Determining Supply Chain Inventory Locations Through Product Classification

A Case Study of a Sealing Materials Company

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Abstract

Nowadays firms must develop inventory policies that enable them to cope with the changing marketplace. Determining proper inventory locations can help decrease costs related to inventory holding and transportation. Moreover, this allows firms to respond in a timely manner to customers’ requirements. As a result, profit margins can be enhanced as well as the competitiveness of a firm. However, the decision of where to locate inventory in a supply chain is difficult since many companies are managed independently.

The present research is developed as a case study where product classification, customer and supplier segmentation schemes are reviewed in order to determine appropriate inventory locations along the supply chain.

The thesis is written upon literature and empirical research, where most of the data was collected through personal interviews and observations at the supply chain management offices of a distributor for sealing material parts in Europe.

Our conclusion shows that product classification has an important impact on inventory location decisions. Also, we conclude that products should be classified based on both physical characteristics and demand factors, as well as according to customers’ requirements. Another factor to be considered when deciding on inventory location is supply risks, due to issues related to raw material availability and capacity. Nonetheless, the selection of classification variables is challenging as it is hard to determine which factors are more relevant than others as this varies depending on each firm’s needs. In addition, we find that supply chain strategies are not realistic due to the constant changes in the business environment and the inability of a firm to manage whole supply chains. Furthermore, a high level of communication among supply chain partners is fundamental, especially when a centralized inventory policy and a postponement strategy are in place.
Acknowledgments

We would like to thank our supervisor Leif-Magnus Jensen for his guidance and counseling throughout the duration of this project. Likewise, we want to thank Jonas Karlsson for giving us the opportunity to conduct this study and for offering his support from the very beginning of our thesis. In addition, we express our gratitude to all those who took part of their valuable time to participate in the interviews. And finally, we want thank our families and friends for their input and motivation.

Lizza Castro & Caleb Rangel

May 2012
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I Introduction

1.1 Background

In today’s fast-paced, changing business environment, firms struggle to maintain their profitability and remain competitive in the market (Pugh, 2011). Hence, they take cost reduction measures in order to improve their efficiency and to maximize their margins. However, they must be able to achieve a certain degree of responsiveness and flexibility to ensure customer satisfaction. Therefore, it is important that suppliers understand their customer needs in order to provide a better service. This includes having stock strategically located at one or different points along the supply chain, depending on the product or customer requirements for speed in terms of delivery. As a result, firms are required to design different supply chains to meet varying customer demands. Nevertheless, this can represent a challenging task.

Product classification and customer segmentation schemes are important as they help firms to determine which supply chain strategies are appropriate for their markets. For instance, customers can be prioritized according to the number of sales they generate annually or simply by their buying behaviors. On the other hand, some products are more critical in terms of delivery times, manufacturing complexity or customization level, while others are more functional. This suggests that firms should ideally establish a set of supply chain strategies in order to satisfy the requirements of specific customers or markets. In some cases strategy is based on cost, while in other circumstances on differentiation. However, sometimes it is necessary to balance both goals, where efficiency must be balanced against the level of responsiveness desired (Fisher, 1997). Furthermore, supplier segmentation is equally important as it helps firms determine suitable suppliers for their product groups.

The level of responsiveness demanded by customers or required to deliver a product will likely define a supply chain inventory strategy, which comprises inventory location. However, the decision of where to locate inventory in the supply chain is a difficult task as most firms operate independently. Every company participates in many supply chains and thus, supply chain strategies differ for each unit. As a result, firms must still deal with supply and demand uncertainty issues due to the complexity of supply chain networks. This also implies that companies must still develop their own inventory policies and rely on forecasts. Moreover, given that most companies do not have complete control of their entire supply chains, they are forced to adapt to their current operational settings.

