customer service related strategic level logistics problems.

The results of both levels can be utilized either by logistics or marketing management, and especially by the development function of logistics operations. Utilization of the results requires co-operation between customer and deliverer, and in many cases also confidential relations between the parties of the same supply chain in order to determine the appropriate customer service levels, and furthermore, to guarantee the best possible performance of the logistics system. In the past, many researchers have concentrated on quantitative elements when solving strategic level logistic problems, although also qualitative elements have an

important role in problem solving. Hence, one major objective of this study is to take qualitative aspects into consideration when making decisions on strategic level logistics problems.

The problem area covers a wide range of individual strategic level logistics problems to be analyzed within a continuous development framework. Principally, customer service has influence on nearly all strategic level logistics problems, and also therefore customer service elements are emphasized in this study.

3. STRUCTURE OF THE STUDY

This dissertation consists of two parts. In the first part an overview of the work is given, and in the second part eight research papers on logistics are presented. The papers have been or will be published in conference proceedings, international journals or in the Research Report Series of the Department of Industrial Engineering and Management at Lappeenranta University of Technology. The overview in part one consists of four sections. Section one is an introduction to the research area, where the strategic nature of logistics operations, logistics strategic and tactical level problems and the relation of logistics to marketing and customer service are discussed. In section two the objectives of the study are given. In section three the structure of the study and the papers included in the dissertation are presented. In the fourth section the selected research strategy is described and the research papers are arranged according to the type of data and the types of analysis used. Finally, in the last section of part one, challenges for future research are suggested and discussed.

In part two of this dissertation, eight independent research papers are presented. In the first three of these (see the list below) the problem scope is to identify and

categorize development possibilities of logistics processes, and in the following five papers the approach aims at solving some strategic and tactical level logistics problems. The papers included in part two and this dissertation are:

1. Antti Lehmusvaara, Janne Huiskonen: What Prevents Companies from Improving Logistics Operations: Some Empirical Findings
   Paper published in the pre-prints of the Ninth International Seminar on Production Research, Igls, Austria, February 1996, Vol.3, pp. 319-332. Revised paper accepted for publication in the International Journal of Production Economics

2. Antti Lehmusvaara, Benchmarking the Logistics Performance of Municipalities in Finland,
   The paper has been accepted for presentation and has been published in the proceedings of the Third International Symposium on Logistics, Padua, Italy, July 1997, pp. 633-638. Submitted for publication in the Post Conference Journals.

3. Antti Lehmusvaara, Current Performance and Future Trends in the Transportation Operations of Municipalities in Finland
   Paper accepted for presentation in the 8th World Conference on Transport Research, Antwerp, Belgium, July 1998.Submitted for publication in the Post Conference Journals.

4. Antti Lehmusvaara: Transport Time Policy and Service Level as Components in Logistics Strategy: A Case Study
   The abstract has been published in the pre-prints of the Ninth International Seminar on Production Research, Igls, Austria, February 1996, Vol.3, pp.459. The full paper has been accepted for publication in the International Journal of Production Economics.

5. Kalevi Kyläheiko and Antti Lehmusvaara, The influence of Sales Elasticity in Determining Delivery Time Policy
   Paper selected for publication in the proceedings of the Production and Operations Management Society - Cape Town Meeting, South-Africa, June/July 1998.

6. Antti Lehmusvaara, Jukka Korpela: A Customer Oriented Approach to Warehouse Network Evaluation and Design
   The paper has been accepted for publication in the Proceedings of the Ninth International Symposium on Inventories (held in Budapest 1996), which appears as a special issue of the International Journal of Production Economics.

7. Jukka Korpela, Antti Lehmusvaara, Markku Tuominen: Connecting Customers' Preferences and Importance and Logistics Capabilities in Distribution Network Design
   The abbreviation of the paper has been published in the proceedings of the IV International Conference of the European Operations Management Association, Barcelona, June, 1997, pp. 3-8. The full paper is published in the Research Report Series of Department of Industrial Engineering and Management of Lappeenranta University of Technology, Report 101,1998.

