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ROLE OF SUPPLY CHAIN IN INVENTORY SYSTEM

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ABSTRACT

In the present era, where there is a competitive world in the area of business it is very important to control various costs to sustain in the market. And the most importantly customer is to be considered as the most important part of any business. In such fast moving and rapid environment, inventory management plays an important role to make a control over the financial statement of the organization. Inventory involves in the whole process cycle of the organization as it starts with the shop floor to the top level management commitment. In this we will discuss and analyze some of the parameters which directly show the impact of inventory management to the financial statement of the form. This research is based on the fact that intensive competition, higher specialization and companies being focused on core competencies have lead to an increased level of outsourcing, which implies suppliers being included in partnerships. This development can be explained from transaction costs theory and resource-based theory. The chain of suppliers needs to co-operate, and the literature on qualitative supply chain management. In the supply chain a customer refills inventory with replenishments given to the supplier in terms of (un)certain order sizes with (un)certain time intervals. The customer on the other hand is cost optimizing the replenishment orders, which depend on the demand given by his customers. Hence, the ordering process optimized by the customer aspects the performance of the supplier.

Keywords: Lead Time, Logistics, Inventory management, Supply Chain.

INTRODUCTION

The motivation for this research is based on the fact that intensive competition, higher specialization and companies being focused on core competencies have lead to an increased level of outsourcing, which implies suppliers being included in partnerships. This development can be explained from transaction costs theory and resource-based theory. The chain of suppliers needs to co-operate, and the literature on qualitative supply chain management. Introduction and problem statement deals mostly with strategic aspects and empirical surveys of how to manage a chain of suppliers. Quantitative models for supply chain management (see for example Tayur et al. [12]), however, employ topics such as option theory for designing global strategies, evaluation of the impact of information on inventories, contract theory and multi-stage inventory management. Hence, inventory control is an important aspect of managing supply chains. Using inventory theory, this research is therefore based on the more quantitative aspects of how to improve operations between suppliers in a chain.

In the supply chain a customer refills inventory with replenishments given to the supplier in terms of (un)certain order sizes with (un)certain time intervals. The supplier delivers the goods within an (un)certain time in an (un)certain state. The uncertainty and dynamics of the delivery lead time, the timing of the order and the order size are causing problems with reliability and optimal planning in the supply chain; thereby leading to high costs and low service. If the members of a supply chain are operating locally, each supplier is interested in receiving stable replenishment orders both in timing and in size from the customer in order to make smooth and efficient planning. The customer on the other hand is cost optimizing the replenishment orders, which depend on the demand given by his customers. Hence, the ordering process optimized by the customer aspects the performance of the supplier. The relationship between members of a supply chain is illustrated in Figure below. As seen from Figure 1.1 the supplier is in control of the supply process, and 1.1. Supplier relations in a supply chain and thereby the lead time, whereas the customer is in control of the ordering process, i.e. the size and the timing of the order. Naturally, there are cases where the opposite is prevailing. For instance, if the customer picks up the goods at the supplier, the supplier does not control the actual delivery. However, if the goods are not available, there will still be a lead time until availability is restored, which is the supplier's responsibility. Also, there are cases where the customer cannot decide on an arbitrary order size but is restricted to certain order sizes possibly even at specific order times. Hence, all companies in the chain are in control of the ordering process and the supply process. The processes in the supply chain faced by a given company in the chain can be illustrated as in Figure 1.2 below.