The present research is developed as a case study at the supply chain management (SCM) offices of a sealing materials company located in Germany. Due to confidentiality reasons, we do not reveal the actual name of the company. Therefore, we will refer to the firm as SCM Germany. The sealing materials company belongs to a leading global corporation which provides engineered materials based on polymer technology to protect, damp and seal (Sealing Materials, 2012). SCM Germany manages a major regional distribution center in Germany, where all supply chain management decisions are centralized. In order to capture a complete view of SCM Germany’s supply chain, group suppliers and sales companies were also involved in the research.

The firm’s goals for 2012 are to improve its on-time delivery (OTD) and increase its margins. Due to the company’s complex global supply chain network, it becomes a real challenge to design appropriate supply chains to achieve these goals. An approach that could enhance timely deliveries and margins is to classify products and segment customers effectively. This classification would help in the selection of strategies to properly locate inventory along the supply chain, and hence allow SCM Germany to respond in a timely manner to its customers’ demands and to manage financial risks.

1.2 Problem Discussion

Most companies segment their markets and classify their products in order to respond to customer demands successfully. One of the ways to react effectively to market requirements is by strategically locating inventory along the supply chain. Normally, the strategies selected may help determine appropriate inventory locations. However, in reality supply chains are complex by nature and thus,
firms tend to adopt different strategies as business objectives diverge. As a consequence, companies still have to face supply and demand uncertainties as well as other limitations as their control over the entire supply chain network is restricted. Therefore, the current structure of the supply chain in some way limits inventory locations.

Hence, our interest is to find out answers for the following question:

- How to determine appropriate inventory locations according to the current structure of the supply chain?

1.3 Purpose

In order to identify how appropriate inventory locations are determined, we will examine the schemes SCM Germany uses for product classification, customer segmentation and supplier segmentation, as we believe these could influence inventory location decisions. By locating inventory at suitable places along the supply chain, a firm could enhance its competitiveness and profitability as customers’ demands are fulfilled effectively. Moreover, this could have a positive effect on on-time delivery performance. Hence, the aim of this study is to illustrate the impact inventory locations have on a firm’s ability to maximize customer satisfaction and minimize costs, considering the current supply chain structure. In addition, we want to exemplify the required managerial actions in order to find out appropriate inventory locations.

1.4 Perspective

This research problem is studied from the perspective of the supply chain management division of a firm, which liaises suppliers and sales companies.

1.5 Delimitations

We will mainly conduct our research at the supply chain management offices of SCM Germany. This will provide us with the knowledge on how things are managed in practice and also a perspective about the industry in which the firm operates. This will delimit our research since we will not be able to investigate other companies in different industries due to time constraints and confidentiality issues.

1.6 Disposition

The first chapter –Introduction– provides a background of the topic along with a problem discussion, followed by a research question and the purpose of the thesis. The second chapter –Literature Review– outlines the theory behind supply chain management, customer segmentation, product classification, supplier segmentation, supply chain strategies and inventory management, including postponement and inventory location. The relationship between these topics is described as well as its connection with the research question. The third chapter –Methodology– states the study’s structure and the research methods selected. The fourth chapter –Empirical Findings– presents the results from the interviews conducted at the company’s supply chain management offices, together with the data collected from sales companies and group suppliers. In the fifth chapter –Analysis–, the information is analyzed and connected to the literature review. This is followed by the sixth chapter –Conclusion–, where the analysis in regards to the research question found in the first chapter is discussed. The final chapter presents ideas for future research.
2 Literature Review

In this chapter we will discuss customer and supplier segmentation, product classification, supply chain strategies and inventory management. First, we will start our discussion with a brief overview on supply chain management, where we address the importance of customer orientation. This will be followed by customer segmentation and product classification, where we explore key categorization factors that help identify the most suitable supply chain strategies for specific customers or products. In addition, we will address the importance of supplier segmentation. This discussion will lead us to a general review on supply chain strategies. Finally, we will cover several points from the inventory management literature, particularly issues related to inventory location. The connection between the different bodies of literature is that product classification, customer segmentation and in part supplier profiles, altogether define supply chain strategies, and in turn supply chain strategies define inventory strategy. We find important to cover all of these topics to better understand the factors influencing supply chain inventory locations. A comprehensive frame of reference is necessary to find out to which degree theory matches the reality.