8. Jukka Korpela, Antti Lehmusvaara, Markku Tuominen, Customer Service Based Design of the Supply Chain
   The paper has been published in the pre-prints of the Tenth International Seminar on Production Research, Igls, Austria, February 1998, Vol.2, pp. 161-174. Submitted for publication in the International Journal of Production Economics.

In figure 6 the papers are categorized into two sets according to the problem scope. In the first set the approach is to determine developing efforts in logistics operations by a qualitative approach and by quantitative surveys. In the second set qualitative customer service elements are emphasized when strategic level logistics problems are solved. The first ones are approaches and surveys which can be applied in various organizations alone or simultaneously with other quantitative or qualitative approaches. Furthermore, the benefits of these approaches are related to the evaluation and categorization of logistics problems or in finding developing efforts in the implernenting organizations. Determining developing efforts is an important phase in developing any logistics process of any organization or supply chain, because it helps to concentrate on the most important problems. After selecting developing efforts the next phase is to find solutions to the rnost important problems.

The approaches for solving some strategic level logistics problems (see figure 6) include both quantitative and qualitative elements. One common feature for these approaches is that the distribution structure of the case companies has been illustrated by a mathematical model, excluding paper 5, where the sales elasticity

is emphasized. In addition, one target of this dissertation is to introduce more knowledge to the decision making on the possible arrangements in the distribution structure. Furthermore, these five problems can be categorized into strategic level logistics problems.

