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How is the carrying charge determined and what connections can be identified with material planning methods?

- A survey study of Swedish manufacturing engineering companies

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Abstract

The majority of all manufacturing companies are characterized by the fact that they are holding some sort of inventory. The inventory makes up the main asset on their balance sheet and is associated with high costs. These costs can be determined by applying a carrying charge. The carrying charge is further important in inventory management as it is a component used in some order quantity determination formulas. Theory suggests the most common methods for determination of the carrying charge is by calculation, industry standards or experienced based. However, there is a lack of praxis studies concerning how companies actually do determine and apply carrying charge. Furthermore both theorists and industry experts agree that carrying charge is not determined in the most correct way.

The chosen research problem is: ***"How is the carrying charge determined in Swedish manufacturing companies and what connections can be identified between the carrying charge and material planning methods within these companies?"***

The overall aspiration with this thesis is to increase the knowledge of the carrying charge in general, as well as to serve as a foundation on which further research on the topic of carrying charge can be carried out in particular.

As the main research approach for this thesis, a survey study design has been chosen. Empirical data has been collected by conducting telephone interviews among 99 companies with different turnovers, selected by random sampling.

The empirical results show that the carrying charge is not widely applied within Swedish manufacturing engineering companies. Most companies in the sample determine their carrying by calculation. The most frequently included component was the cost of capital. The most common material planning methods among the sample are order based material planning and re-ordering point system. Even though theory suggests connections between the carrying charge and material planning methods, the survey shows that few companies make use of these connections.

Recommended for further research studies on the topic of the carrying charge is to apply a qualitative approach in order to gain a deeper knowledge or to include other components in the carrying charge such as the environment.

Sammanfattning

Majoriteten av alla tillverkande företag innehar ett lager i någon form. Lagret utgör den största delen av tillgångarna på balansräkningen men ger även upphov till stora kostnader. Lagerhållningssärkostnaderna, vilka är en del av de totala lagerkostnaderna, kan fastställas med hjälp av en lagerränta. Lagerräntan kan även användas i lagerstyrningen för att bestämma orderkvantiteter samt påverkar service nivåer och vinst. I dagsläget saknas praxis studier gällande hur lagerräntan fastställs och används i svenska företag. Dock är både teoretiker och branschexperter överens om att lagerräntan inte fastställs på ett korrekt sätt.

Den valda problemställningen för uppsatsen är: ***Hur fastställs lagerräntan i svenska verkstadsindustriföretag och vilka kopplingar kan göras mellan lagerräntan och materialplaneringsmetoderna som används inom företagen?***

Den huvudsakliga ambitionen är att öka den generella kunskapen om lagerräntan samt skapa empiriskt material som kan ligga till grund för fortsatt forskning inom området.

Det empiriska materialet har samlats in genom telefonintervjuer bland 99 företag med olika omsättning som har valts ut genom ett slumpmässigt urval.

Det empiriskt resultat visar att lagerränta inte tillämpas i stor utsträckning bland de undersökta företagen. De flesta företagen som använder sig av en lagerränta fastställer den genom beräkning. Den mest frekvent förekommande komponenten som inkluderas i lagerräntan är kapitalkostnaden. Den vanligaste förekommande materialplaneringsmetoden inom urvalet är orderbaserad materialplanering och beställningspunktssystem. Trots att teorin förespråkar kopplingar mellan materialplanering och lagerräntan så är det enda ett fåtal företag som utnyttjar detta samband.

Rekommendationer för framtida studier inom området skulle kunna innebära att tillämpa en mer kvalitativ metod för att skapa en djupare förståelse eller för att inkludera andra komponenter i lagerräntan såsom miljöaspekter.

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1. Introduction

The opening chapter of this thesis describes the background and relevant context of the carrying charge as well as sheds light on its topicality and importance. The introduction chapter further provides a description and discussion of the studied problem, resulting in the problem formulation.

1.1. Background

For the past years there has been a great conflict regarding holding inventory and the demand for increased flexibility and reduced product life cycle (Lambert, Stock & Ellram, 1998). Holding inventory is a necessity in order to handle fluctuations in customer demand, furthermore the costs are increasing in order to meet the demand. Therefore, companies need to make trade-offs between the possibility to meet fluctuations in customer demand and reducing inventory costs.

1.1.1. Holding inventory

The main difference between a manufacturing company and a service company is that the result of the former's activities is a psychical product. Moreover, in a service producing company, the service is consumed at the same time it is produced (Lantz, 2003). In a manufacturing company however, goods can be produced at one point in time and consumed, by other companies or consumers, at another. When manufacturing and consumption do not coincide at the same point in time, raw materials (input), as well as finished goods (output) need to be stored. Thus, manufacturing companies can use inventories.

In broad outlines, three main types of inventory can be discerned (Lambert et al, 1998). (1) In a raw materials inventory, companies store components and other inputs not yet used in manufacturing. (2) An in-process inventory contains material that is used in the production but needs to be worked on before delivered to customers. (3) A finished good inventory does, naturally, contain products that have passed through the whole production process and are considered "ready" (Lambert et al, 1998). Moreover, a last type of inventory is that containing spare parts and consumer goods (Lantz, 2003).

In general, companies hold inventory for one or several of the following reasons (Meng, 2006). First, holding inventory enables independence in operations, reduces the number

of setups and enables scale production. Second, unexpected delays or interruptions, due to strike or other problems, in delivery of material from suppliers can be compensated by an inventory which serves as a safety limit. Third, inventories are beneficial as they manage the production schedule and enable and enhance a smother flow in the production. Fourth, from a financial perspective, inventories are beneficial as they enable purchase of large quantities and orders during off season periods which, every so often, result in quantity discounts and improved conditions of purchase. Fifth, holding inventory is essential in order to be able to match variations in customer demand, as the exact demand seldom is known on beforehand.

For many of these manufacturing companies, inventories represent the main asset on their balance sheet (Lambert et al, 1998). However, in spite of the above mentioned advantages associated with holding inventory, most contemporary companies strive to reduce their inventory levels or make their inventory management more efficient. The reason for this is because holding inventory is associated with a number of different, generally high costs (Lambert et al, 1998). The incremental costs, which are a part of the total inventory costs, can be divided into four main components; the cost of capital, inventory service costs, storage space costs and inventory risk costs (Lambert et al, 1998). It can be argued that these costs, referred to as inventory carrying costs, make up the main part of manufacturing companies` total logistic costs (Lambert et al., 1998).

As a general measure of the inventory carrying costs, a carrying charge can be applied (Jonsson, 2005) The incremental costs (explained in glossary) associated with holding one entity in inventory during a specific period of time can be calculated as that period's carrying charge times the purchase price or the selling price of the entity. The carrying charge should therefore reflect all incremental costs, associated with holding inventory (Lantz, 1993). A further area of application of the carrying charge is in inventory management, where the carrying charge underlies dimensioning of, for example, order quantities (Jonsson, 2005). Hence, an important, nevertheless easy or obvious, task is therefore to determine the size of the carrying charge.

1.1.2. The Swedish manufacturing engineering industry

The engineering industry is considered the foundation of the Swedish manufacturing sector as it generates more than 52 percent of the sector's total production (Swedish

Institute, 2006). Furthermore, the engineering industry's importance for the Swedish economy as a whole is substantial, as it accounts for approximately 10 percent of Sweden's total gross domestic product (Swedish Institute, 2006).

The emergence of the sizeable and versatile Swedish engineering sector can be dated all the way back to the 17th century (Swedish Institute, 2006). The accumulation of knowledge and increased competition over time has, accompanied by a number of Swedish technical improvements and inventions, shaped the characteristics of today's relatively heterogeneous engineering sector (Swedish Institute, 2006). Ranging all the way from simple production to highly advanced manufacturing processes; one can distinguish five major subsections; telecommunications, electrical engineering, metal products, mechanical engineering and the vehicle industry. The engineering industry is further described as knowledge intensive and export oriented and characterized by its "very high degree of internationalization and exposure to international competition" (Swedish Institute, 2006). As a result, approximately two thirds of all production generated by the engineering industry is exported (Swedish Institute, 2006).

Despite large, internationally successful, companies like Volvo, SKF and Atlas Copco (among others), the Swedish engineering industry mainly consists of small and medium sized companies. Less than one percent of all companies within the sector employ more than 500 people. Nevertheless, the larger companies generate approximately half of all employment within the sector (Swedish Institute, 2006).

Furthermore, according to Stig-Arne Mattsson[1] the engineering sector is the sector within the manufacturing industry that is the most developed and prominent in terms of inventory management.

1.2. Problem discussion

The importance and relevance of the determination of the carrying charge arise from the fact that the size of the carrying charge plays a significant part in inventory management (Berling, 2005) as well as affect company profit (Lambert et al, 1998). Hence,

[1] Stig-Arne Mattson, Professor Technical Logistics , Lund University, telephone interview 27th April, 2007

decisions regarding the carrying charge will have consequences for both the financial and operational parts of a company. Ultimately, applying a carrying charge that does not correctly reflect the company's inventory carrying costs will result in management decisions that are not optimal and the accounting of incorrect profit (Lambert et al, 1998).

One important task in inventory management is to decide how much and when to order (Berling, 2005). In order to decide the order quantity, companies can use the EOQ formula also known as the Wilson formula (Berling, 2005). The inventory carrying costs are one component of this formula and they can as discussed previously be determined by the carrying charge. The relationship of the carrying charge and the EOQ will be explained further in the theoretical frame of reference.

In 2005, Jonsson and Mattson carried out a survey concerning how Swedish companies decide and control their inventory levels. 76 percent of the surveyed companies were manufacturing engineering companies. Among other things, the survey aimed at investigating what different methods was used for deciding order quantity. The survey concluded that out of those companies applying a material planning method that enable them to influence the size of the order quantity, approximately one third use the above mentioned EOQ (Wilson formula)[2]. The carrying charge is a component in the formula for determining the order quantity. Therefore, a carrying charge that either is determined too small or too large, hence does not correctly reflect the company's inventory carrying costs, will result in non-optimal order quantities. According to Jonsson (2005), companies that apply a carrying charge in inventory management ought to investigate how it is determined in order achieve a reasonable size.

Closely related to the implications of the carrying charge, when deciding the optimal order quantity, are the concepts concerning service levels and shortage costs. In order to avoid shortage of inventory, companies tend to hold a safety stock as a buffer Lumsden, 2006) The size of the safety stock is determined by the service level. The service level can be defined as the probability, for a company, to not end up with a shortage in

[2] A majority of all companies in the survey did use a material planning method that enables them to control the order quantities (Jonsson & Mattsson, 2005).

inventory (Lantz, 2003). When determining the service level, companies have to balance the shortage costs against the carrying costs for holding a safety stock. If the carrying charge is inaccurately determined, the carrying costs for holding inventory are incorrect, resulting in either a too high or too low service level in comparison to what the company actually can afford (Lumsden, 2006).

Moreover, the size of the inventory carrying costs, hence indirectly the carrying charge, affects the company's profit. According to Lambert et. al (1998), there are mainly two ways in which company profit is affected by inventory levels. Initially, a company's net profit is reduced by inventory related costs such as taxes, insurances and interest expenses. Secondly, a company's total assets are affected by a decrease or an increase in inventory levels. If inventory levels are increased, the company's total assets increases and capital is tied up in the inventory investment, hence restrain the company's possibility to invest in other types of assets. (Lambert et. al, 1998)

Research and theories on how companies determine their carrying charge tend to approach how the carrying charge is defined, rather than describe and explain how it is determined and applied in companies. Hence, there exists a lack of research in terms of praxis studies in the field of carrying charge. Even though, as concluded in previous sections, the correct way to determine the carrying charge is to include all relevant incremental costs associated with holding inventory, it has been pointed out that companies use other approaches. Mattsson (2003) even argue that, according to his experience, determination of the carrying charge by calculation is the least used method among companies. Jonsson (2005) further argue it is common among companies that the carrying charge is a fixed, experienced based percentage, which is determined centrally in the company. Jonsson (2005) further conclude that it is not unusual for companies, with more or less the same business, to apply carrying charges ranging between 5 and 40 percent.

Another frequently used approach for determine the carrying charge among companies is, derived from Mattsson`s (2003) experience, to use the same carrying charge as others within the same business, that is, to use a percentage found in textbooks or other industry periodicals. Lambert et al. (1998) support this approach, by arguing that com-

panies often consider carrying charges set by industry standards, when determining the company's own carrying charge.

A third approach for companies to determine their carrying charge is to view it as a policy variable and use it as an instrument to reduce tied up capital (Mattsson, 2003). These, by Jonsson and Mattsson, identified approaches used by companies to determine the carrying charge are conclusions from many years of work and experience.

Berling (2005) has distinguished between the same approaches for determining the carrying charge as Jonsson and Mattsson. He further points out that the textbooks frequently advice companies to use a carrying charge of 25 percent. "A small survey, carried out by Berling in 2004 at a Swedish conference for both professionals and academia within the logistics field, showed that a carrying charge of 25 percent still is in use in many fields, ranging from medical supplies to airplane components" (Berling, 2005 p. 7) However, Berling (2005) does not give an account of what companies took part in the survey and what method that was used, resulting in lack of information concerning the possibility to generalize the study's findings to concern all companies.

A number of bachelor and master thesis containing the concept of carrying charge can be found (Gjirja, Stragnefors and Petersson, 2006 and Linderson and Palm, 2002). However, these thesis's are not focused on how the carrying charge is determined, rather views it as exogenous predetermined figure.

1.2.1. Problem formulation

As the previous section intended to illustrate, modest attempts to investigate how the carrying charge is determined in Swedish manufacturing engineering companies have been made. Nevertheless, theorists as well as industry experts agree companies probably do not determine the carrying charge in the most correct way, which is to calculate it (Jonsson, 2005, Mattsson, 2003) Furthermore material planning methods are as discussed in previous section a substantial part in inventory management and carrying charge is used in several of these methods. Therefore, this study will be dedicated to investigate and conclude;

"How is the carrying charge determined in Swedish manufacturing companies and what connections can be identified between the carrying charge and material planning methods within these companies?"