2.1 Supply Chain Management

A supply chain features a network of units that procure raw materials, transform them into a semi-finished state, and finally into finished goods (Huang, Uppal & Shi, 2002). Basically, supply chain management (SCM) features a set of practices which aims at coordinating and controlling the entire supply chain, from raw material suppliers to the ultimate customer. Hence, the overall objective of SCM is to improve the entire process rather than focusing on local optimization of business units (Heikkilä, 2002). Likewise, the goal of SCM for any firm is to generate revenue and increase its market share. This requires the focal firm, together with its fellow supply chain members, to offer a product to the customer (Childerhouse & Towill, 2000). Thus, we deduce that the primary goal of SCM is customer satisfaction. The success or failure of supply chains is ultimately determined in the marketplace (Agarwal, Shankar & Tiwari, 2006).

Anderson, Britt and Favre (1997) discuss the seven principles of SCM (Table 2.1), which support the efforts required to balance customer satisfaction with the need for profitable growth. The first four principles highlight the importance of customer orientation by addressing the need for customer segmentation, customized logistics solutions, demand planning and product differentiation. However, companies normally focus on the supply side of the chain and fail to recognize customer demands. This implies that customer segmentation is usually not the starting point for managers to begin their supply chain improvement efforts (Heikkilä, 2002).

<table>
<thead>
<tr>
<th>Table 2.1: Seven Principles of SCM.</th>
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<tbody>
<tr>
<td>1. Segment customers based on service needs.</td>
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<td>2. Customize the logistics network.</td>
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<tr>
<td>3. Listen to signals of market demand and plan accordingly.</td>
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<tr>
<td>4. Differentiate product closer to the customer.</td>
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<tr>
<td>5. Source strategically.</td>
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<tr>
<td>6. Develop a supply chain wide technology strategy.</td>
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<td>7. Adopt channel-spanning performance measures.</td>
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Source: Anderson et al. (1997).
Kopczak and Johnson (2003) claim that SCM has led to six main shifts in business focus. Among the most outstanding changes is the shift from physical efficiency to market mediation; from supply focus to demand focus; and from mass-market supply to tailored offerings. Once again the importance of customer orientation is emphasized. For instance, market mediation costs have escalated as demand in general is becoming more unstable. As a result, market-responsive supply chain strategies are increasingly being adopted. In addition, firms have increased their efforts in mitigating demand uncertainty through demand management instruments, such as pricing policies. Moreover, companies have discovered that better business opportunities exist by combining innovative supply chains with new market approaches. Lastly, businesses have realized that customers are not equally profitable and have different preferences (Kopczak & Johnson, 2003).

The literature demonstrates that there is general consensus that companies should focus more on their customer demands rather than on cost minimization and efficiency, as this proves to be a more effective approach to generate profits. This suggests that firms should concentrate their efforts on studying their markets and differentiating the demand for their products. This is possible through customer segmentation and product classification.

2.2 Customer/Market Segmentation

Customer or market segmentation is the process of dividing customers within a market into different groups where similar requirements or differences can be identified (McDonald & Dunbar, 1998). Companies follow either a concentration or a multi-segment approach. The concentration approach entails the development of a marketing strategy for a single market segment with the aim to specialize on one segment. On the other hand, the multi-segment approach involves aiming at various segments with a different strategy for each group (Fridriksson, 2010). Firms should aim for strategic segmentation, an approach that combines customer focus and a high level of organizational integration. Thus, the firm is able to apply customer-based data in order to develop segments of customers and integrate them across key functional activities (McDonald & Dunbar, 1998).