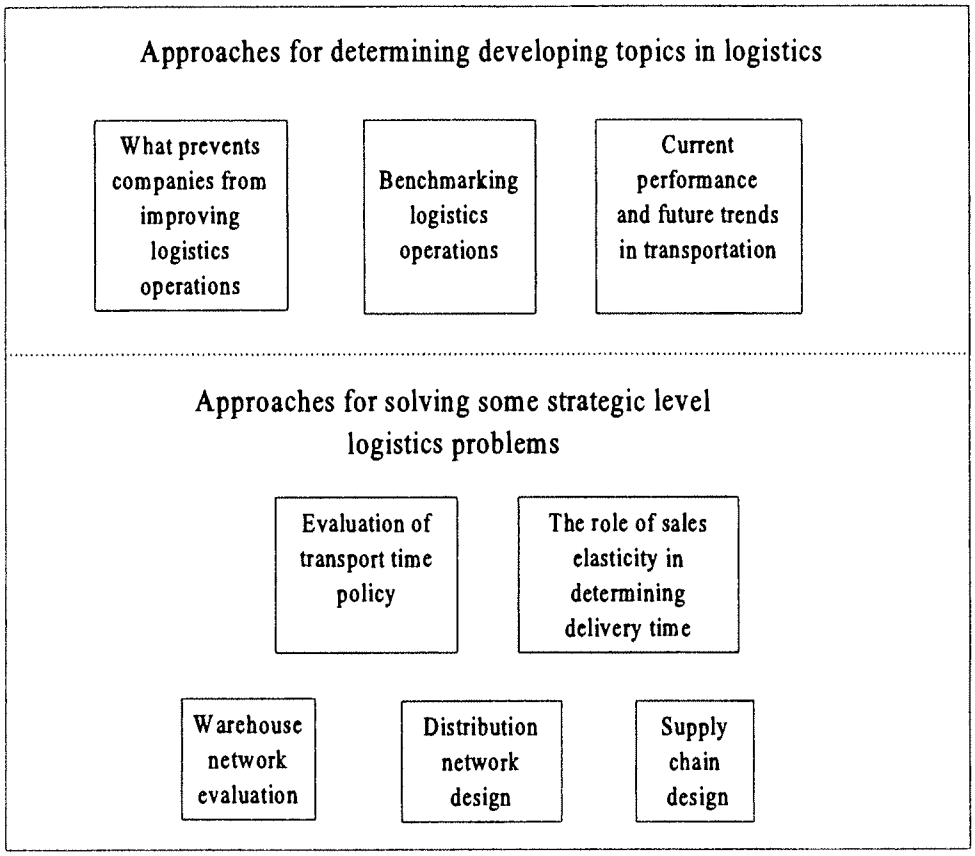

Figure 6.The scope and structure of the problem

The first paper (*What Prevents Companies from Improving Logistics Operations*) of set one, which introduces a qualitative approach for finding and for the categorization of developing efforts for the logistics operations, belongs to the first level of the objectives of this dissertation. In the first phase of the paper the aim

was to find practical and operational examples from the logistics operations of the case company, which have or presumably have increased costs or decreased revenues. Plenty of examples were found. Secondly, these cases were classified into logical groups, which were found to be: missing or negligently followed operational rules, lack of control or physical systems, and organizational conflicts. Sub categories to these groups were also found. Thirdly, developing efforts were suggested based on the classification. The aim of the presented approach is to focus directly on the most essential problems, which helps in forgetting the minor problems and therefore saves time in developing logistics operations in the companies using the approach, compared e.g. to the logistic stage analysis presented by A.T. Kearney [54][55][56]. The idea for preparing paper one came from the authors, who also was responsible for carrying out the case studies and writing the paper regarding to the cases.

The second paper (*Benchmarking the Logistics Performance of Municipalities in Finland*) presents a starting point of a continuous benchmarking project on the logistics operations of the Finnish municipalities, and therefore can be classified to the first level of the objectives of this dissertation. In the paper the annual logistics costs of the municipalities per inhabitant are reported as well as the current and future developing efforts of their logistics operations. The cost elements concerned were purchasing and warehousing of goods, costs of purchasing personnel, transportation of goods, personnel and customers, as well as the costs of personnel managing transportations. Furthermore, the municipalities were divided into groups according to their current performance stage in logistics operations. The stages were established on the basis of the extent of managing operations in different logistics sectors. The results reported in the paper were obtained through an inquiry mailed to the Finnish municipalities and municipal organizations. The results of the inquiry are reported (in Finnish) in detail in the final report of the benchmarking study [57] and also in paper 3 below.

The logistics costs per inhabitant in the municipalities are only reported in paper 2. The final report was published later than paper 2, and therefore the final report is not in the reference list of paper 2. The author of this dissertation was nominated as logistics expert in the project and is responsible e.g. for such issues like the content of the questionnaire and writing the final report.

The third paper (*Current Performance and Future Trends in the Transportation Operations of Municipalities in Finland*) gives results from the same study as paper two, but from the transportations point of view. The total transportation costs and the share of transportation costs inside municipalities are reported. The centralization degree and the location of centralized organizations inside municipalities are given. Furthermore, aspects of planning and organizing transport routes, as well as the utilization of IT systems in transport routing are reported. In addition, current and planned developing activities of municipalities and companies owned by municipalities in regard to transportation operations are given. Finally, the development and the further projects which were established for performing logistics and transportation operations in the municipalities are discussed.

In the fourth paper (*Transport Time Policy and Service Level as Components in Logistics Strategy: A Case Study*) the focus is on evaluating different transport time and service level policies. The target of the paper is to solve one strategic level logistics problem and is therefore related to the second level of the objectives of this dissertation. The aim of the paper is to calculate how much more sales volume or how much higher sales price we would have to have, if we wished to operate with shorter transport time or service level. In the first part of the paper the distribution structure of the case company is modelled, and the cost differences between different transport time and service level policies are evaluated. In the second phase the functions between the costs of different transport time policies

and required additional sales volumes and sales prices to achieve new policies are derived.