The determined research problem is relevant both from a theoretical as well as practical perspective. As the conducted problem discussion shows, virtually no empirical studies have been carried out on how companies determine their carrying charge. Hence, there exist no scientific theories on the subject. From a practical perspective, determination of the carrying charge is significant as it is a component in inventory management such as the EOQ-formula. Moreover, research shows companies do apply the EOQ-method in order to determine their order quantity, which implies they need to know and determine their inventory carrying costs. The discussed and proposed approaches emerged from previous expertise and studies, serves as a starting point for this study.

1.3. Purpose statement

The main purpose of this thesis is to further explain the concept of carrying charge and its components in order to generalize and explain the connections between carrying charge and material planning methods. The overall aspiration with this thesis is to increase the knowledge of the carrying charge in general, and serve as a foundation on which further research on the topic of carrying charge can be carried out in particular.

2. Theoretical frame of reference

Investments in inventory can, in some companies, represent more than 20 percent of the total assets (Lambert et al, 1998). These inventories tie up a great deal of capital and prevent companies from making other investments (Lambert et al, 1998). One can distinguish between a number of different costs associated with carrying inventory. According to Bowersox and Closs (1996), referred to in Berling (2005), the carrying cost can make up as much as 37 per cent of the total logistic costs within a manufacturing company.

2.1. Inventory carrying costs

Inventory carrying costs are the total cost for holding inventory (Lambert et al, 1998). The different types of inventory carrying costs can be divided into four groups. Nevertheless, these costs are all incremental costs and vary with inventory quantity (Lambert et al, 1998). This means that if the quantity of inventory held would be increased, these costs would also increase, and vice versa. Obviously, there are common costs associated with holding inventory. However, the common costs are not considered in this thesis since they are not included the carrying charge.

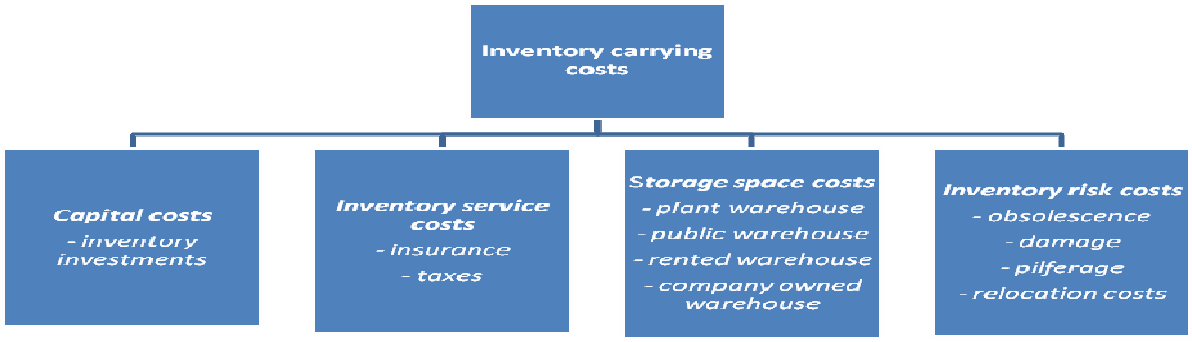

Figure 1: Inventory carrying costs

Source: Lambert et al, 1998

2.1.1. Capital costs

The component capital cost is related to the cost of that capital that is tied up when carrying inventory (Lambert, 1998). Inventory should be viewed as an investment and the company needs to decide if it is more beneficial to hold a certain amount of inventory or to invest that amount of money somewhere else. The capital costs are affected by the number of articles stored in the inventory, principle used for the inventory and the type of capital cost that is being used (Lambert et al 1998). Generally to determine the cost of capital there are two things that the company needs to estimate; the value of the warehouse's products, *videlicet* the value of the products being stored, and the expected return on the invested capital (Berling, 2005).

The value of products held in inventory can be determined in several ways, depending on where and how products are being stored. There are three different methods to decide the value of the product being stored. It can be determined as the value of the product's purchase price, selling price or an average between the two.

The return that a company expects from an investment in inventory can be determined either by calculating the company's opportunity cost of capital or by using its weighted average cost of capital, WACC (Berling, 2005). "The opportunity cost of capital is the return that the company could have obtained from an alternative investment that poses the same degree of risk" (Berling, 2005 p 10). The opportunity cost of capital can bee seen as the rate of return that the company misses out on when it undertakes an investment instead of another. "A company's WACC is computed as the sum of the cost for each source of funding multiplied by its proportion of the total funds" (Berling, 2005). Nevertheless, a survey carried out by Gaither and Fraser (1984), referred to in Berling (2005), shows it is more common to determined the cost of capital for carrying inventory by using the cost of borrowing capital[3]. A reason for this may be because it is an understandable and less complicated method. Furthermore, a common argument used to defend this approach is that investments in inventory is often financed by debt,

[3] The survey contained 124 companies out of which 67.7 percent answered they used the cost of borrowing to calculate the cost of capital for inventory investments (Berling, 2005).

hence justifying the usage cost of borrowing as the company's cost of capital (Berling, 2005).

2.1.2. Inventory service costs

Service costs are, according to Lambert et al. 1998, insurance and taxes. The tax is usually applied as a percentage of the inventory value (Berling, 2005). The insurance rate on the other hand can be set as a percentage of the average storage value (Berling, 2005). This cost is generally determined for a specific period and can vary depending on the product type and the insurance company.

2.1.3. Storage space costs

The inventory costs included in this component are typical rent, lighting and heating (Berling, 2005). Depending on how your warehouse is managed, this cost will vary. According to Berling (2005), there are three different types of warehouse management that can be identified. These are company owned warehouses, public warehouses, rented or leased warehouses.

The cost for the company owned warehouse is generally a fixed cost and will not affect the inventory carrying cost. However, an opportunity cost can be charged if there is an alternative use of the storage space. This means that if a company that, otherwise let a part of their warehouse, needs to use that space themselves due to increased inventory quantities, this loss of income must be considered as an inventory carrying cost. In the public warehouse an independent organisation is lending a full service storage space, where everything is included. The inventory carrying costs therefore depend on the amount held in storage. Concerning a rented or leased warehouse, the costs associated can be regarded fixed costs. These costs are contracted for a specific time and no additional charge on the amount being held in the warehouse exists. (Lambert et al, 1998)

2.1.4. Inventory risk costs

Holding inventory is associated with certain types of risk, such as the risk for obsolescence, damages, pilferages and relocation. All of these different types of risks generate costs that increase with the size of the inventory (Jonsson, 2005)

Obsolescence costs are costs associated with holding a large amount of products in inventory. There is a risk that the products will go out of style making it impossible for the company to sell it to its original price (Lambert et al, 1998). This is especially important with certain types of products, such as technical products or groceries, where the product life length is limited.

Damage costs arise when a product, due to handling in storage, is damaged and therefore can either not be sold to its full price or, more likely, can not be sold at all.

Pilferage costs constitute substantial inventory carrying costs, especially for American companies where it these costs lately have increased significantly (Lambert et al 1998). These costs occur due to theft from the inventory.

Relocation costs occur when products need to be relocated from one inventory to another, in order to handle shortage or avoid obsolescence. These costs also include the cost of lost goods due to incorrectly delivered, or lack of delivery of shipments to customers. Generally, the risk for all of theses events mentioned above increases with the size of the warehouse (Lambert et al, 1998).

2.2. Determination of the carrying charge

The carrying charge can be used to calculate the cost of holding inventory for a certain product in order to minimize the total holding cost (Jonsson et al, 2005). The carrying charge therefore vary depending on the characteristics of the product and hence, should either be used separately for each product, as an average of the various rates, or as the highest cost. (Jonsson, 2005). It is important that the costs are stated in before tax numbers in order to make them comparable to other numbers (Lambert et al, 1998). The thesis is basically discussing two methods for determination of the carrying charge; by calculation or by approximation, which will be further explained in the next sections.

2.2.1. Determination of carrying charge based on cost calculations

According to Lambert et al (1998), the following formula can be used to calculate the carrying charge.

$$Carrying\ \text{charge} = \frac{\sum Cost\ of\ capital + \sum Storage\ \text{cost} + \sum Cost\ of\ risk + \sum Service\ \text{cost}}{Average\ storage\ value}$$

Equation 1: Carrying charge definition 1

Source: Lambert et al, 1998

Also Johnsson (2005) has constructed a formula to calculate the carrying charge;

$$Carrying\ \text{charge} = \frac{\sum Cost\ of\ capital + \sum Storage\ \text{cost} + \sum Cost\ of\ uncertainty}{Average\ storage\ value}$$

Equation 2: Carrying charge definition 2

Source: Jonsson (2005)

The component cost of uncertainty corresponds to Lambert et al's cost of risk and service cost but is excluding taxes (Jonsson, 2005)

2.2.2. Determination of carrying charge based on approximation

If a company does not calculate their carrying charge, they can choose to determine the carrying charge either by applying an industry index or use recommended numbers from purchasing handbooks or textbooks (Berling, 2005). As mentioned in the introduction, Berling (2005) argue the same carrying charge percentage advised in textbooks in 1940, still is used by companies today. According to Mattson (2003), the recommended carrying charges in textbooks and industry periodicals range between as little as 10 percent to as much as 50 percent. Companies using advised carrying charges can either choose to use it as it is, or adjust it for the specific characteristics and conditions in their company.

The carrying charge can also be determined in other ways such as using a fixed rate, decided centrally within the company or be based on practice and previous knowledge (Jonsson, 2005). This approach is according to Lambert (1998) the most common one.

Another approach that companies use to determine their carrying charge is to view it as a policy variable and use it as an instrument to reduce tied up capital (Mattsson,

2003). The carrying charge is determined centrally high up in the company hierarchy and can be set to a high level in order to lower the capital tied up in inventory. In this context, the carrying charge can not be considered a neutral, objective way to determine inventory carrying costs or order quantities; rather it is a part of the company's changing process towards lower inventory levels (Mattsson, 2003 p 1). This is an approach more often applied than the method of calculate the carrying charge. According to Mattsson (2003), a number of articles have been written, encourage companies to use their carrying charge as a policy variable, and determine the inventory levels according to that. However this has consequences, as the method is disregarding the service level and therefore more stock out opportunities could occur (Mattsson, 2003).

2.3. Carrying Charge - Areas of application

The carrying charge can be applied in different areas within inventory management, such as material requirement planning and lot size techniques such as the Silver Meal, Wagner-Whitin and EOQ-method (Lumsden, 2006). However, the most widely usage of carrying charge is in calculation of economic order quantity, EOQ, also referred to as the Wilson formula (Jonsson, 2005).The decision concerning how much to order comprises a balance between additional inventory carrying costs or additional order costs. Additional order costs are independent of the order quantity and can be defined as all costs that arise when companies undertake a new order (Berling 2005) Hence, the greater the quantity ordered, the smaller the total ordering costs but the greater the inventory carrying costs. In order to decide the order quantity that minimizes the total inventory costs (total ordering costs + total holding costs), companies can use the economic order quantity formula (EOQ). The EOQ can be applied in different ways; the EOQ for purchase, the EOQ with the own manufacturing, EOQ with lead time, and the EOQ with limited resource of inventory system. The EOQ affected by the carrying charge, and as appointed in this thesis the EOQ for purchase. (Lumsden 2006):

$$Q = \sqrt{\frac{RD2}{H}}$$

Equation 3: The Economic order quantity formula for purchase

Source: Lumsden (2006)

Where,

Q = Economic order quantity
R = Reorder cost
D =Average demand
H = Holding cost (Carrying cost)

2.4. Material planning methods

In order to determine the point in time when an order should be place, companies apply different types of material planning methods. The most commonly addressed material planning methods throughout this thesis will be accounted of below. The others methods will be found in appendix A.

Material requirements planning (MRP): The material that a firm acquires to meet their demand can be determined by a computer-based information system for ordering and scheduling of dependent-demand inventories, MRP. Accuracy is very important for a system like MRP. The MRP considers three sources, the Master Production Schedule, Bill of Materials and the Inventory record files. The MRP considers net requirement and is therefore based on carrying as little inventory as possible.(Stevensson & Hojati, 2004).

Re-ordering point system: A certain level of inventory is set and when that inventory level is reached, the system alerts and a re-ordering process is initiated. Here, is the quantity fixed and time between orders varies. The reorder point can be expressed as:

$$ROP = d \times LT$$

Equation 4: Re-ordering point formula

Source Stevensson & Hojati (2004)

Where,

d= demand rate (units per day or week)
LT= lead time in days or weeks

The lead time is decided by the service level and as discussed that is decided with the carrying charge. There are also variances of this method but it is not being address in this thesis.

Kanban: This is a Japanese material planning method that means visual proof. It is based on a pull system (material is pulled to a work station when it is needed) A station communicates demand for a work or material on the device (Hojati & Stevensson 2004)

There are generally two types of Kanban cards, production or transportation kanbans, which can be used separately or integrated (Slack, Chambers,Johnston, 2004). The principle for these kanbans are the same, the kanban triggers either start of production or material replenishment.

The ideal number of production kanban cards can be calculated by following formula:

$$N = \frac{DT(1+X)}{C}$$

Equation 5: Kanban

Source Stevensson & Hojati (2004)

Where,

N=Total number of containers (1 card per container)
D=Planned usage rate of using work center
T=Average waiting time for replenishment of one container
X=Policy variable set by management that reflects possible inefficiency in the system, represents the safety stock
C= Capacity of a standard container

The policy variable, the safety stock, is as explained earlier a decision depending on how much inventory the company can carry which is affected by what service level the company want to contain. Indirectly therefore the carrying charge will affect the Kanban system since the carrying charge is affecting the service level.