Different bases are suggested to segment consumer markets and industrial markets. Yet, in both cases the common variables include the customer's background as well as attitudinal and behavioral characteristics. For instance, in industrial markets, the customer can be classified according to industry type, company size, location, technical capability, power structures, purchasing policies and product application. Attitudinal features refer to the purchasing criteria of customers and entails focusing on differences in why customers buy. Behavioral issues relevant to segmenting business markets may include buyers’ personal characteristics and product status and volume. Thus, business goods markets can be segmented by buyer-seller similarity, buyer motivation and buyer risk perceptions. Identifying major purchasers through volume purchased and identifying the final use of the product is very useful (Hooley, Piercy & Nicouland, 2012).

2.3 Product Classification

Product classification schemes are essential since they help determine appropriate supply chain strategies. This is required to identify different groupings of products in order to provide appropriate customer service (Childerhouse & Towill, 2000). In addition, not all products contribute equally to the profitability of a supply chain. A potential flaw for companies is to focus too much on products that do not generate profit (Mentzer, 2004). Likewise, each product has a different risk profile depending upon its market, profile and value. Both supply side and demand side risks exist. Supply side risks vary according to supplier reliability, while demand side risks depend on forecasting errors (Emmett & Granville, 2007). Therefore, product classification serves as a fundamental base to support supply chain strategies including inventory decisions. In general, products are classified based on their specific features including physical characteristics, demand/market factors and supply/source factors.
2.3.1 Product Characteristics

Products are generally categorized by their type or design. They can be functional or innovative, as suggested by Fisher (1997). However, other authors suggest that products can also be classified as hybrid (Huang, Mohit & Shi, 2002). Functional products are usually simple items, with a standard design, long life-cycles and predictable demand patterns. Conversely, innovative products are new products developed by firms to capture new markets. They normally have an uncertain demand and are positioned in the introduction or growth stage of the life cycle (Huang et al., 2002). Moreover, they often represent a breakthrough in design and command a premium price (Vonderembse, Uppal, Huang & Dismukes, 2006). On the other hand, hybrid products consist of either different combinations of standard components or a mix of standard and innovative components (Huang et al., 2002).

Another characteristic that differentiates functional products from innovative ones is profit margin contribution, where innovative items normally have significantly higher margins. In addition, functional products have a lower cost of obsolescence compared to innovative products (Lee, 2002).

Products can be classified according to their stage in the product life cycle. Likewise, the classification can be done by considering the duration of the life cycle (Childerhouse, Aitken & Towill, 2002). The product life cycle is one of the most important factors in product classification. It illustrates unit sales for a specific product category over time and it is divided into four separate stages: introduction, growth, maturity and decline. The shape of the sales curve reflects the belief that a product’s sales begin slowly during the introductory stage, followed by a rapid growth, reaching a peak relatively early in a product’s life. During the maturity phase, demand may grow slowly for a long period of time before it begins to decrease. This growth is usually accompanied by changes in competition, strategies and performance. Innovative products become standardized as demand increases and competitors surface (Vonderembse et al., 2006). Pagh and Cooper (1998) address that the focus in the first two stages is mainly on customer service, while cost minimization is preferable in the final two stages.

Another widely recognized factor in product classification is value density, which comprises the product’s size and weight. Product value density is a main determinant of the level of inventory centralization. Also, high value density products are normally manufactured at few large-scale factories (Lovell, Saw & Stimson, 2005). Similarly, Pagh and Cooper (1998) address the significance of value in product classification. However, they define it as monetary density, which expresses the ratio between the monetary value of a product and its weight or volume. Products with high monetary density are costly to store but inexpensive to transport. Moreover, Pagh and Cooper (1998) mention that products can be categorized by their value profile, which refers to when and how much a product increases in value through its processing along the chain.

On the other hand, Payne and Peters (2004) cluster products according to average order-line value and average order-line weight. An average order-line value refers exclusively to the monetary value of the product. Order-line values have an effect on profitability after considering supply chain costs. Since supply chain costs are activity driven, higher value order-line products can stand a higher amount of activity as the articles are processed along the supply chain, and yet generate a reasonable return. However, low order-line value products would suffer a reduction in profitability if it experiences a lot of activity as it passes through the supply chain. In addition, order-line weights have a significant impact on transport costs (Payne & Peters, 2004).