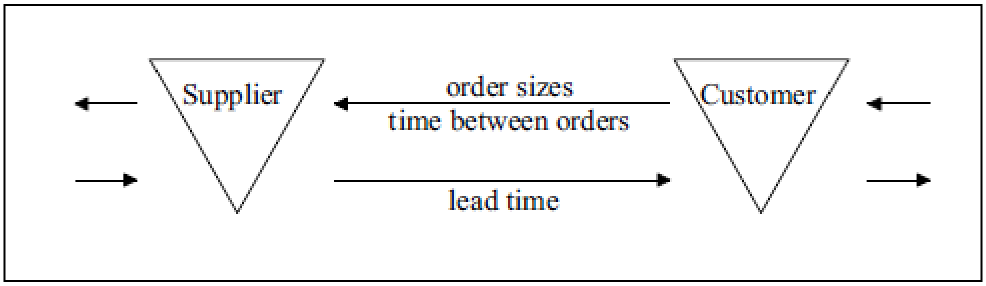

Figure 1.1

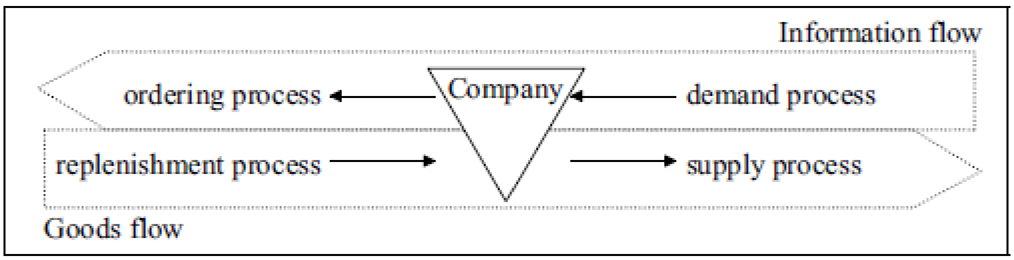

Figure 1.2

The demand process contains the demand of the customers arriving to the stocking point of the company. The ordering process is the process related to the orders released by the company to the suppliers. The demand and ordering processes are part of the information
flow in the supply chain. The goods flow, on the other hand, constitutes the arrival of replenishments from the suppliers, which is characterized as the replenishment process, and the delivery of goods to customers, which is characterized as the supply process. Hence, the ordering process generated at the company is actually a part of the demand process faced by the supplier. Likewise, the supply process from the supplier is regarded as the replenishment process of the company. Furthermore, the ordering process and the replenishment process need not be just a shift in time due to the lead time. In case there is insufficient material at the supplier the actual size of the replenishment can be smaller than the order. If backordering at the supplier is possible, the converse may apply as well, since an order could be augmented by the existing backorder that is resolved.

SUPPLY CHAIN MANAGEMENT, LOGISTICS AND INVENTORY THEORY

The uncertainty and variability of the timing and content of both the in-formation flow and the goods flow imply uncertain planning and, possibly, increased costs, stock outs and delays. Therefore, there is a need for techniques to deal with these uncertainties and dynamics on the operational level. To reduce the uncertainties, there is also a need for strategies applied both at the tactical and at the strategic level of company management. The main objective of this thesis is therefore to gain insight into how elements of inventory theory can be used to improve relations between companies in a supply chain. Hence, the use of inventory control techniques to manage uncertainties and to reduce variability will be analyzed. More specifically, this thesis focuses on how to manage the variability of lead times, order sizes and timing of orders from an inventory control perspective.

The development from logistics to supply chain management

This section briefly presents the main elements of logistics and supply chain management (SCM), and a comparison of the two topics will be provided. The purpose is to clarify the relevance of the supply chain management perspective and to combine inventory theory with the supply chain perspective.
A significant change in the paradigm of modern business management is that companies no longer compete solely as individual entities, but rather as supply chains. The survival of the single company depends on the management's

ability to integrate the company in a network. Therefore, successful SCM will determine the ultimate success of the single enterprise. This requires companies to be far more open and to engage in a closer and more integrated cooperation with other companies than has previously been the case.

By a formulation from 1998, Council of Logistics Management defines logistics as:

> "Logistics is that part of the supply chain processes that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements." (Source: Council of Logistics Management: www.clm1.org/about/purpose.asp#definitions).

Traditional functions within the logistics domain are: purchasing, transportation, distribution, facility location, routing, packaging, labeling, stock design, materials handling, handling of order requests, procurement, service, software and integrated enterprise systems (Enterprise Resource Planning - ERP) for the control and management of stock.The logistics concept has evolved over time, and now a new concept is complementing the operational logistics paradigm, namely supply chain management. The supply chain management literature offers many variations on the same theme when defining the management of a supply chain. The Global Supply Chain Forum defines supply chain management (SCM) as:

> "SCM is the integration of key business processes from end-user through original suppliers that provides products, services and in-formation that add value for customers and other stake holders. SCM encompasses every effort involved in producing and delivering a final product or service, from the supplier's supplier to the customer's customer."

Council of Logistics Management defines supply chain management as:

> "Supply Chain Management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."