2.5. Conceptions and Definitions

Throughout the thesis, various conceptions and definitions are used, some which are well accepted among professionals and academicians within the business and logistics field. Nevertheless, in order to facilitate for the reader of this thesis, a glossary with conceptions and definitions used to a large extent throughout this thesis has been constructed. The glossary is found in appendix A. Readers unfamiliar with conceptions and definitions within inventory management benefit from reading the glossary before reading the chapter where the empirical results are presented.

3. Methodology

The main concern when choosing a research design and data collection method for a study is that the methodological tools must be able to generate the empirical results needed to properly, correctly and fairly answer the stated problem. However, the chosen method should further be proportioned to the given time limit, the available financial resources, the minimum level of quality accepted and the knowledge, experience and preference of the authors (Johansson-Lindfors, 1993, Creswell, 2002).

3.1. Research design

The following sections will describe the chosen research design and data collection method that has been applied in this thesis in order to answer the research problem. Moreover, a sample reduction analysis will be presented, the methodological choices made will be evaluated and the study's credibility will be discussed.

3.1.1. Defining the population

The first part of the research process is to specify the study's population. A population can be defined as the group of phenomena that the survey aims to comment on (Esaiasson et al, 2007, p 178). The cases that are included in the population all share the same predetermined characteristics, and the cases that are excluded lack one or more of these characteristics. The chosen population for this study can be defined as "Active Swedish manufacturing companies within the manufacturing engineering industry with a turnover larger than SEK 20 millions. The reason for eliminating companies with a turnover less than SEK 20 millions, so called micro companies (EU-Upplysningen Sveriges riksdag, 2007) is that these companies are considered too small to have a sophisticated and documented method for determining the carrying charge.

A Swedish company is defined as a joint-stock company, private or public, that has a Swedish organization number. "Manufacturing is defined as production of goods primarily by the application of labour and capital to raw materials and other intermediate inputs" (Deardorff, 2001). The underlying logic for choosing the manufacturing industry is that manufacturing companies should, by definition, treat goods which at some stage in the supply chain should require a space. Hence, manufacturing of products requires, in most cases, an inventory. However, there are other types of industries that can be of

interest for this study, such as the distribution or food-and beverage industry. However, due to the given time limit, only one industry can be chosen. The decision to conduct the survey within the manufacturing engineering industry in particular was reached after consultation with an expert within the logistics field, Stig-Arne Mattsson[4]. He agreed with us that a study of this character would be most suitable and interesting to conduct on companies within the manufacturing engineering industry.

3.1.2. Feasibility study

In order to enhance the quality of the study, a feasibility study was conducted. The purpose was to examine the knowledge and interest of the topic by the companies that were intended for the study, as well as to test the appropriateness of the chosen research design and data collection method. Originally, a qualitative approach in terms of a multiple case study design and in-depth interviews had been chosen. A case study research design is used when questions such as ***why*** and ***how*** are explained within some real-life context (Yin, 2003). In-depth interviews are appropriate when one is approaching a relatively unexplored subject or topic (Esaiasson Gilljam, Oscarsson and Wängnerud, 2007). "In general, convenience, access and geographic proximity can be the main criteria for the pilot (feasibility) case or cases" (Yin, 2003, p.79). With respect to this, two companies were selected using the same approach as the one described in the section *random sampling*. The two chosen companies were then contacted and telephone interviews were conducted.

The feasibility study generated several important findings that resulted in consequences for both the studied subject in general, as well as the chosen method in particular. First, it became clear that neither a case study design, nor in-depth interviews are appropriate methods for the research problem. As it turns out, the awareness and knowledge of exactly how the carrying charge is determined is modest among companies. Therefore, conducting in-depth interviews would probably not generate a deeper knowledge and understanding of this subject.

[4] Stig-Arne Mattson, Professor Technical Logistics , at Lund University, telephone interview 27th April, 2007

As a result, the research design, as well as the data collection method was changed. A quantitative survey study in which a sample of Swedish companies are studied in a less in-depth way in order to make generalizing conclusions on how the carrying charge is determined has been chosen.

3.1.3. Random sampling

When the population has been established, the specific cases (entities of analyses) that should be analyzed must be decided (Easiasson et al, 2007). The aim of this study is to be able to generalize the results from the studied entities of analysis to the remaining cases in the population. Hence, the sample must be representative of the total population. According to Johansson-Lindfors (1993), only random sampling can guarantee generalization. Therefore, the sample of entities of analysis studied in the survey will be chosen using random sampling. A random sample can be defined as a selection where all entities of analysis have a known probability, greater than zero, to be selected (Esaiasson et al, 2003, p 196).

The population has been divided into three groups (stratum); small- medium and large companies in order to be able to indicate differences between the companies related to their turnover[5]. When classifying companies, the yearly turnover has been chosen as a measurement of the company size. Small companies are defined as companies with a turnover greater than SEK 20 millions but less than SEK 100 millions, medium sized companies are defined as companies with a turnover greater than SEK 100 millions but less than SEK 500 millions, and large companies are those companies with a turnover greater than SEK 500 millions (EU-Upplysningen Sveriges Riksadag 2007). The entities of analysis were randomly selected from each stratum, referred to as stratified sampling (Esaiasson et al, 2007).

Next step is to determine the sample size. Obviously, the larger the sample size, the greater the certainty by which the sample results can be generalized to the total population. As there is no ambition as to analyze the empirical data using statistical methods, no consideration needs to be made regarding the size of the sample necessary in order

[5] Margareta Westberg, Universitets adjunkt, School of Business, Economics and Law at Göteborgs Universitet, Göteborg 23rd April 2007.

to achieve a certain level of significance or margin for error. Instead, the sample size has been determined to the greatest possible number of entities of analysis that is, in terms of money and time, manageable. As a result, the sample size has been determined to 99 entities of analysis. Furthermore, it has been decided that the stratifying should be proportional. This means that an equal number of cases should be selected from each stratum, regardless of the population distribution (Esaiasson et al, 2007). This means that even though most companies in the population can be categorized small or medium sized, 33 companies will be selected from each stratum. This approach has been chosen as it enables the authors to make statements regarding the results in the different stratum with the same certainty, since the same number of companies has been studied.

In order to carry out a random sample, a list of all cases in the population, from which the sample should be selected, needs to be established (Esaiasson et al, 2007). Svenskt Näringslivs Index (SNI), conducted by Statistics Sweden (SCB, 2003) is an approach to classify and organize Swedish companies in which every industry has been given a letter (SCB, 2007). The manufacturing industry as a whole has been given the letter D and the specific sub industries within, has each been given a number. According to Fabrefaccio (2005), companies within the manufacturing engineering industry can be found in the categories (codes) 28-35. In order to compose a list of those companies in the categories of interest, the database *Affärsdata* was used. Affärsdata is a database in which one can search for companies within each SNI code. Furthermore, the search can be restricted by a number of variables. To establish a list of all cases in the population, companies with a turnover less than SEK 20 million was eliminated. For every SNI code three searches were made, one for each strata, by adjusting the turnover restriction. The final list of entities of analysis within each stratum was alphabetical and began with the first company in SNI category 28, and ended with the last company in category 35. The population in total contained 2973 companies, 2076 small, 686 medium and 175 large sized ones. Out of each stratum, 33 companies were selected using random sampling.

The random sample itself was carried out in the statistic program SPSS. More specifically, the procedure was to let SPSS randomly choose 33 numbers out of the population in each stratum. For example, within the stratum containing large companies, SPSS se-

lected 33 numbers between 1 and 175. Then, the companies corresponding to those numbers, in the created list from Affärsdata, were selected.

3.1.4. Designing the study

The chosen research design can be classified as a quantitative, non-experimental survey (Creswell, 2002). A survey can be either of an explaining or describing character (Esaiasson et. al, 2007). This thesis is mainly of a descriptive character, clarifying how the carrying charge is determined. Due to the nature of research problem and the lack of previous research within the field, the survey can also be labeled as explorative (Kvale, 1997).

3.2. Collecting empirical data

When collecting empirical data, one can distinguish between two types; primary data and secondary data. Secondary data refer to data that is already available as it has been collected and analyzed for other purposes (Johansson-Lindfors, 1993). Primary data, on the other hand is collected primarily for the specific purpose in question. Secondary data, in this thesis, consist of the material in the theoretical frame of reference. The primary data in this thesis consists exclusively of information generated by phone interviews. However, the questions asked during the interviews draw heavily upon the material in the theoretical frame of reference.

3.2.1. Primary data collection

There exist a number of different techniques for collecting primary data. By and large, these methods can be divided into three broad categories; to ask people, to observe people and to observe physical traces and evidences of human activities (Esaiasson et el, 2002, p.215).

The overall approach for collecting primary data applied in this study has been to interview persons. The aim has been to find out what each asked person has to say about the research problem. In principle, the same questions have been proposed to all persons taking part in the survey. Therefore, the chosen method can be classified a *respondent survey* (Esaiasson, 2002).

Furthermore, within the field of respondent surveys, one can choose to carry out either an in-depth interview survey or a question interview survey (Esaiasson, 2002). Each of the

two methods is more suitable for some research problems than others. The aim with an in-depth survey is to gain deep knowledge concerning the interviewed person's answers on the research subject. A question interview survey on the other hand, is more structured, with the researcher asking the interviewed persons the same questions. The aim is to be able to describe how common different answers are in a certain population of people. (Esaiasson, 2002) As a result of the feasibility study, as well as the characteristics of the chosen research problem, a question interview is preferable in this thesis.

Question interviews: A survey can be carried out either by distributing questionnaires by post or by conducting telephone-or personal interviews (Esaiasson et al, 2002). In this survey study, telephone interviews have been chosen as the primary method for collecting (primary) data.

One can identify a number of advantages associated with conducting telephone interviews. As our intent is to investigate our research problem on a nation wide level, it is more cost-efficient to carry out interviews over the phone then in person. Furthermore, telephone interviews are preferable to other methods when the study includes a large number of respondents and when few, rather than many, questions will be asked (Esaiasson et al, 2002). As this is the case in our study, we find the chosen data collection method justified. Moreover, it has been noted that people are more willing to participate in an interview than to answer a written questionnaire (Esaiasson et al, 2002). The given time limit, naturally, favours a telephone interview approach.

A phone interview approach does, however, generate a few less desirable consequences. During a personal interview, the researcher is able to observe the respondents body language in order to make sure that the respondent has understood the question. However, during a telephone interview, the researcher is limited to only the respondent's voice when evaluating if the respondent has understood the question correctly. Regardless of the type of interview, telephone- or personal, it is likely that the interviewed person will be affected, whether he/she is aware of it or not, by the researcher. This is referred to as the "interviewer effect" (Esaiasson et al, 2002). This "disturbance" can arise from a number of things, such as the pitch in which the researcher speaks and the speed of his/hers voice.

The respondent's refer to the persons that we have spoken to in the companies that are included in the survey. They have been chosen due to the belief that they are the ones with the greatest knowledge of the carrying charge. After deliberation, it has been decided that a chief of business or a chief of logistics/purchase probably is the best person to interview. In those cases where the first person spoken to does not have sufficient knowledge of the subject, he/she has been asked to direct us the person that has this knowledge.

The general procedure when carrying out the phone interviews has been as follows;

1. Call the "telephone switchboard" of the actual company.
2. Explain the purpose and subject of the thesis and ask for the respondent or, if suggested by the receptionist, someone more appropriate for the interview.
3. Interview that person, possibly call another person within the company or call back another day.
4. Summarize the result.

Designing the questionnaire: Method literature provides a number of suggestions and recommendations when it comes to designing questionnaires. As the questionnaire used in this study will not be sent out to the respondents, the aspect concerning the importance of a visually appealing layout will not be addressed.

The questions asked during the telephone interviews in this study have been designed with the method literature as a staring point and the final decision was researched after consultation with our supervisor. The questionnaire is composed of both open-ended and closed questions. Open-ended questions are questions without predetermined answering alternatives (Esaiasson, 2002, p.259) and are useful when there exist many possible answers to a question or when one wishes to establish the importance and topicality of a subject (Eriksson and Wiedersheim-Paul, 2001).

Moreover, one must pay attention to the order in which the planned questions are asked. The telephone interviews will begin with a few general questions that are neutral and easy to answer. The intent is to welcome the respondent into the interview and create a positive atmosphere (Esaiasson, 2002, p 271). Then, different questions will fol-

low for different respondents, depending on their previous answers. Finally, the last section of the interview will contain questions that one might referee to as sensitive issues (Trost, 2001). In the case of our survey, the sensitive question concerns the actual size of the companies` carrying charge. As our study is of a quantitative character, it is neither interesting, nor important, to identify which company has given which answer. The respondents can therefore be guaranteed anonymity, which naturally increase their willingness to answer.

A final concern when creating a questionnaire is the design of the actual questions. Creating neutral, unbiased and relevant questions can be considered one of the most difficult tasks when designing a survey (Esaiasson, 2002, p.272). Therefore, a lot of effort has been put into determining and creating the actual questions in order to preventing this type of error. Primarily, effort has been made to eliminate so called leading questions. To further increase the quality of the questions, the questionnaire has been tested on three persons chosen by convenience.

Presenting the results: The conducted survey generated a substantial amount of primary data. The overall approach has been to illustrate how the results differ between companies with different turnovers. Thus, bar charts have been used to present the answer frequency in each turnover stratum. In some of the diagrams, a bar labeled not applicable (n/a) has been included. This category contains those cases where no data has been available. The lack of information is a result of the respondent's inadequate answers or total lack of knowledge of the subject. Furthermore, those cases in which the interviewer has decided that there is no use in asking the question, as a result of the respondent's lack of understanding and willingness to answer, has been comprised in this category. The "not applicable" category has been constructed in order to eliminate those cases with inadequate reliability, in order to enhance the quality and reliability of the survey as a whole. Moreover, all diagrams show absolute numbers. Some of the results from the survey are not relevant for the main purpose for this thesis Therefore, these results, which are not presented and analyzed in the following chapters, can be found in appendix D.