Other characteristics that are taken into consideration when classifying products include the product’s shelf life or obsolescence, handling requirements and substitutability. Lee (2002) addresses product obsolescence as one of the key characteristics that differentiate functional and innovative products. Fisher (1997) argues that because innovative items have short life-cycles, the risk of obsolescence is higher. Likewise, Lovell et al. (2005) discuss that products with a short shelf life, that is a high rate of obsolescence, would lend themselves to networks that hold low levels of inventory and use quicker transport modes. In addition, these authors mention that differences in handling characteristics can impact supply chain costs. For instance, differences in the weight of the product or the level of security of the vehicle can affect the mode selection of transport and lead to network constraints in the
type of operation that can be utilized (Lovell et al., 2005). Lastly, substitutability refers to a firm’s ability to replace a product which is out of stock for another one (Payne & Peters, 2004).

2.3.2 Demand/Market Factors

Emmett and Granville (2007) stress that products must be categorized according to demand behavior and suggest that this can be done by distinguishing between independent and dependent demand. Independent demand is that which is independent of all other products, whereas dependent demand is that derived from consumer demand which produces end-use products. Generally, dependent demand is more consistent and there is a greater degree of certainty about orders (Emmett & Granville, 2007).

One of the most common variables to classify products is demand uncertainty. Functional items have highly predictable demand patterns whereas innovative items usually have unstable demand (Fisher, 1997). Some authors refer to demand uncertainty as demand predictability (Christopher, Peck & Towill, 2006), while others refer it as demand variability (Childerhouse et al., 2002; Lovell et al., 2005) or demand volatility (Payne & Peters, 2004). Demand uncertainty significantly affects capacity utilization and it increases the risk of obsolescence and lost sales (Childerhouse et al., 2002).

The product’s time window for delivery or delivery lead time reveals the responsiveness requirements placed on the supply chain. For instance, some products required rapid response if they are selling very fast. Also, increasing competitive pressure constantly reduces acceptable response times (Childerhouse et al., 2002). Pagh and Cooper (1998) address delivery time as a significant determinant for supply chain strategy, but they refer to it as the average delivery time to customers in proportion to the average manufacturing and delivery lead time. Despite the importance of customer lead time due to its impact on profitability, this factor has not been widely considered in product classification schemes.

Product demand volume is another key characteristic in classification systems. Childerhouse et al. (2002) suggest that attention should be given to products that are both high in volume and high in profit because of their significance to the firm. The volume is an indication of the level of demand in terms of quantity. Volume can be accounted in terms of units or pallets, as suggested by Payne and Peters (2004). Other authors refer to demand volume as demand level or throughput. This refers particularly to the amount of products processed within a given time. This attribute is also important as it helps determine the design of the supply chain network and has an effect on decisions concerning transport modes and warehousing. In addition, the concept of classifying products by demand levels is exemplified in the Pareto analysis, which is normally used to optimize inventory policy in relation to throughput level (Lovell et al. 2005). Furthermore, Lovell et al. (2005) also consider demand dispersion/location as a potential product classification variable, since it can also affect supply chain costs.

Another factor in product classification is delivery frequency, referred by Pagh and Cooper (1998) as the average delivery frequency to customers in proportion to the average manufacturing and delivery cycle time. This factor helps differentiate products in terms of how actively they are ordered by customers (Payne & Peters, 2004). This way a company may be able to determine how much to stock for each item by categorizing products as fast-moving or slow-moving articles.

Demand variety is considered as a key classification variable by some authors. Childerhouse et al. (2002) recognize that product variety is more important than ever as nowadays demand chains compete on the basis of added value in relation to color, form or function. Also, they advise firms to evaluate their products continuously as they move through the different stages of the life cycle.