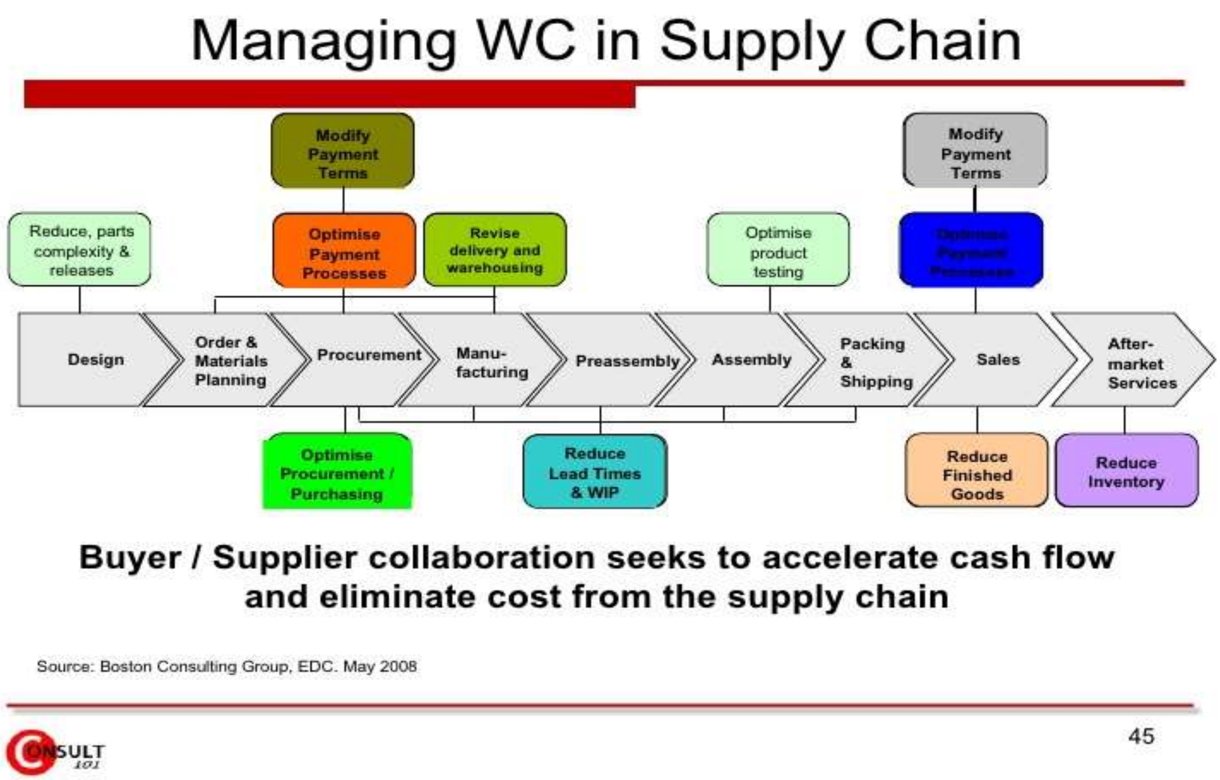

Figure 2.1

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LEAD TIME CONSIDERATIONS

The lead time concept

In this chapter the concept and applications of lead time in inventory models will be presented and discussed. The literature dealing with uncertain lead time will be studied, and some inventory models including variable lead times will be presented.

In most inventory and production planning problems there is an interval of time between the decision to place an order for more stock and the availability of the stock from that order to meet customer demand or a production setup. This time interval is called the lead time. Lead time can roughly be divided into time phases defined by the following time points:

- At time point 1 the customer sends the order request.
- At time point 2 the supplier receives the order request.
- At time point 3 the supplier sends the physical goods to satisfy the order.
- At time point 4 the customer receives the goods.
- At time point 5 the goods are placed on shelves ready for use or sale.

STOCHASTIC LEAD TIME

The literature on how to model the behavior of stochastic lead times in inventory control can be divided into a number of classes. For instance some studies use queuing theory, and others use mathematical programming. Some of the models include the dependence between lot size and lead time, and others focus on how to derive the compound distribution of demand during lead time. In this section a number of aspects of inventory modeling including variable lead time will be reviewed. Karmarkar [7] makes an extensive review on manufacturing lead times and their relation to the production environment, such as the production philosophy, the order release, capacity planning, batching and scheduling. Hence, that literature review is mainly focused on lead time in a manufacturing context.