3.2.2. Secondary data collection

Secondary data used in this thesis, presented in the theoretical frame of reference, consists mainly of technical literature rather than scientific articles. This is due to the fact that not much research has been done on the subject of carrying charge. A lot of time and effort has been put into the search for scientific articles. Reliable and well known databases covering business economic subjects such as Business Source Premier, Emerald Insight and S-WoBa have been used. In order to provide a context of the carrying charge, papers and thesis contiguous to the subject has been used, as the lack of focus on the topic is present in this category of sources as well. Therefore, the extent to which the thesis relies on primary data is great.

3.3. Credibility of the study and the empirical material

The following sections will discuss the credibility of the study and empirical material. Great emphasis has been put on the sample selection method.

3.3.1. Reliability and Validity

The reliability of the survey is to what extent one can trust the results that are received by the instrument of measure, in this case the questionnaire. The same questions are asked and asked in the same order, however three different authors have asked the selected companies and due to that the questions and answers have a grade of subjectivity. The reliability explains to what extent the result would take the same shape if it would have been conducted several times. Random sample, subjectivity and incorrect interpreted people are factors that contribute to a low grade of reliability. (DePoy & Gitlin 1994)

Validity is referring to what extent the results are correct and reflecting the main purpose of the survey. The validity can be explained from different points of view, internal, external, statistical, and validity of conception. Concerning our conducted survey the internal validity is vague due to the fact that the instrument of measure is the answer sheet of the survey, which has a grade of subjectivity. To be able to generalize the results, the external validity, is of importance. The aim is to generalize; however, the aim is not fulfilled since only a small number of companies actually make use of a carrying charge. Expressions and terms that are used might not have the same meaning to all responents. Therefore, the respondent might have understood the question differently than

the original aim. This can be referred to as the validity of conception. If there was a greater time period for the study, it would have been possible to call those companies', that has given inadequate answers, again and ask confirming questions in order to fulfil parts that may be important for the survey. (Depoy & Gitlin 1994)

3.3.2. Reduction of entities of analysis

One frequently occurring source of error in random sampling is the reduction of entities of analysis. Generally, one should count on a reduction between 20-35 percent of the proposed cases (Esaiasson et al, 2007). It is important to discuss what the reduction will mean for the representative of the sample, as well as analyze what flaws in the chosen method has given rise to the reduction.

In our study, the original sample suffered a reduction of 33 entities of analysis. Part of the reduction was 13 companies that could not be included due to lack of update in SNI. These companies did not hold an inventory, were not a producing company or did not have correct contact information Therefore should these companies be replaced by a new random sample. However, due to the time limit it was not possible. Hence, these companies are counted as a reduction of the sample even thought they should be excluded and should be replaced by a new random sample.

The distribution of the reduction was to a great extent distributed evenly between the different strata. 23 small companies, 23 medium sized companies and 20 large companies remained after the reduction. As a result, one can argue the sample is still representative of the original stratified population. Furthermore, not all questions have been answered by all companies. A fairly large reduction of answers can be found in most of the questions concerning the actual determination and application of the carrying charge. Those questions where a reduction of answers has been substantial have been eliminated from the empirics as well as the analysis. However, some questions with large answer reduction have been kept as they are still of importance to the study.

It is important to analyze what has caused the reduction. Essentially, the reduction of companies not participating in the study at all is a result of the list containing all cases in the population being inadequate. However, the SNI-system and Affärsdata are probably not inadequate in themselves, only unsuitable as a tool to separate the population in this study. For example, quit a few companies that were suppose to be manufacturer,

did in fact, not produce any goods, hence did not belong to the population. Some companies were classified in two categories at the same time. Other companies had gone bankruptcy or gotten acquired. Neither of these companies had been eliminated nor reclassified. Moreover, companies within the same group all occurred separately. As a result, some entities of analysis had a greater probability being selected for the sample. In general, this caused the main part of the reduction of entities of analysis. The second reason companies did not participate in the survey was because the authors had problems getting hold of the respondents. A dead line had to be set as to when the data collection should be finished. As a result, it was not possible to get a hold of all respondents. Surprisingly few companies actually declined to participate in the survey. Nevertheless, the authors are, on the whole, content with the chosen approach to use SNI and Affärsdata as there, to our knowledge, exist no better approach.

As of the reduction of answers for certain questions, the selection of respondents at each company has to be discussed. The choice upon which the respondents have been selected is purely subjective. It was the authors` believes that the respondent either should be a chief of logistic or a chief of business. In some cases, respondents were controllers or CEOs. However, as illustrated by the empirical result, quit a lot of the respondents were either not asked some of the questions, or could not answer them, due to their inadequate knowledge of the subject. This implies wrong respondents have been chosen to participate. In some cases where the respondent clearly was not able to answer the questions, another person within the company has been contacted. The reduction of answers is a consequence of the fact that the authors were unable to accurately foresee which occupation the respondent should have in order to possess a wide knowledge of the subject. To our defense should, however, be said that in some companies the lack of knowledge concerning the carrying charge was total, regardless of whom was asked.

4. Empirical results

The following part of this section provides a description of the distribution of the studied sample. The population consists of 2076 small companies, 686 medium sized companies and 175 large companies. The characteristics of the population and the sample are defined and discussed in the methodology chapter. The sample studied in the survey comprises 23 small companies, 23 medium sized companies and 20 large companies.

4.1. Inventory structure and management

This section aims to illustrate the inventory structure and inventory management among the surveyed companies. First, the different types of inventories, as well as the number of inventories, in the surveyed companies are accounted of. Then, the empirical results concerning different approaches of inventory management are shown. As discussed in previous chapters, inventory management concern when and how much to order.

The following diagram presents the different inventory types, categorized as raw materials inventory, process inventory and finished good inventory. As seen in the diagram all three types of inventory are found in each stratum. There is a difference between the strata concerning finished good inventories, which are more commonly found in medium and large companies. Other inventory refers to inventories for spare parts. It can be seen that some companies have a finished good inventory but not a raw materials inventory and vice versa.

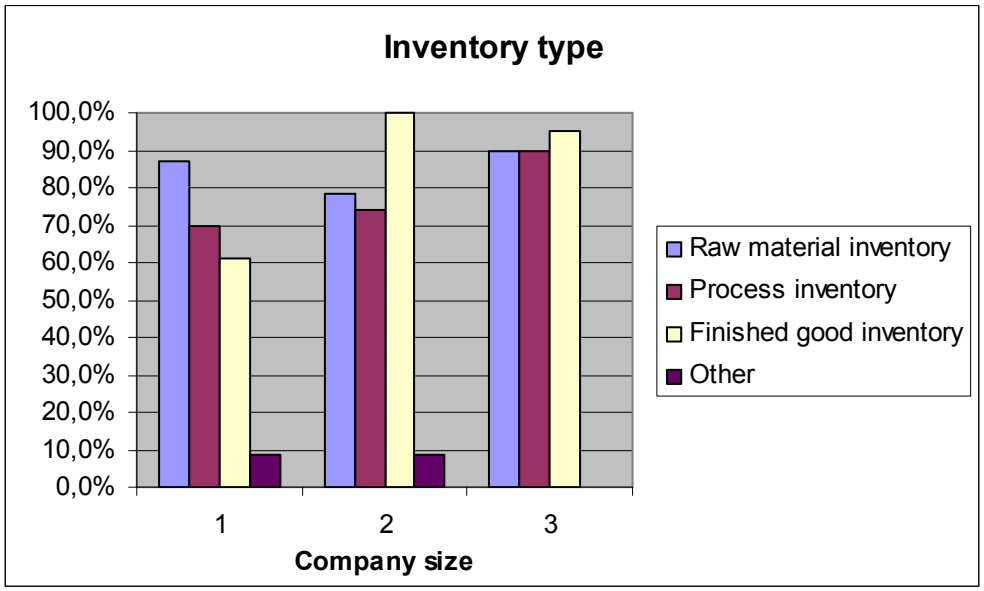

Diagram 1: Inventory types

To further emphasize the inventory structure, the following diagram has been constructed. It presents the same data as the previous one, only expressed in a different way. The diagram show how many companies have one, two or three of the mentioned different inventory types.

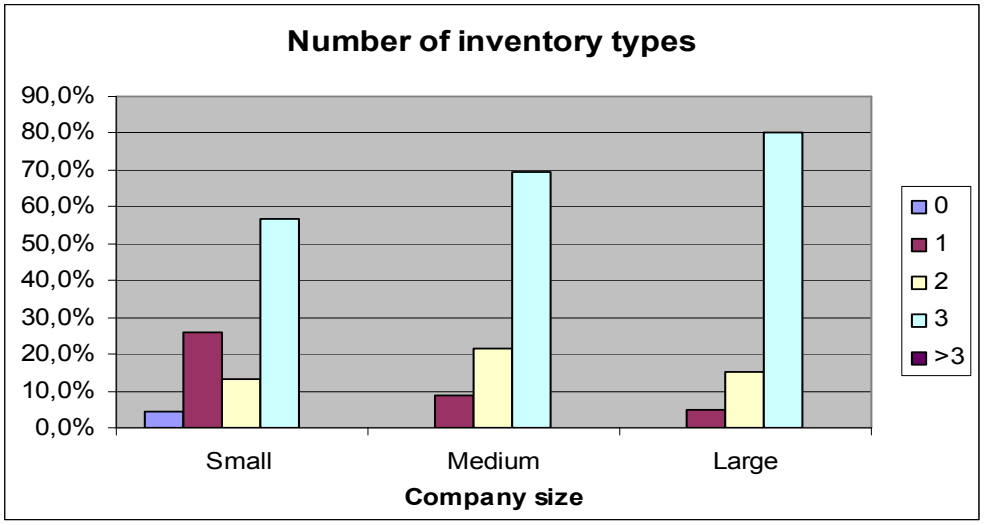

Diagram 2: Number of inventory types

It is most common among the companies in the sample to have all three types of inventory. Having fewer inventories than three is most frequent in small companies, in comparison to the other stratum.

4.1.1. Material planning methods

Material planning methods are used to determine the point in time when an order should be placed. The respondents were given predetermined answers to this question that they could choose from. However, some other answers did occur that did not fit into any category, hence new categories were created. The questionnaire, containing the original predetermined answer categories can be found in appendix C. The new answers emerging during the data collection were, among other; Forecasting, Experience based and Business solution. The category "other" contains a variety of different approaches to material planning specific for different companies.

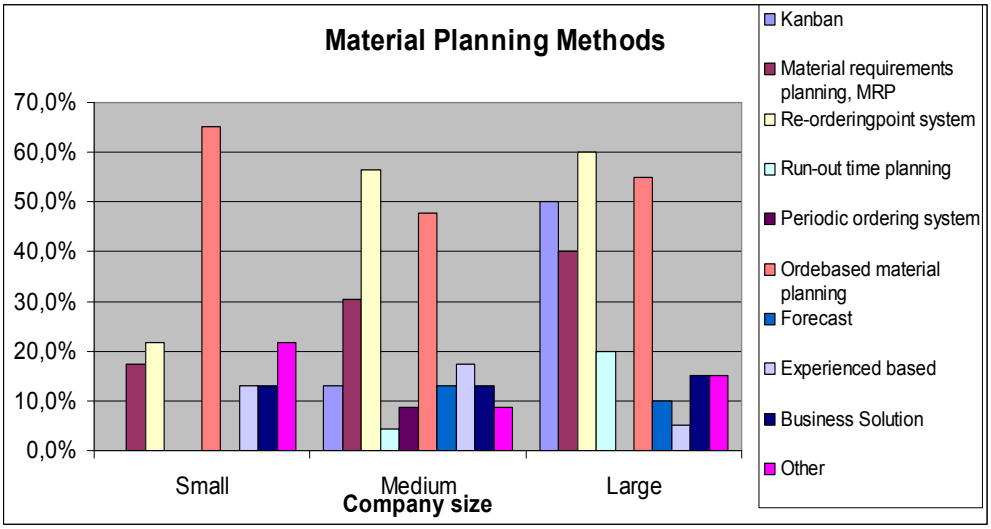

Diagram 3: Material Planning Methods

One method is dominating the total usage of material planning methods; order based material planning. This method is more common in the stratum with small companies than it is in the larger companies. Re-ordering point systems and periodic ordering system are the next two most common methods in all different company sizes. Kanban is used fairly often among the larger companies meanwhile it is not used at all in the smaller companies. Experience based ordering methods, which might not be seen as a traditional material planning method, is more commonly exercised in the small and medium sized companies than in the large sized companies. Other suggested solutions, that came up as answers during the survey, concerning the determination of the point in time when to place an order was to use safety stock as a measurement, purchase when the inventory was empty, consignation with supplier or an outsourced yearly plan forecasting when to order. These answers are included in the category "other".

4.1.2. Order quantity determination methods

The second decision within inventory management is to determine how much should be ordered, *videlicet*, the order quantity. Four different categories by which a company can establish their order quantity has been constructed; EOQ, experienced based, order based or other methods. This presentation is chosen in order to distinguish and emphasize the number of companies using EOQ versus other methods. It is interesting to

compare the number of companies using EOQ with the number of companies that apply a carrying charge as the EOQ- formula includes the inventory carrying costs as a component.