Lastly, the number of customers buying the product is a critical factor used to assess the risk of obsolescence. Hence, if a product is purchased by a small number of customers in a year it can be categorized as customized (Payne and Peters, 2004). On the other hand, the classification can be done according to service expectations (Lovell et al., 2005). However, this label seems too broad and we deduce that it can be determined by analyzing the different demand features.
2.3.3 Supply/Source Factors

Source factors often act as a constraint to supply chain design. Limitations on raw material availability imply that all supply chains for a specific product must originate at very few locations (Lovell et al., 2005).

A significant supply factor in product classification is replenishment lead time, or supplier lead time. This is the time it would take the supply chain to respond to an increase in demand if materials had to be sourced or manufactured. If the time is measured in months rather than days, it suggests that the product has a long re-supply lead time (Christopher et al., 2006).

Another important supply factor is economies of scale. For instance, when fixed costs are high, volume becomes critical so it is feasible to manufacture the products at large plants at lower prices (Lovell et al., 2005). Pagh and Cooper (1998) also address economies of scale as a constraint within manufacturing and logistics processes. Moreover, they include special knowledge/capabilities as a further limitation. This can be related to the level of manufacturing complexity involved. For example, innovative products will probably require special know-how and manufacturing techniques compared to functional items.

Finally, products can be classified according to supply uncertainty. Lee (2002) categorizes supply characteristics into stable and evolving. He explains that a stable supply process is one where the manufacturing stage has reached maturity and where the supply base is well-established. Conversely, an evolving supply process is where the manufacturing stage is still under development and is constantly changing. In addition, the supply base may be limited in terms of size and experience (Lee, 2002).

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<th>Table 2.2: Product Classification Factors – Summary</th>
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<tr>
<td><strong>Product Characteristics</strong></td>
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<tr>
<td>Type/Design</td>
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<tr>
<td>Lifecycle Stage &amp; Duration</td>
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<tr>
<td>Value Density &amp; Monetary Value</td>
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<tr>
<td>Order-line Weight</td>
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<tr>
<td>Order-line Value</td>
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<tr>
<td>Shelf Life/Obsolescence</td>
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<tr>
<td>Handling Requirements</td>
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<tr>
<td>Substitutability</td>
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<tr>
<td>Demand Type (Independent or Dependent)</td>
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<tr>
<td>Demand Uncertainty</td>
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<tr>
<td>Delivery Lead Time</td>
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<tr>
<td>Demand Volume (Level or Throughput)</td>
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<tr>
<td>Demand Location/Dispersion</td>
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<tr>
<td>Delivery Frequency</td>
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<tr>
<td>Demand Variety</td>
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<td>Number of Customers</td>
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<td><strong>Source/Supply Factors</strong></td>
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<tr>
<td>Replenishment Lead Time</td>
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<tr>
<td>Economies of Scale</td>
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<tr>
<td>Special Capability/Knowledge</td>
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<tr>
<td>Supply Uncertainty</td>
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2.3.4  ABC Analysis: The Pareto Concept

A managerial tool to identify products based on importance is ABC analysis (Emmett & Granville, 2007). ABC analysis features a technique to identify categories of stock, thus enabling managers to focus their attention on items that outstand in terms of time and effort (Hines, 2004). This method applies the law developed by Pareto, who recognized that 80 percent of the wealth lay in the hands of 20 percent of the population. This suggests that a high incidence in one set of variables equates to a smaller incidence in a corresponding set of variables (Emmett & Granville, 2007).

The degree of importance can be analyzed based on different ranking factors, such as cash flows, stock-outs, stock-out costs, profitability or sales volume (Coyle, Bardi & Langley, 2003). This implies that ABC analysis can be applied to different supply chain issues (Hines, 2004). In order to perform the classification a ranking factor or criterion must be selected, such as sales revenues. Then, break points are chosen for classes, which are normally categorized as letters (A, B, C and so on). Subsequently, products are placed in descending order of importance according to the criterion chosen and finally these are placed into discrete classes.