In the fifth paper (*The influence of Sales Elasticity in Determining Delivery Time Policy)* the idea is to study cost and demand related factors which affect the choice of an optimum delivery time policy. In this study an important role is given to sales elasticity and demand-related uncertainty when determining delivery time policy or service level for a company. A basic formulation of the optimum service level policy of a firm is introduced and the role played by the point elasticity of demand is emphasized in this formulation. Based on the formulation some basic lessons for a monopoly firm profiting from increasing its service level are given.

The aim of the sixth paper (*A Customer Oriented Approach to Warehouse Network Evaluation and Design*) was to present a customer oriented approach to the evaluation and selection of alternative warehouse operators, which can be categorized to be a strategic level problem. The Analytic Hierarchy Process (AHP) is used for analyzing the customer-specific requirements for logistics services and for evaluating the alternative warehouse operators. The AHP-based analysis results in a customer-specific priority for each alternative warehouse operator. This priority describes how well a certain warehouse operator is expected to satisfy a certain customer´s performance requirements. The priorities are then entered to a Mixed Integer Linear Programming (MILP) -model which is used for maximizing the overall service performance of the warehouse network under relevant restrictions, such as required minimum throughput volume to open a warehouse and maximum allowed number of warehouses in the solution. Thus, the warehouse network can be designed based on multiple quantitative and qualitative criteria instead of only costs or profits alone. An illustrative example to demonstrate the proposed approach is offered. The contribution of the author in papers 6-8 deals with selecting research problems, structuring the problems and in solving the Mixed

Integer Programming phases of the problems. Therefore, the author has an independent role in preparing papers 6-8.

In the seventh paper (*Connecting Customers' Preferences and Importance and Logistics Capabilities in Distribution Network Design*) the distribution network design is determined by an approach which aims to guarantee the best possible service to the most important customers. Distribution network design is a strategic level logistics problem, and therefore can be classified to the second level of the objectives of this dissertation. In the approach the customers' preferences on the different distribution structure and the deliverers' strategic views are analyzed by the AHP procedure. Finally, after the AHP -analysis both preferences are maximized by a MIP model. Some illustrative examples are given to demonstrate the progress of the approach and to give an idea of the proposed use of the framework.

In the eighth paper (*Customer Service Based Design of the Supply Chain*) different frameworks for distribution network design are discussed and an approach to customer service -based design of the supply chain is proposed. In addition to the traditional cost based optimization, customer service elements and the company's own strategies are included in the decision making process of this strategic level logistics problem. The approach is based on the integrated use of the Analytic Hierarchy Process and Mixed Integer Programming. In this paper a strategic level problem is solved, firstly by carrying out a customer-oriented evaluation of each alternative link and node in the logistics network and, secondly, by maximizing the overall customer service capacity of the network. Restrictions are given in the maximization phase to the number of allowed sea transport providers and truck companies, and also to the required transportation volume of truck carriers. The utilization of the proposed approach is demonstrated with a numerical, illustrative example.

4. RESEARCH STRATEGY

Since this dissertation consists of eight papers, there was a possibility to select and use several methodologies. The research methodologies and approaches used in this dissertation were the case study method (paper 1), quantitative survey (papers 2 and 3) and normative approach (papers 4-8). The use of several methodologies and approaches has certainly given the author a lot of useful experience which can be utilized in further research.

Case study as a research method has received substantial interest and prevelance among researchers (see e.g. Burgelman [58], Galunic [59] and Eisenhardt [60], Pirttilä [61] or Tinnilä [19]). One reason for its popularity is that it can be used to analyse one or a few complex processes when enough cases or observations, e.g. for statistical analysis, can not be found or other similar cases do not exist at all. In addition, case studies are considered an appropriate research strategy especially for new topic areas, where qualitative data is needed and where through a profound understanding of single cases even a new generalized theory could be built. (cf. Eisenhart [60], Yin [62], Olkkonen [63] or Pirttilä [61]).