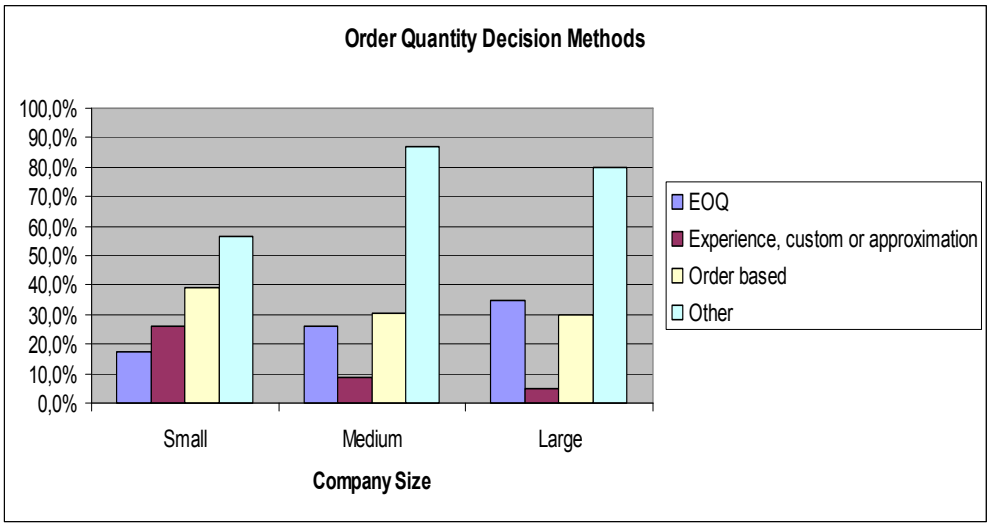

Diagram 4: Order Quantity Decision Methods

The diagram shows, EOQ is used by four small companies, six medium sized companies and seven large companies. In comparison to the category "other methods", EOQ is used less frequently. However, the category "other methods" contains a number of different methods such as; minimization of logistics costs determines order quantity, fixed order quantity, and MRP. The only single method used by more companies than EOQ is order quantities determined by the company's own orders (order based), which was the case in the stratum with small and medium sized companies. In the stratum with large companies, EOQ was the most used order quantity determination method, followed by the order based approach.

4.2. Usage of carrying charge

The following section will provide an overview of the results from the more significant part of the survey, namely that concerning the usage and determination of the carrying charge. First, the distribution of users versus non users of carrying charge is accounted of. Then, amongst those companies that apply a carrying charge, the results regarding

how it is determined are presented. Finally, data on companies that do not apply a carrying charge is shown.

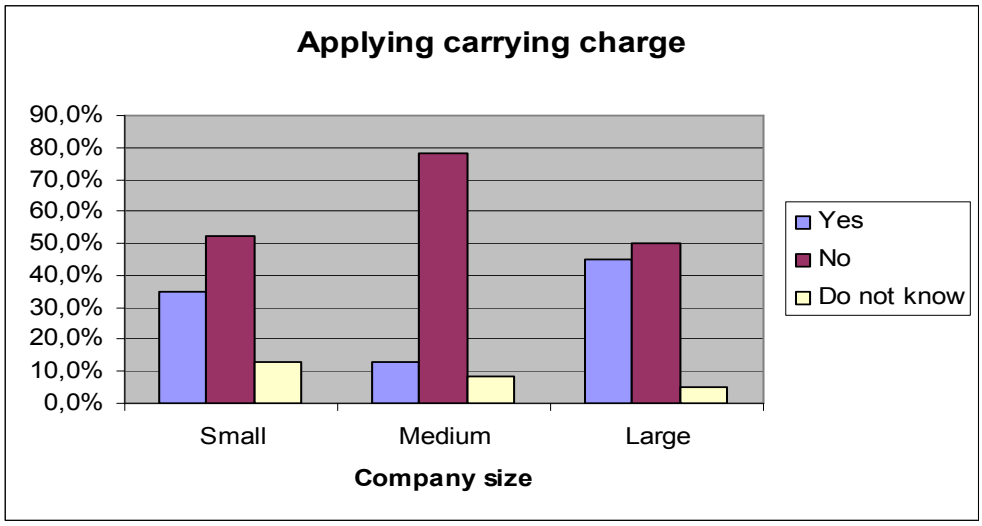

Diagram 5: Application of carrying charge

As can bee seen in the diagram, approximately one third of all companies in the remaining sample apply carrying charge. However, the distribution varies between the three stratums. In the stratum containing large companies, nine companies apply carrying charge, in the stratum containing small companies, eight companies use carrying charge and in the stratum containing medium sized companies, only three companies apply carrying charge. Moreover, a total of six companies did not know if a carrying charge was applied. The remaining 40 companies in the sample did not apply a carrying charge.

Furthermore, those companies not applying carrying charge were generally not at all, or only to a small extent, familiar with the concept.

4.2.1 Carrying charge applied

This section will provide a description of how the carrying charge is managed in those companies that apply it. The intent is to illustrate who in the company makes the decisions regarding the carrying charge as well as to establish its (the carrying charge's) relative importance.

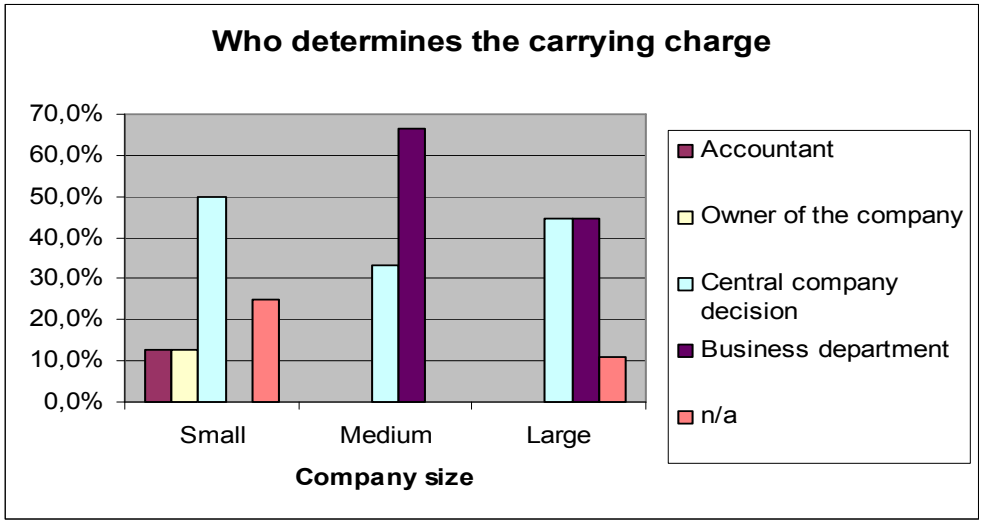

Diagram 6: Who determines the carrying charge

The diagram aims to illustrate where in the company the decision regarding the size of the carrying charge is taken. More specifically, the presented data show the department in charge of determining the carrying charge. As can be seen in the diagram, two answers dominate;. Either the carrying charge is determined by the company's business department, which is locally, situated on the work place where the interviewed person works. Or the carrying charge is determined by a central company authority, which is found higher in the organization, and given to the company. The latter refers to situations in which a company is part of a group and the carrying charge is predetermined by a mutual central department.

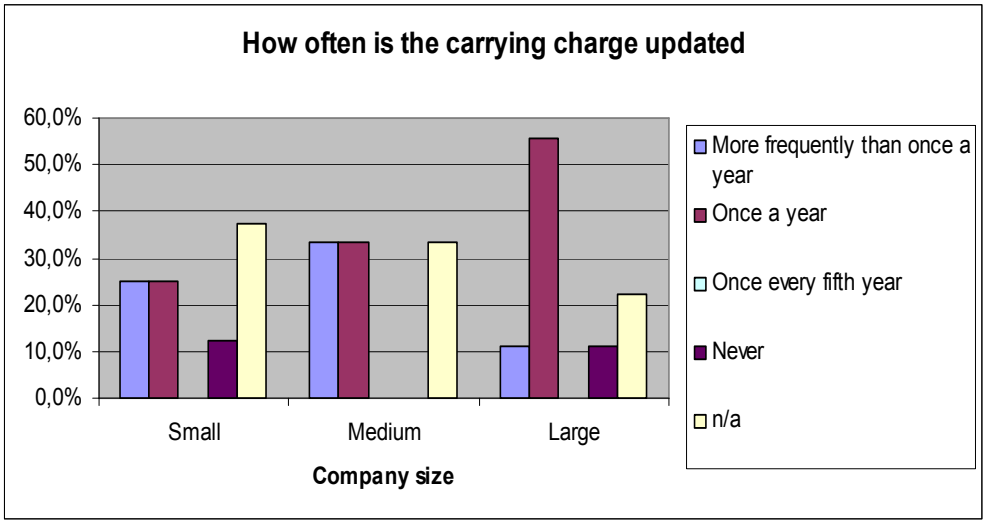

Diagram 7: How often is the carrying charge update

The diagram shows it is most common among the total number of companies in general, and large companies in particular, to update the carrying charge once a year. In the stratum containing small companies, fewer companies were aware of how often their carrying charge is updated. Some companies update their carrying charge more frequent than once a year, for example every sixth months or every third months. In contrast, two respondents answered they had never changed their carrying charge.

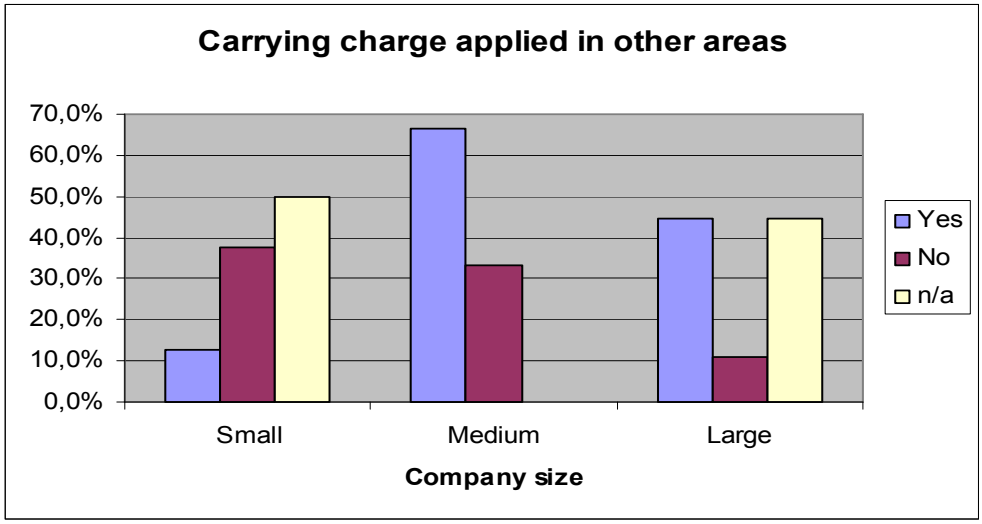

Diagram 8: Carrying charge applied in other areas

The diagram illustrates the usage of carrying charge in other areas than to determine inventory carrying costs. By other areas, the authors refers to situations in which the carrying charge is used a financial means of control or serves as basic data for decision-making. As can be seen in the diagram, it is more common to use the carrying charge for other purposes than to calculate inventory carrying costs in large companies than it is in smaller and medium sized companies.

The actual size, expressed as a percentage, of the carrying charge in the companies in the sample is presented in the diagram below.

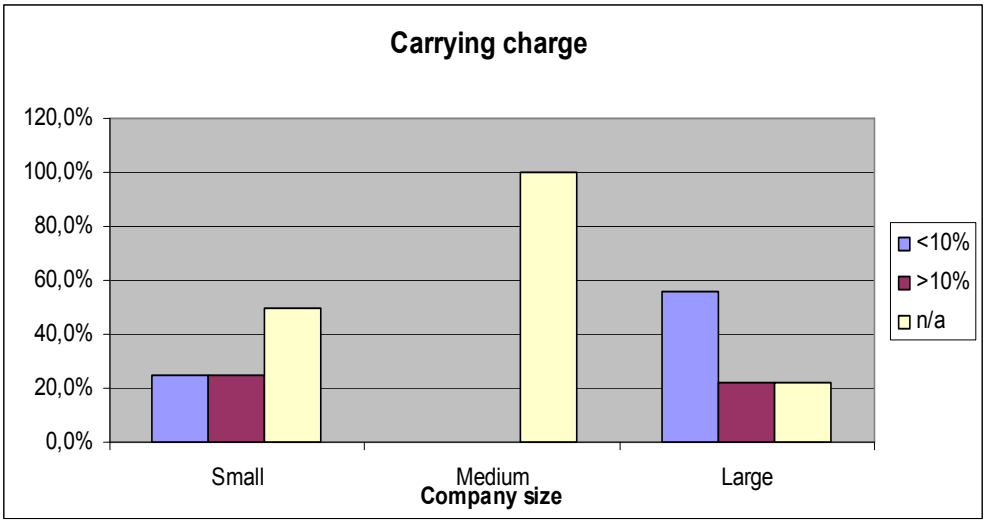

Diagram 9: Size of the carrying charge

4.2.2 Determination of the carrying charge

According to this survey, there are mainly two different methods used for determination of the carrying charge; by calculation or by approximation. Following section will present how the companies within the stratums determine their carrying charge.