For instance, 80 percent of total sales can be attributed to 20 percent of the items in a particular product line. This example suggests that those products accounting for 80 percent of total sales should receive further attention and classified as “A” items. However, managers should avoid thinking that “B” or “C” items are less significant than “A” items, and thus avoid neglecting other product lines. For instance, a decision to assure high in-stock levels for “A” items and limited or no availability for “B” and “C” items is misleading as all items regardless of their category are important to a certain degree, and each group of items deserves its own strategy to assure availability at a low cost. This notion led firms to differentiate inventory stocking policies by ABC category, making sure that “A” items are available immediately, while other items only available at an upstream location (Coyle et al., 2003).

The same concept can be applied to segment customers. For example, 80 percent of total sales can be attributed to only 20 percent of the customers. This illustration suggests that 20 percent of the customer base should be prioritized and classified as “A” customers (Hines, 2004). Therefore, managers should be careful when analyzing their products’ impact on profitability. Figure 2.1 shows the ABC Analysis graph. In this example, 20 percent of the firm’s products account for 80 percent of profits.

*Figure 2.1: ABC Analysis Graph.*

![ABC Analysis Graph](Source: Woe (2010)).
2.4 Supplier Segmentation

Effective categorization of suppliers is essential in supplier relationship management, a tool to reduce logistics costs (Zhang, Huang, Qian, Xu & Jing, 2006). Supplier categorization involves dividing suppliers into groups with different needs, characteristics, or behaviors, requiring different types of inter-firm relationship structures in order to realize value from an exchange (Day, Magnan & Moeller, 2010). Similarly, Guo and Xu (2007) address that supplier categorization determines the level of resources to be utilized as well as what expectations are placed on suppliers. The idea is to manage supplier risks and optimize value from exchange. A firm can reduce chances of opportunism under circumstances of information asymmetry by having a better understanding of its position. A driver for supply base management is to decrease the number of suppliers to reduce costs and leverage relationships for lower prices. Also, developing close relationships with fewer suppliers can provide access to complementary assets and innovation (Day et al., 2010).

An approach for supplier segmentation is the portfolio matrix. The value of portfolio management results from balancing the expected return from an investment, given the expected level of risk (Day et al., 2010). Some guidelines to categorize suppliers include product growth, market drivers (price vs. technology), length of desired involvement, level of criticality, requirements (standard vs. customized), project types (tactical vs. strategic) and switching costs. Normally, there are four types of suppliers: Type I (low value/low risk and convenience sources), type II (high value/low risk and multiples sources), type III (low value/high risk and sole sources), and type IV (high value/high risk and single sources). Likewise, suppliers can be classified as: strategic suppliers, key item suppliers, manage-by-exception suppliers and approved suppliers. Long-term relationships are preferred with strategic suppliers, which are related with Type I. On the other hand, key item suppliers require some involvement due to the criticality of the product they provide. These are most likely Type II suppliers. Manage-by-exception suppliers could be any of the four types. In this case it may be necessary to engage in a short-term relationship due to a change in the firm’s processes or a problem caused by the supplier. Finally, approved suppliers include those which are not identified as belonging to one of the other categories, but are nonetheless approved by the firm. Minimal resources should be devoted to these types of suppliers (Guo & Xu, 2007).

Zhang, Huang, Qian, Xu and Jing (2006) present a data-driven method to categorize suppliers from the suppliers’ business behaviors. A supplier business behavior refers to a set of product items the supplier has provided in a given time period, the amount of each item in each order, the frequencies of orders, as well as other attributes such as product quality, product arrival time, etc. Dynamic categorization of suppliers based on business behaviors give a clear insight to the business with suppliers (Zhang, Huang, Qian, Xu & Jing, 2006).