Stochastic lead time inventory models

The concept of order crossing arises when it is possible for more than one order to be outstanding at the time. Then it is theoretically possible that a later order arrives prior to an earlier order. In practice, however, this is not likely to occur. Axsäter [1] gives a short introduction to the topic of stochastic lead times in inventory models. He mainly distinguishes between demand independent lead time, not allowing for order crossing, and successive lead times being stochastic and independent, thus allowing for order crossing. The latter corresponds to orders being served from a number of independent servers. Kaplan

[5] uses dynamic programming to minimize the total of ordering, holding and shortage costs in a discrete time environment under the assumption of stochastic lead times. For stochastic lead times, the state space is very big and Kaplan shows how the multi-dimensional model can be represented by a sequence of one-dimensional minimizations, which reduces the state space. Kaplan is probably among the first to take into account the problem of order crossing when lead times are assumed independent, by formulating the model such that order crossing is not possible. Erhardt [3] elaborates on Kaplan's models and suggests some adjustments especially in terms of infinite horizons and conditions for optimality of myopic base stock policies. Also Zipkin [12] extends the model of Kaplan to a more general setting. Song and Zipkin [11] assume that over time the inventory system gets information about the supply conditions, i.e. the lead time is dynamic, and this is included in the inventory control system which is modelled by a discrete-time Markov process. Using results from queuing theory, Diks and van der Heiden [2] develop simple lead time processes for use in multi-echelon inventory systems that guarantee no order crossing and ensure that target means and variances are met.

Lead time as waiting time in queuing models

The lead time of an order can be regarded as the waiting time of a customer arrival in a queuing system. A number of authors have derived expressions for the waiting time distribution of different inventory control systems. Higa et al. [4] for instance derive an approximation of the steady state probabilities of the waiting time in an (S; 1; S) inventory control system with Poisson arrivals and negative exponential lead times from the supplier. They show that the mean waiting time is a beta function, and they provide a numerical example to illustrate how to determine the adequate order-up-to-level given certain requirement of service. Sherbrooke [8] complements the work of Higa et al. [4] by deriving an exact expression for the waiting time distribution with constant supplier lead times.

Lot size dependent lead time

The size of a customer order may have an impact on the lead time. However, this is mostly the case when products are made to order (MTO), where the production time is related to the quantity produced. Make to stock (MTS) type of companies and wholesalers are in general able to deliver instantly from stock, and therefore the size of a customer order should not influence the lead time. An exception arises if the size of the order is big enough to empty the on-hand stock. Then, obviously some additional delay will occur. If the lead time indeed depends on the order size, this needs to be accounted for in the inventory control policy. Karmarkar [7] argues that a big batch size in a production setup will put pressure on capacity leading to queuing of work, which thereby increases the lead time of production.

Karmarkar [6] models such a relationship using queuing models and moreover refers to a number of other research studies accounting for the influence of the batch size on the lead time related to capacity constraints. In a recent study, Kuik and Tielemans [9] also investigate the relationship between batch sizes and lead time variability. Based on the formulation of a job shop queuing model they conclude that reducing the amount of work-in-process will not reduce the lead time variability.

As identified by Bagchi et al. [10] there are a number of solution methods to finding the lead time demand distribution:

1. The use of discrete empirical probability distributions of demand and lead time.
2. Stochastic processes (e.g. Markov chains or random walk model).

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3. Monte Carlo simulation.
4. Historical data of lead time demand.
5. Theoretical distributions of demand and lead time to find the com-pound lead time demand distribution analytically.

A literature review was provided in order to explore which topics of stochastic lead times have been analyzed. It can be concluded that big effort have been made into analyzing the effect of lead time variability on costs. Also many proposals of the compound lead time distribution are available based on different combinations of assumptions on the demand distribution and the lead time distribution, although in practice and in leading textbooks lead time demand is usually assumed to be normally distributed. A clear disadvantage of using the compound distribution approach is that there exists no universal compound distribution, which is applicable for a wide range of situations

CONCLUSION

From the supply chain management literature, partially discussed in, it can be concluded that in order to reduce demand and supply variability, cooperation between suppliers in a chain is needed. The cooperation consists of better forecasting, shared forecasting, shared information on relevant data, vendor managed inventory, Just-In-Time, strategic alliances and partnerships, business process redesign and systems dynamics thinking. Moreover, it is important to find the causes of lead time variability and delays in order to reduce variability.

Through the modeling of inventory problems, important aspects of supplier relations have been highlighted. For example, the inclusion of the lead time demand variable in the inventory related decision rules directly emphasizes the importance of the distribution of lead time demand, which will be analyzed in this research work. The inventory models thus include information about the replenishment process (lead times) and the demand process directly in the decision rules. Also, the output of these decision rules directly affects the ordering process (in terms of replenishment orders to the supplier) and the supply process (in terms of service levels experienced by the customer). Hence, the inventory decision making is influenced by and has influence on all the supply and demand processes linking a supplier and a customer.

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