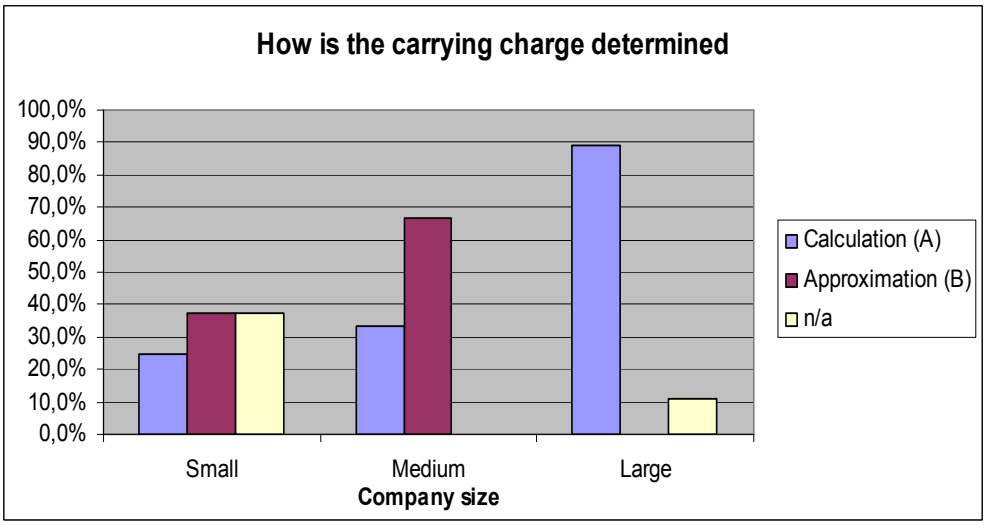

Diagram 10: Determination of the carrying charge

A great deal of the large sized companies determines their carrying charge by using some sort of method to calculate the carrying charge. In the small and medium sized companies the approximation method is more common.

4.2.3 Carrying charge calculated

Companies calculating the carrying charge take a number of different components into consideration. These components are cost of capital, storage costs, risk cost and/or service cost. Following diagram shows how frequent the different components are within the different companies.

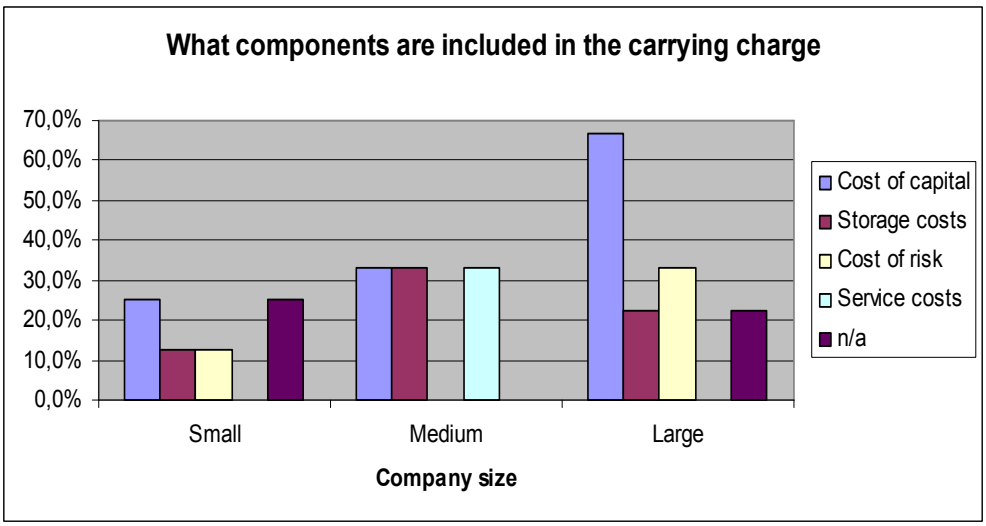

Diagram 11: Components included in the carrying charge

The most frequently applied component in the stratum with large companies is the cost of capital, followed by the component cost of risk which is also frequently applied. As shown above, the component cost of capital is moreover commonly applied among the companies in the other two stratums, small and medium sized companies. On the other hand, according to this survey the component service cost, is not applied at all within the large companies and no more than one medium sized company is taking this cost into consideration. Storage cost, is also considered in all three different stratums. However, it is more frequently applied among large companies than it is within small and medium sized companies.

Cost of capital: To calculate the cost of capital most companies in the sample calculate the required income from capital invested in inventory. To calculate this, the borrowing interest rate is considered. In one company a predetermined formula is decided in order to appoint the cost of capital. The occurrence of the WACC as an estimate of the cost of capital does not exist at all in the surveyed companies; however, one company has applied the WACC previously but has abandoned this method.

Storage cost: Components that were found in this cost were: Salaries to warehouse personnel, equipment, storage space, and cost of managing, depreciation.

Cost of risk: In general the cost of risk composes a very small part of the carrying charge. Most of the suggested answers stated in the questionnaire were parts of this cost. (see appendix C) Cost of obsolescence is a cost that is considered in all the surveyed companies. In two of the companies, wastage is included in the cost of risk, but in the other two this cost was too small to be considered.

Service cost: Only one company admitted to include the service cost in the carrying charge and their cost consisted of insurance and taxes.

4.2.4 Carrying charge approximated

In the carried out survey, the result showed that some companies approximate their carrying charge. Among these companies it is interesting to know what the approximation is based on. Nevertheless, few companies actually knew what their approximated carrying charge was based on.

Among the companies that determine the carrying charge by approximation, the question whether the respondent has the possibility to affect the carrying charge, or not was asked. The result from this question shows that only among the small companies the respondents have the possibilities to affect the carrying charge. This question is not presented in a diagram, since the possibility to affect the carrying charge is quite small.

4.2.5 Carrying charge not applied

The majority of all companies participating in the survey did not apply a carrying charge in order to calculate their inventory carrying costs. More exactly, 40 of those 66

asked companies, answered that they did not use carrying charge. Of interest, therefore, is to identify why the carrying charge is not applied and also what is used instead.

The answers to this question varied quite substantial among the respondents, resulting in a fairly large frequency of "other" variants in the diagram. Some companies considered the actual costs of manufacturing whereas others focused on the level of tied up capital. Moreover, focus on cost reduction, shortage costs and cost level limits are answers that are categorized as "other". However, most of the companies answering this question stated that inventory carrying costs were calculated and considered in some sort of sales or cost estimate as an additional charge. Also, some companies stated they did not calculate inventory carrying costs at all. Finally, a few companies answered that they focused on the inventory turnover rate rather than the inventory carrying costs.

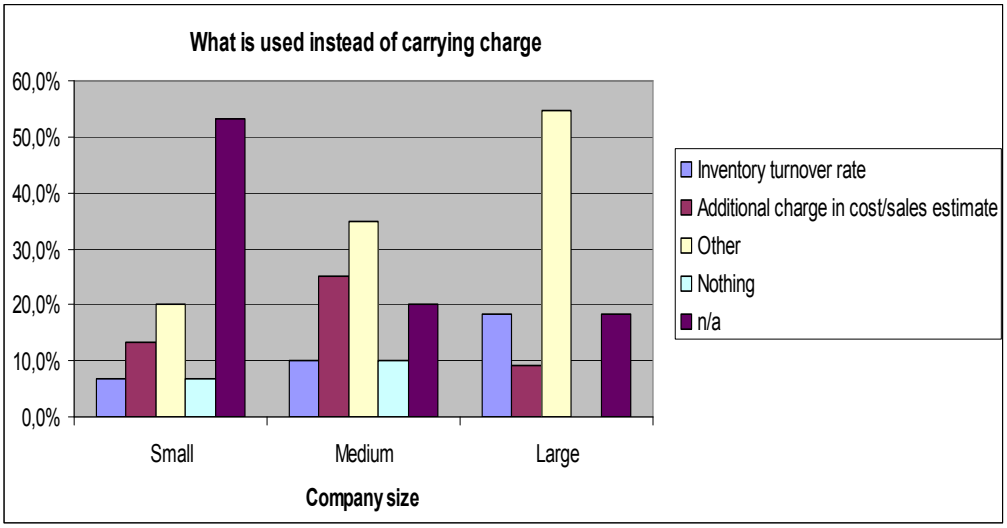

Diagram 12: Alternative ways to consider the inventory carrying costs

The most common reason for not applying a carrying charge, among the small companies in the survey, is because stated reasons such the size of their company, or inventory is too small. In the medium sized and large companies, carrying charge is not used as other measurements, rather than inventory carrying costs, are considered important and hence used.

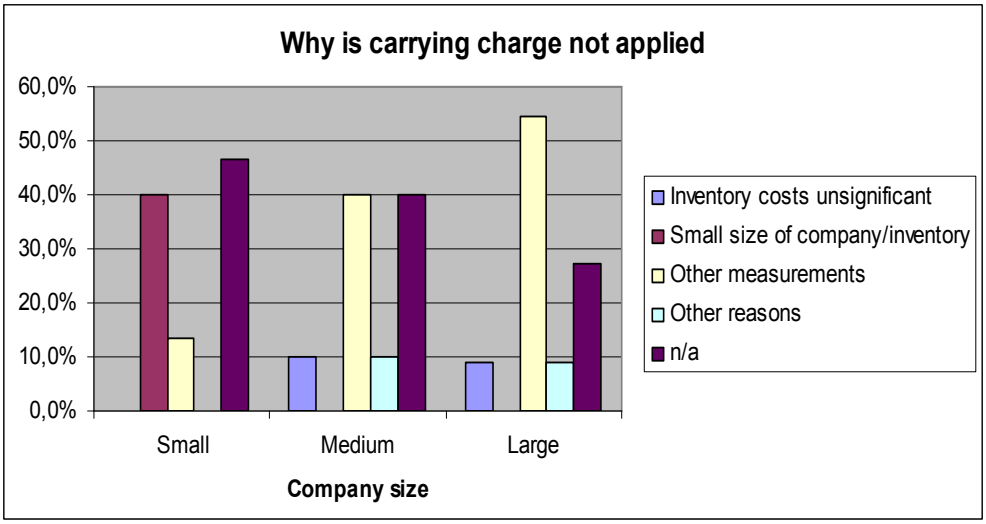

Diagram 13: Why carrying charge is not applied

5. Analysis

This chapter will provide an analysis of the research problem, with respect to the empirical result and theoretical framework. Before conduction this analysis of the empirical result the analysis model for this thesis will be explained.

5.2 Analysis model

For the analysis a quite straight forward method has been created and applied. An analysis is based on the empirical material with reference to the theoretical framework presented. The figure below illustrates the constructed analysis model for this research problem.

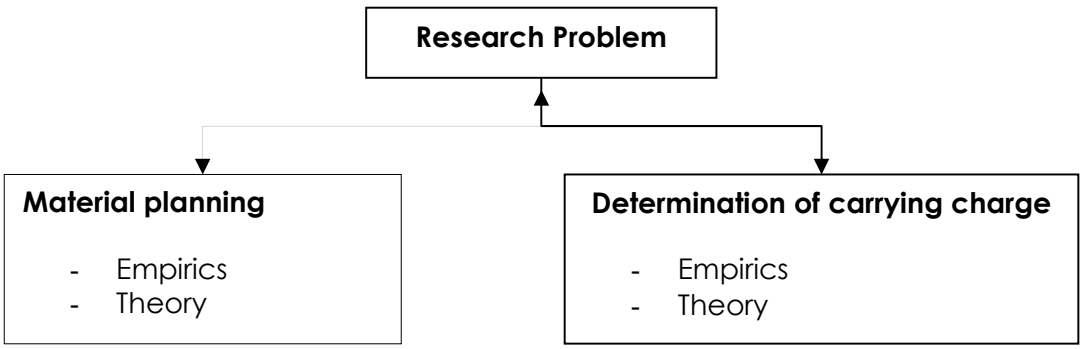

Figure 2: Analysis model

The model is based on the research problem and has thereafter been divided into the two problem parts; material planning, determination of carrying charge and the connections between the two. Both of these parts will be analyzed by comparing the empirical data with the theoretical framework.

5.3 Material planning

When to order is one of the basic questions in inventory management. Companies can, as addressed in the theoretical frame of reference, use different methods to resolve these issues. When analyzing the extent to which Swedish manufacturing engineering companies use a carrying charge, one can investigate what method they use in inven-

tory management in order to see if it is necessary for these companies to apply a carrying charge.

All of the companies in the survey carry inventory either before, during or after the production process. Therefore, they need to consider how to manage their inventory. In our survey there is rather widely spread result concerning the use of material planning methods. However the most common used methods are order based material planning and re-ordering point system. Moreover, in large companies it is common to use kanban. In comparison to the results of the survey of Jonsson and Mattsson (2005) as discussed in the introduction chapter the result is not surprising. Their findings also show that the re-ordering point system is used to some extent by 73 percent of their surveyed companies. They also found that kanban was used in the larger companies but not in the smaller companies which coincide with our findings. Out of the most common methods for material planning, in our survey, it is only the re-ordering point system that can be associated with the application of carrying charge. This is because, as explained in the theory, the re-ordering point is set as a result of weighing the cost of holding inventory to the short out cost. Therefore it could be argued that since a large number of the companies in the survey use this method they also need to be aware of their inventory carrying costs. However, not as many percentages that have a re-order point system are applying a carrying charge. Nevertheless it should be said that these companies could be deciding their inventory carrying cost by using other means than the carrying charge.

5.4 Determination of carrying charge

Not a large percentage of our surveyed companies use carrying charge. As shown in the empirics, 20 out of the 66 companies in the carried out survey use a carrying charge. This part of the analysis will be focused on how those companies that use carrying charge determines it. As explained in previous chapters there are two basic methods for determination of carrying charge; calculation or approximation.

11 out of those 16 companies that could answer how they determined their carrying charge stated that they calculate it. Even though that this survey can not claim that this is generally how the carrying charge is determined in the overall population, this implies calculation is the most common method amongst the companies in the survey. When

comparing our findings with the theoretical references and experiences of others, our results differ. This is due to the fact that for example Mattsson (2003) state that according to his experience, calculation method is the least used method for determination of the carrying charge. Also Jonsson (2005) argues that other methods than calculation is common. Berling (2005) supports Jonssons and Mattssons statements regarding the carrying charge as he argues that the calculation method is seldom used. The difference between our findings can be a result of the different methods used to investigate this matter.

As explained in previous chapters, when calculating the carrying charge, different components can be included. However, far from all companies in the survey that calculates the carrying charge include all of those components. The occurrence and frequency of these components are analysed below.