According to the definition given by Yin [62] the case study method is an empirical inquiry that:

- investigates a contemporary phenomenon within its real-life context when
- the boundaries between the phenomenon and the context are not clearly evident and in which
- multiple sources of evidence are used

According to the lecture given by Eisenhardt [64] conductive case study is an

interview study where it is important to get to know and to write down all qualitative and quantitative data, even if they do not sound interesting. Based on these characteristics, paper 1 can be classified as a conductive case study. Paper 1 is also inductive in nature, as generalizations are derived from several independent observations.

In papers 2 and 3 a survey of the municipalities was carried out by sending out a questionnaire and by analysing the returns. Therefore, these two papers can be categorized to be quantitative surveys where empirical data is used. Principally, surveys give a strong empirical evidence concerning specific variables and relations based on a large sample of companies. However, due to their narrow scope, surveys are not able to cover the whole phenomenon or reveal new variables and relations [19]. This can be problematic, if an inductive phase exists in the research, when conclusions are derived from the data of a survey. Therefore, it is extremely important to design the content of the needed questionnaire carefully and test it in practise before using it. In the testing phase it also important to make sure that questions are understood in a similar way by all interviewees in order to get as reliable answers as possible.

Papers 4,5,6,7 and 8 were based on integrating logistics, economics, operations research or decision support systems. In these papers the object was to develop and propose analytic frameworks or approaches for solving specific logistics related problems. Therefore, it can be stated that a normative approach is applied. According to Kasanen et al. [65] normative research can be divided to a decision methodological approach (translation made by Rantanen [66]) or to a constructive approach. The decision methodological approach has a theoretical nature while in constructive approach the nature is empirical. Furthermore, according to Kasanen et al. (see also Korpela [42]) the typical characteristics of constructive research are the following:

1. it produces an innovative and theoretically warranted solution for a relevant real-word problem
2. the offered solution is shown to work in practice
3. the solution is shown to be at least potentially adequate more generally as well

Based on the division of Kasanen et al. paper 5 can be classified to the decision methodological approach, because of its theoretical nature. Paper 4, on the other hand, presents a normative study including a practical case, and the developed approach can be used in other process industry companies as well. Therefore, paper 4 can be classified to the constructive approach.

In papers 6-8 the purpose is to propose an approach for solving customer service related, strategic level logistic problems by integrating the Analytic Hierarchy Process (AHP) and Mixed Integer Linear Optimization (MIP). Therefore, the first characteristic of the constructive approach is satisfied. According to Kasanen et al. the second characteristic of the constructive research can be constructed from a theoretical solution especially if time or other resources do not allow the implementation in practice. The practical applicability of papers 6-8 is based on the experience of the authors over the logistics management and management systems. The proposed approaches are potentially adaptable to other companies after revising company specific characteristics, and therefore also the third characteristic is satisfied.

Research methodologies can be classified according to the type of data used and the type of analysis performed on the data [67]. In accordance with figure 7, the type of data can be either empirical or modelled. Empirical data is gathered from real world analysis or via surveys or case studies, and modelled data is from hypothetical or real world data artificially manipulated by a model. It is also possible

for the data to have both features, and thus be both empirical and modelled.

Types of Analysis

Type of Data	Primarily Quantitative	Primarily Qualitative
Empirical	Survey data, secondary data, in conjunction with stastistical analysis such as: factor analysis cluster analysis discriminant analysis	Case studies, participant observations, ethnography. Characterized by: limited statistical analysis, often non-parametric
Modelled	- simulation - linear programming - mathematical programming - decision analysis	- simulation - role playing

Figure 7. Basic research design

When we categorize the papers of this dissertation according to the type of data and to the type of analysis, we get table 2. The type of data is empirical in papers one, two, three and four. In paper one the origin of the data is observations of the case companies' managers and therefore it is empirical in nature, furthermore the approach of the analysis in paper one is qualitative. In paper four the input data of the model is from a real case, and the analysis is based on mathematical modelling. In papers six, seven and eight there are illustrative examples to demonstrate integrated approaches. This means that the input data of the approaches is more modelled than empirical, and the type of analysis is quantitative, because decision analysis and programming are used. In papers two and three the input data is based on a survey, and therefore it is classified to

quantitative analysis with empirical data.