The cost of capital is applied in most of the companies in the carried out survey in their calculation of the carrying charge. This cost is believed to be one of the largest components of the inventory carrying cost (Berling, 2005), which is probably an indication of why this component is so widely used among the companies in the survey. According to theory, the cost of capital should reflect the company's expected rate of return of the invested capital in inventory. Therefore a good approximation of the cost of capital could be the company's WACC or opportunity cost capital. However the companies in our survey answer they use the borrowing cost to determine their cost of capital. These findings are in line with the findings of Gaither and Fraser (1984) referred to in Berling (2005) that shows that most companies are using the borrowing rate to determine cost of capital. To use the borrowing rate and not another financial measurement, such as WACC or the opportunity cost could be justified since the borrowing rate is easy to determine and as most companies to borrow money in order to finance their inventory investment (Berling, 2005). The consequences of using a borrowing rate is that it does not take into consideration the return that could have been received from other investments made possibly by that capital.

Storage costs are not included as often as the cost of capital. The reason for this could be that the main part of the storage costs does not vary significantly with the level of the inventory. Mattsson (2003) argues that since the carrying charge should reflect the

incremental costs, the component storage cost would make up an insignificant part of the carrying charge. Four of the companies in the survey include storage cost in their calculation of carrying charge which can either imply that the incremental storage cost are substantial or that this cost is simply intuitive.

The cost of risk as explained in theory (Jonsson, 2005) is very hard to estimate. This might be the reason only four companies include this cost in their calculation of carrying charge. Among these companies, that include this cost, most include the subcomponent obsolescence cost. The reason for this could be that it is a cost that naturally should be included. The other subcomponents such as pilferage and damage are costs that could be avoided with correct internal controls. Obsolescence cost on the other hand is affected by external factors that can not be controlled. According to Mattson (2003) the carrying may not be the best tool considering the cost of risk.

According to theory, the service cost is a very small cost included in the carrying charge, usually less than one percent according Mattsson (2005). In the survey only one company included service cost. A substantial part of the service cost is the insurance cost. The insurance cost depends of the value of inventory and are generally set for a fixed period of time. If the time period is short then the insurance cost can be seen as to vary with average inventory level and therefore can be seen as an incremental cost that should be included in the carrying charge (Berling, 2005).

The second method for determination of the carrying charge is approximation. This method is applied in 5 of the surveyed companies in contrast to theory which suggest that approximation is the most common method for the determination of the carrying charge (Berling, 2005; Lambert et al, 1998; Mattsson, 2003). To determine the carrying charge based on approximation can be seen as an easier method to apply than to calculate the carrying charge, the cost of applying it is rather low. Out of those companies approximating the carrying charge, one company stated their approximation was based on a recommended figure from an economic handbook. One other company received a carrying charge based on an industry average carrying charge recommended by an industry organisation. Both these methods for approximation of the carrying are methods that are frequently mentioned in literature.

One other dimension of the determination of carrying charge, apart from the components included in it, is the frequency by which it is updated. That is, how well changes in the included components result in changes of the size in the carrying charge. There exits no specific theory regarding how often the carrying charge should be updated. However, as discussed in previous chapters of the thesis, Berling (2005) has found that the size of the carrying charge used among many companies today have been recommended in textbooks dating back to the 1940`s, implying the aversion, or lack of necessity, amongst companies to update the carrying charge. Our survey shows that very few companies in the sample never or seldom update their carrying charge. The majority of the companies update their carrying charge once a year. However, some companies updated their carrying charge more frequently.

Explanations for changing the carrying charge frequently, in comparison to never change it; can be that the included component when calculating the carrying charge changes. For example, companies including a cost of capital, which most of our surveyed companies does, might update this component if conditions affecting their cost of capital changes. It can be argued that an update of the carrying charge is done at the same time as other financial decisions, such as budgeting and annual reports. The results further shows companies update their carrying charge more frequently than once a year. Other financial instruments, for example the interest rate on borrowing set by the national bank is updated more frequently than once a year. Furthermore, the WACC changes as soon as the specific company risk, capital structure or cost of capital changes. As most of the companies calculate their carrying charge base their capital cost on the borrowing rate, they have reason to update their carrying charge when their borrowing rate changes. Naturally, companies that have decided the size of their carrying charge by using industry standards or consulted a textbook are less inclined to update the charge than those who calculate it.

After discussion how to determine and when to update the carrying charge it is also important to analyze who decides the level of carrying charge, either when approximated or calculated. Jonsson (2005) argues it is not unusually that the determination of the carrying charge is a central decision. In most of our surveyed companies, the carrying charge is determined by the business department or by a central company unit; such as the company management or by central management if the company belongs to a

group. By definition, this means that the carrying charge is not determined by those actually affected by it, *videlicet*, the inventory managers or chief of logistics. This implies the carrying charge is a financial matter rather than a question for the logistics department. This statement can be strengthened by the fact that, during the carried out survey, those respondents having the greatest knowledge of the carrying charge were those working either in the business department or at a high management level.

The final aspect on the determination of carrying charge is the actual level of it. It is especially interesting to compare with theory and textbooks recommendation. As discussed in the above sections Berling (2005) carried out a survey in which he found support for a carrying a charge of 25 percent being used among companies. According to our survey there were only three companies having a carrying charge greater than 17 percent. The majority of the companies that were aware of their carrying charge level stated it was less than 10 percent. One possible explanation for the divergence for the two studies could be that the surveyed companies have included different components in their carrying charge.

Finally, it can also be mentioned that during the survey, illustrated by the empirical data, a few companies did not know how their carrying charge was determined, *videlicet*, what factors affect it. Reasons for this result and why companies actually are making use of an inventory control tool without having any further information about it can vary. Primary it can be explained by the lack of resources, such as time and money.

5.5 Connection between carrying charge and material planning

One of the main areas of application for the carrying charge is in economic order quantity determination. In order to apply the Wilson formula, the company needs to establish their inventory carrying cost as it is included in the equation. In our survey 17 companies stated they applied economic order quantity, 4 small, 6 medium and 7 large sized companies. However there are 8 small, 3 medium and 9 large sized companies which state that they apply a carrying charge. Therefore it is important to emphasize that there are companies applying the EOQ model and not applying a carrying charge and vice versa. The two combinations are discussed separately. According to Jonsson (2005) it is important to be aware of how the carrying charge is determined when applying it in the determination of economic order quantity.

The first combination which is going to be addressed is when companies apply an economic order quantity but not a carrying charge. In our surveyed companies it is only 3 companies that have an EOQ but not a carrying charge. This is all medium sized companies. To apply a formula which is containing a component that does not exist within a company could be explained by various reasons. For example the company might calculate the holding cots by other means than the carrying charge. There could also be a variant of the EOQ formula which has been altered to be used without a carrying charge. One could argue that this is not correct since the basic principle here is to weigh the cost of placing an extra order towards the cost of holding one extra unit in inventory.

The other combination is to have a carrying charge but not apply EOQ. This was the case in four small companies and 2 large companies. The companies that are applying a carrying charge and not an EOQ model is an interesting field, in that sense they have a component that is not used n the logic field of application. Therefore, one can argue if it is a necessity or not to apply a carrying charge in the absence of an EOQ.

In conclusion, one might want to analyze whether or not the surveyed companies or any company have a reason to apply a carrying charge at all, *videlicet*, do they not apply one simply because it does not serve a purpose. According to the survey by Jonsson and Mattsson (2005), there are not many companies that actually apply an economic order quantity today. As discussed in the introduction chapter a third of the companies which also applies a material planning that enable them to influence the size of their order quantity use EOQ. In our survey we see the same tendency, as only 17 out of 66 companies (26 %) apply EOQ. However, we are not able to see the same correlation between the material planning method and EOQ. A reason that so few companies in the survey apply a carrying charge may be because they not use EOQ.

As shown in the compilation of the empirical data, the majority of all surveyed companies, regardless of size, possess three types of inventory. Per definition the calculated carrying charge includes the component, average value of inventory. The product in each inventory can not be claimed to have same value. Therefore, one can argue that a differentiated carrying should be used. Depending on the level of processing the product value will vary substantially. Jonsson (2005) further argues that it is common to

use one carrying charge for all the different products in the different inventories. Having to calculate multiple carrying charges imply, naturally, a lot more work and effort in order to determine the inventory carrying costs. This may be one reason why companies may choose not to apply multiple carrying charges. This statement is also supported by our survey where none of companies applied several carrying charges.

The empirics show several companies actually make use of the carrying charge in other fields than calculating inventory costs. For example, in one company the carrying charge was applied to control inventory levels and in another it was used as a base for other decision making. It can be discussed that companies using the carrying charge for other purposes might have more sophisticated methods for determination as well as more knowledge of the carrying charge in general. One can question if the usage of the carrying charge in other fields would affect the determination and size of it. Mattsson (2003) have been discussing the use of carrying charge as policy variable in order to control inventory levels. However we can not determine from our survey if the companies that use carrying charge for other purposes have determined the level of the charge based on other criteria's in order to be able to use it as a policy variable rather than reflecting the true inventory carrying costs.

Companies that are, according to themselves, too small in terms of overall activity or size of the actual inventory, have answered this is the reason a carrying charge is not applied. Furthermore, companies stating they have insignificant inventory carrying costs refer to this as their argument for not using a carrying charge. Furthermore, in a small company, there might not be a need to use such a complicated method as the carrying charge for determining the inventory carrying costs. This may be due to the fact that there are too scarce resources for these kinds of activities within a small company. The lack of knowledge among smaller companies concerning the concept of carrying charge may also be a reason they do not apply it at all. Mattson (2007)[6] also mention the lack of resources and knowledge as a possible explanation to why carrying charge is not applied in these companies.

[6] Stig-Arne Mattson, Professor Technical Logistics , Lund University, email correspondence 28th May, 2007

6. Conclusions

The overall aspiration of this thesis was to generalize to the overall population, due to the fairly large reduction of the sample, the conclusions derived from the empirical results the generalization can be made to a certain extent. Furthermore since the numbers of surveyed companies in each stratum are rather few it is not possible to make any conclusions regarding differences between companies with different turnover. As the results show, only 20 out of 66 surveyed companies applied a carrying charge. Therefore, only indications of possible patterns and regularities concerning the determination and application of the carrying charge can be made. Nevertheless it is still interesting to present the conclusions of the findings for this survey as not many investigations have been made before. The conclusions that can be made from the analysis of the empirical material are the following.

Primarily, within the sample there are few companies that use a carrying charge or an EOQ. It could be considered that the reason for the modest usage of carrying is due to the fact that companies do not need it since they do not apply an EOQ-model. A conclusion that was not surprising to logistic professor Stig-Arne Mattsson.

Furthermore, concerning the determination of the carrying charge the tendency in the sample has been that companies to a large extent use the borrowing rate. The result of using the borrowing cost, which can be seen as an incorrect measure of the capital cost has been discussed in the analysis chapter but our survey has not further explored the consequences for those companies applying the borrowing rate only.

As an overall conclusion it can be said, there is a general lack of knowledge about the carrying charge amongst the surveyed companies, especially the smaller companies. This can however be a result of the general confusion of ideas within this field.

Altogether there can be said that there is more to be done in order further explore the concept and application of the carrying charge. Therefore the next chapter will provide a discussion concerning areas for further research.

7. Recommendations for future research

We strongly recommend more research to be carried out on the topic of how the carrying charge is determined and applied in Swedish manufacturing industry.

For a future study we would recommend the same research problem to be studied but using a different method with a larger number of respondents. This would preferably be designed to be a more quantitative survey. This would help to quantify the findings in order to be able to conduct a statistical analysis. Regarding to the data collection method more questions with predetermined answers are preferable as it enables the researcher to categorize the respondents answer. Regarding the questionnaire a different structure should be used in order to enhance the outcome. An even further concept explanation should also be made in order for the respondent to be sure of the true meaning of our questions.

As of the chosen population, it can be argued that only companies applying EOQ should be included in the survey, as they are most likely to apply a carrying charge. In order distinguish these respondent that have an EOQ a feasibility study can be made to investigate this. It would be valuable to conduct a data correlation analysis to see if there is a statistically significant relationship between the usage of EOQ and the occurrence of a carrying charge in the company. Furthermore the respondents should probably be persons working at business department as our survey shows that they in general have more knowledge about the carrying charge. One approach would be to use PLAN:s register as in previous studies in order to assure that a respondent with an interest and knowledge would be contacted.

A different problem approach could also be considered as a next step for future research after conducting a quantitative survey would be to select representative companies and conduct a case study. The aim of the case study could be to investigate and explore the use of carrying charge as a financial means of control. This would be of interest in order to gain deeper knowledge of how the carrying charge is affecting inventory control and inventory levels and as well explore environmental issues connected to inventory control.

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9. Appendix A: Glossary

Business solution system: A business solution system is computerized system which tries to integrate different functions within in a company. One example of a business solution system is Enterprise resource planning (ERP) which is development of the previous systems MRP and MRP II (MRP = Material resource planning). (Mattsson, 2004)

Common costs: Are costs that are independent of much you are storing. One example of this could be administrative cost or cost for location. Naturally, it is not totally independent how much you are storing but almost to a certain limit (Jonsson &Mattsson, 2005).

Consignment stock: This type of warehouse is owned by the supplier and the customer only pays for the items used the rest is the property of the supplier. (Mattsson, 2004)

Cost reduction focus: With a cost reduction focus a company is constantly trying to reduce their cost.

Experienced based material planning: With this method the material planning within a company is based on previous experience. Similar to the Forecasting material planning but not based on historical data. (Mattsson, 2004)

Fixed order quantity: This method implies that one specific fixed order quantity is used every time an order is placed. This quantity can be manually determined or calculated. (Mattsson, 2004)

Incremental cost: is a cost that can be separated which is affected by the main object and does not arise due to other objects. (Mattson, 2004)

Incremental costs are related to storing one additional product in storage. Example of these kinds of costs is for example storage space if it is paid for how much you are storing (Jonsson & Mattsson, 2005).

Inventory turnover rate: A business ratio providing a possibility to make comparisons between time in a certain warehouse and is determining how many times per year the inventory is replaced. (Mattsson, 2004))

Kanban: A Japanese material planning method that means visual proof. It is based on a pull system (material is pulled to a work station when it is needed) A station communicates demand for a work or material on the device (Hojati & Stevensson 2004)

Material requirements planning (MRP): The material that a firm acquires to meet the demand, a computer-based information system for ordering and scheduling of dependent-demand inventories (Hojati et al 2004).

Orderbased material planning: Method based on the actual order and is placed to cover specific orders, both quantity and time has to be considered. (Mattsson, 2004)

Re-ordering point system: A certain level of inventory is set and when a certain inventory level is reached, the system alerts and the re-ordering is initiated. Here is the quantity fixed and time between orders varies. (Mattsson, 2004))

Run-Out time planning: Method similar to the re-ordering point method. The inventory level is set to a certain level making it possible to manage the consumption during the lead-time. (Mattsson, 2004)

Periodic ordering system: A system where the company makes orders at a certain time and the quantity varies with the approximated demand closely linked to the re-ordering point system. (Matttsson, 2004)

Cost charge increase in sales cost estimation: These are costs that are associated with producing one unit. The costs are for example, manufacturing costs, wages and warehouse costs. (Matttsson, 2004)

Service level: The service level is describing the company's ability to serve their customers. The definition is that the service level should be one minus the probability for shortage. The service level can be controlled by applying a safety stock. The usage of a high or low service level is depending on the character and relationship on to the customer. (Lumsden, 2006)

Short out cost: This cost is related to not meeting the customers demand. This could be balanced with using a safety stock. There has to be a optimal balance between holding inventory and also meeting customers demand. This level is determined with the choice of service level. (Berling, 2005)

WACC: One common used capital cost measurement is Weighted Average Cost of Capital (WACC) This term take capital structure of the company into consideration. The term that is already used in inventory rate is the opportunity cost of capital for the company, that is what the company could use its money to instead that would generate profit to the company. (Brealy et al, 2004).

WACC can be used instead of the interest rate when making investment decisions. In terms of using this in the carrying charge, one can mention that it is not always useful to apply this since often contains much lower risk than other investments and thereby are not totally applicable. More correct would be to use the bank lending rate as inventory investments are often financed by taking on a loan (Berling, 2005).

10. Appendix B: Questions for the feasibility case

1. What does the inventory structure look like? Regarding size, development, in-, and outgoing inventory.
2. Who is deciding the level of the inventory rate, and what is the decision making based on? On what decision making is the size of the inventory based on?
3. How often is this decision making redeveloped or changed?
4. How do you use the inventory rate?
5. Do you change the inventory rate, and if so, when does this occur?
6. How can you find it necessary to control and change the inventory rate? How do you use the inventory rate as a financial tool?
7. What (other) financial tools do you use for valuing inventory?
8. What financial tools do you use for valuing the company?
9. How can you find a connection between the financial tools for inventory and other financial tools in the organization?

11. Appendix C: Interview Questions

Introduction questions

1. **What is your position within the firm X?**
2. **How long have you worked within the firm X?**
3. **Which one(s) of the following inventory types occur in the company?**
    - Raw material
    - Process inventory
    - Finished goods inventory?
4. **In what business industry do your main customers act in?**
5. **Which one of the following material planning methods do you apply, in order to find out when to order?**
    - Kanban
    - Material requirements planning (MRP)
    - Re-ordering point systemm
    - Run-out time system
    - Periodic ordering system
    - Order based materiel planning
6. **Which quantity planning method are you applying in order to determine how much to order?**
    - EOQ
    - Other, describe method
7. **What is the average process value of your products in inventory? (in percent %)**

8. **Do you apply carrying charge in order to determine you carrying cost?**
    - Yes (if carrying charge is applied then the questions associated with yes are asked)
    - No (If no then next following questions are asked)
        - Why is carrying charge not used?
        - What is used instead?
        - Has carrying charge been used before?
        - Why did you stop using carrying charge?

(Carrying charge is applied)

9. **Is carrying charge used in other context than to determine the inventory carrying costs?**
10. **Who determines the carrying charge?**

- Department
- Person

11. **How often is the carrying charge updated?**
12. **How is the carrying charge determined?**

- By calculation (if calculation, then ask question associated with calculation)
- By approximation (if approximation, ask questions associated with approximation)

11.2.1 Calculated carrying charge

What components are you including in your carrying charge?

(Mark the following components (cost of capital, storage cost, cost of risk and service cost, following ask the sub questions)

Cost of capital

The cost of capital is the alternative use of capital return of investment, which could be used to something else if not being tied up in inventory. (Jonsson, 2005).

- How do you calculate the cost of capital?

  Does the cost of capital vary if the investment varies?

Storage cost

Cost of inventor, personnel, equipment and space associated with inventory, depreciation and administration. (Jonsson, 2005)

- What storage cost do you include in your carrying charge?
- Will any of these costs be affected if the inventory level decreases or increases?
- Do you use the entire inventory space yourself? (if yes)
  - How do you calculate the alternative cost that would occur if an increase in inventory level would occur and you are not able to sublease the storage space anymore?

Cost of Risk

Which components of the following possible answers do you include in your risk costs?

- Damage
- Obscolescence
- Pilfrage
- Relocation costs

Service cost

Cost of taxes and insurance

- What components do you include in your service cost?
- How does these change when the inventory level changes?

11.2.2 Approximated carrying charge

Comparison

- What company or industry have you compared your company to in order to determine your carrying charge?
- Companies with the same industry or with similar qualities?

  (Industry average?)
- Have you made any corrections to adapt the carrying charge to your specific situation?

Decision from other department, such as consultant or top management decision?

- Where does the decision come from? Who recommends you to use this carrying charge?
- How has the carrying charge been determined?
- Is there a possibility for you to get in contact with the responsible for the carrying charge?

11.2.3 Concluding question when carrying charge is applied

How much is your carrying charge at the moment? (Let hem know that it is a anonymous survey)

12. Appendix D: Diagrams not presented or analysed

The respondent's occupation was asked in order to ensure what person one was interviewing. The result has been affected of who has been asked, however this is discussed in the chapter of the methodology.

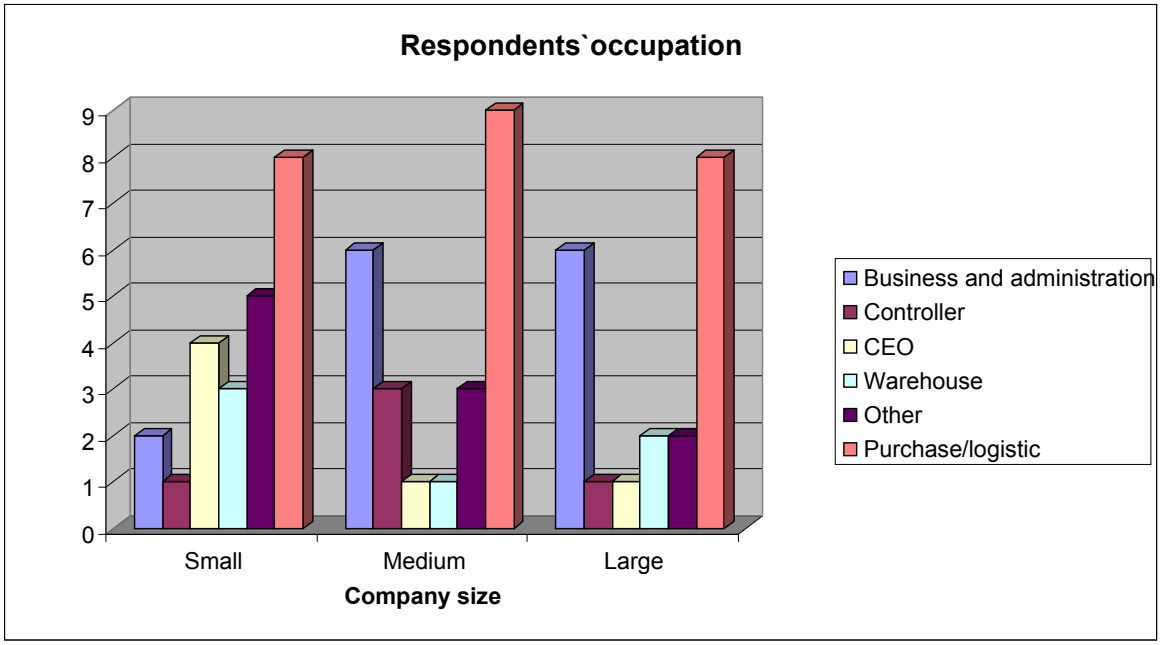

Diagram 14: The respondent's occupation

The respondents' years within the company was asked, however it was concluded it has no importance of the determination of the carrying charge. The following diagram presents the distribution of the years worked within the company over the three strata.

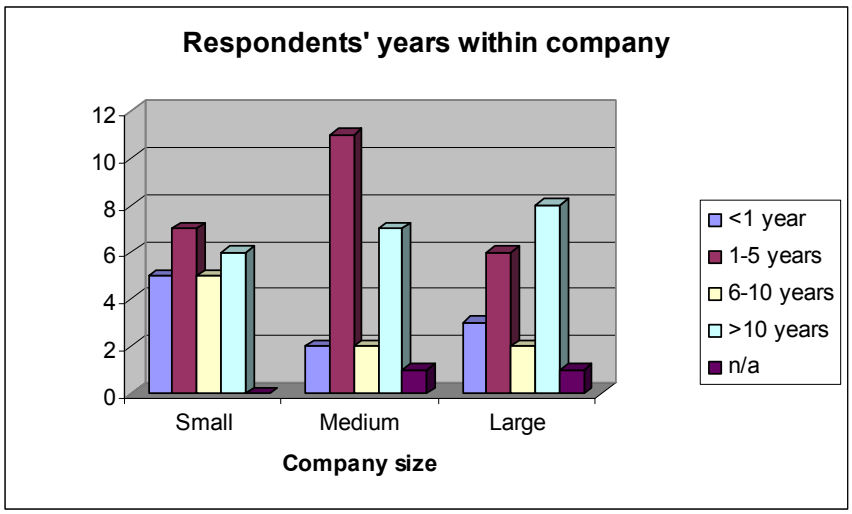

Diagram 15: The respondent's years within the company

When the companies answered that they do not apply a carrying charge it was asked however it had been used before. As the diagram shows the result was quite unusual. Most companies that do not apply a carrying charge are mostly companies that were not aware of the expression carrying charge, therefore it was not possible to ask whether it had been used before. Among the companies where it was possible to ask, none of them had applied it before.

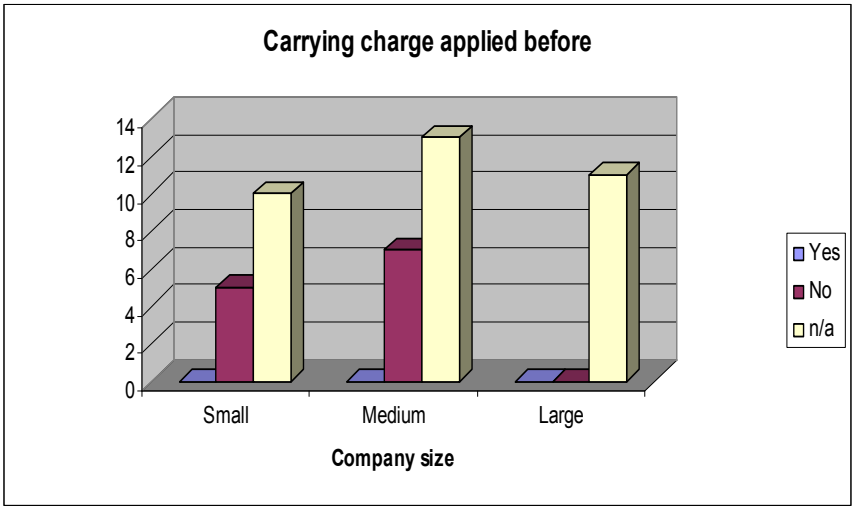

Diagram 16: Carrying charge applied before

When companies answered they apply a carrying charge and it is determined by approximation the question what the approximation was based on as stated in the questionnaire was asked.

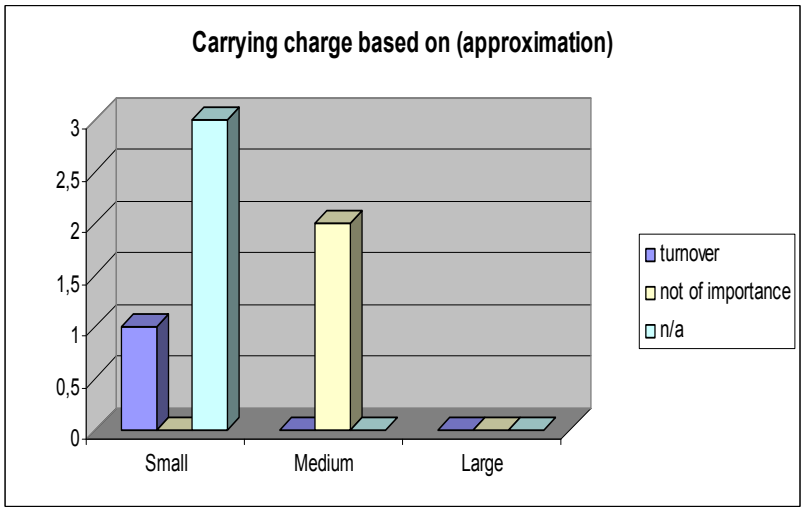

Diagram 17: Approximated carrying charge based on

Companies tended to not be aware of what the approximation based on and the decision was most of the time from another department. Therefore it resulted in this result with only one company stated it was based on the yearly turnover.