Table 1. Categorization of the papers

The number and name of the paper	Type of Data		Type of Analysis	
	Empirical	Modelled	Qualitative	Quantitative
Paper 1 What Prevents Companies from ...	X		X	
Paper 2 Benchmarking the Logistics ...	X			X
Paper 3 Current Performance and Future ...	X			X
Paper 4 Transport Time Policy and Service ...	X		X	
Paper 5 The Influence of Sales Elasticity ...		X	X	
Paper 6 A Customer Oriented Approach to ...		X		x
Paper 7 Connecting Customer Preferences ...		X		X
Paper 8 Customer Service Based Design of ...		X		x

5. CONTRIBUTION OF THE RESEARCH

The objective of the study is continuous development of logistics processes. The contents of the papers deal first with finding and selecting development projects and secondly with solving some strategic level logistics problems. The contribution of the papers where the objective is to find development projects is in paper one (What Prevents Companies from Improving Logistics Operations) to improve the

existing approaches by finding out more relevant and better justified developing projects, whereas in papers 2 (Benchmarking the Logistics Performance of Municipalities in Finland) and 3 (Current Performance and Future Trends in the Transportation Operations of Municipalities in Finland) the contribution is rather on the new research findings than on developing the benchmarking process itself. In the fourth (Transport Time Policy and Service Level as Components in Logistics Strategy: A Case Study) and fifth (The Influence of Sales Elasticity in Determining Delivery Time Policy) paper the contribution is on evaluating the costs of different transport time alternatives, and furthermore on supporting to find economically relevant solutions for achieving another transport time policy level. In the fifth paper also the connection between sales elasticity and delivery time policy is formulated.

The contribution of papers six (A Customer Oriented Approach for to Warehouse Network Evaluation and Design), seven (Connecting Customers' Preferences and Importance and Logistics Capabilities in Distribution Network Design) and eight (Customer Service Based Design of the Supply Chain) results from the intention of expanding the traditional cost minimization and the profit maximization approaches towards more customer driven ones in the logistics decision making process by taking more qualitative elements to the objective function. In addition, normal qualitative cost and profit items, physical restrictions of the supply chain and deliverers' strategic decisions are included directly to the objective function or as restrictions of the model. Therefore, the contribution comes from expanding the number of optimized items or items which have been taken into account in the different phases of the optimization procedure, and not from using the AHP and linear or mixed integer optimization simultaneously or from developing the AHP or optimization methodologies.

6. CHALLENGES FOR FUTURE RESEARCH

In most companies there exists software systems and applications to support operative level logistics functions. The tasks of these tools vary from taking care of one logistics sector to the support of integrated logistics. The speed of development in information technology is most probably fast in the future as well, which means better applications and systems to support logistics operations. In the future, massive parallel processors will be available to support logistics decisions [46]. On the operative level more information will be available to customers, e.g. on the current status of the delivery. On the strategic level the only excuse for not taking advantage of the modelling technology will be "I don't know how." The popular excuses "I can't afford it" and "It doesn't apply to my problem" will be eliminated [68]. In addition, according to the results of a survey of 300 multinational companies, the development of information technology is seen as a key factor enabling both the integration and rationalization of logistics operations and management [69]. Despite the declaration in many quarters of the coming of the information age and the rapid growth of technology, information systems which support logistics management are rare [70].

In most companies the focus of logistics has been changed or will be changed in the near future from suboptimization of one logistics function towards the logistics or integrated logistics concept. In fact, these are factors which will contribute to the need of more advanced analyzing tools for logistics operations, after the development of information technology for operative level decision making has advanced to the required level. It will be easier and easier to find valid input figures for strategic and tactical level analysis, and it will be possible to take into account more variables and restrictions in the optimizing procedures. This development will have a positive effect on the reliability of the results, which will persuade more

organizations to rely on the results and, therefore, to utilize more analyses and models.

The importance of customer service requirements as a core element in logistics decision making process has been emphasized. Therefore, more attention and new approaches are needed to evaluate the impacts of different service requirements and policies on logistics decisions. One approach to support better understanding of the influences of different service elements is to integrate the AHP and MIP techniques, which are proposed in part two of this paper for solving three logistics problems (see papers 6,7 and 8).

Because of the above reasons, there is now a good opportunity and a right time for logistics researchers to concentrate more on the strategic and tactical level analysis, where there can be found many problems to work at, and where there can also be found many companies who are interested in utilizing the results of research.

In the future there will be available more ready made and tailored software tools for analyzing strategic and tactical level logistics problems or for determining developing topics in logistics. The key components in successful introduction of these tools are:

- the systems have to be user friendly and flexible enough to be taken into use by logistics managers
- the validity of the input data have to be on an acceptable level
- the systems have to have direct connections to input and output databases.

It is important that logistics managers are able to make at least some modifications to the software application themselves, because there are changes in the logistics structures every now and then, and, in addition, there are many alternative operation policies to be analyzed. If the system is not simple enough for the managers to use, then some specialists have to be nominated, which will raise the costs and will make it more difficult to implement the results of the analysis. If the validity of the input data is not satisfactory, then there is no sense to use any further developed analyzing tool. In this case, the most actual problem is to concentrate on the problems behind the invalid input data instead of developing analyzing tools. Also, all required data to make a decision must be available. Hopefully it can be transfered direct from a database to make the system more user friendly and the results in most cases more accurate, because personal errors will be eliminated. If the results of the analysis can be delivered to the end users by a computer system, it will make the implementations of the decisions faster, which will be more and more important in the competing world.

Qualitative analyses are another possibility for analyzing strategic and tactical level logistics problems or for determining developing topics in logistics. Often the advantage of these analyses is that they make it easier to include customer expectations and other relevant qualitative information to the decision making process. Three examples on qualitative analyses for determining developing topics are given in part two (papers 1, 2 and three).

Some examples of holistic strategic and/or tactical and/or operative level analyzing tools for logistics can be found even today, for example LINDEN [71] and STRATOVISION [72][73]. The idea of LINDEN is to offer an integrated network providing several tools to support decisions of logistics managers on strategic, tactical and operative level, e.g., designing, monitoring and controlling logistics network. STRATOVISION is a modelling system for logistics strategic planning,

e.g., for analyzing the logistic structure of companies, using a combination of algorithms and recent advances in software development environments. It combines simulation, optimization, heuristics and analytic models to support the analyst and the decision maker.

Because of the wide expected potentials of the analyzing and modelling tools, there will be much more possibilities for companies to purchase them in the future. This also means that tighter competition will make the tools more competitive and wanted. According to the results of a survey made by Ballou and Masters [74] the most important selection factors for commercial-grade warehouse location models are user friendliness, graphics features and technical support, and the less important ones are computational speed, price of the model and hardware requirements. The results of this survey may also be generalized to other areas of logistics models.

One significant developing area in strategic and tactical level analysis is to bring together two or more "new" or less used approaches. The possibilities of combining different approaches have not been developed deeply mainly because most of the researchers have concentrated on their own particular research areas, and have developed them as deep as possible. For this reason, there is more room for combining existing approaches. Petri-net models [75] and Scenario modelling [76] can be given as examples of "new" or less used approaches for logistics planning. Also, the integration of the AHP and MIP techniques, which is used in papers 6,7 and 8, can be fitted to this category.

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