Product classification also facilitates supplier segmentation, as it enables firms to identify their sources according to the relevance of the product. Kraljic (1983) establishes a model that relates strategies to different classes of purchase. The model features a 2x2 matrix (Figure 2.2) which illustrates the relation between the importance of purchasing and supply market complexity (Malcolm, 1997). Firms can classify their purchased items in terms of financial impact and supply risk (Kraljic, 1983). For instance, routine items have both low supply risk and low financial impact, thus they are non-critical products. On the other extreme, strategic items have both high supply risk and financial impact.
2.5 Supply Chain Strategies

A supply chain strategy establishes the nature of procurement of raw materials, transportation, production and distribution, along with any follow-up services. It specifies whether these processes are performed in-house or outsourced, and the extension to which the operations, distribution and service functions should do particularly well. Furthermore, a supply chain strategy defines the role played by each supply chain entity and includes decisions regarding information flows, facilities and inventory (Chopra & Meindl, 2001). Lee (2002) suggests that firms should understand the need to customize supply chains to meet customer demands in order to succeed in a highly competitive environment.

Fisher (1997) argues that functional products should be supplied with responsive supply chains, whereas innovative products should be supplied with efficient supply chains (Figure 2.3). Selldin and Olhager (2007) test the relationship among product design and supply chain design, with reference to the product-supply chain model developed by Fisher. Their data reveal significant relationships between product types and supply chain types. However, they address that there is a limitation to use Fisher’s model in practice, as a firm may not always have the resources to create a perfect supply chain for their products. Rather, they are forced to manage within their existing supply chain structures as other members along the chain might dominate the supply chain. As a result, all firms are not able to design the supply chain of their choice (Selldin & Olhager, 2007).

![Figure 2.3: Fisher’s Model.](source: Fisher (1997).)
Other researchers have developed frameworks to assist firms in selecting appropriate supply chain strategies, mostly based on different product attributes and demand variables. For instance, Huang et al. (2002) develop a questionnaire to obtain the feedback necessary to match products with desired supply chains. They consider the product’s demand predictability, customer requirements volatility, the duration of the product’s life cycle, special knowledge requirements, and the need for timeliness in product delivery among others. On the other hand, Christopher et al. (2006) develop a taxonomy for supply chain strategy selection, where they stress both supply and demand predictability, and replenishment lead times. Similarly, Lee (2002) constructs an uncertainty framework in order to characterize a product when seeking to formulate the right supply chain strategy. Both Lee (2002) and Christopher et al. (2006) expand Fisher’s model to include supply uncertainty. Conversely, Vonderembse et al. (2006) develop a framework to categorize supply chains according to product type and stage of the product life cycle. Moreover, Pagh & Cooper (1998) build a “Profile Analysis” to assist managers in selecting appropriate supply chain strategies. Their framework is very comprehensive as it includes several product attributes as well as demand and manufacturing factors. Furthermore, Lovell et al. (2005) develop a framework that highlights the importance of product value density, throughput volume and product availability in selecting a supply chain strategy.

There has been a tendency for these prescriptive models for SC strategy to differentiate by product type. However, some researchers suggest this should change to buying behavior (Godsell, Harrison, Emberson & Storey, 2006). Thus, demand should be stressed over product type. Likewise, these models serve in most cases as managerial guidelines. Some of them are straightforward, whereas others are more complex yet more inclusive. However, in reality these frameworks are not very practical as they do not take into consideration a firm’s operational capacity and supply chain control limitation, as Selldin and Olhager (2007) suggest in relation to the Fisher model.

The Fisher model has been focused on examining two basic supply chain strategies: Lean, which is the equivalent to Fisher’s efficient supply chain, and agile, which corresponds to Fisher’s responsive supply chain (Qi, Boyer & Zhao, 2009). There is a body of literature that classifies supply chains into three categories: lean, agile and “leagile”, a hybrid form of lean and agile theories. At both extremes, high product quality levels are required. In addition, the lead time to satisfy consumer demands is important for both lean and agile, but the reasoning differs in each case (Agarwal, Shankar & Tiwari, 2006). Essentially, the difference along the two ends is the variability in demand, and thus, the conditions in which they are most applicable (Childerhouse & Towill, 2000).

2.5.1 Lean Supply Chains

The focus of the lean approach is on waste elimination (Naylor et al., 1999). Hence, lean is about doing more with less. Lean concepts work well where demand is stable and predictable, as well as where variety is low (Agarwal et al., 2006). In lean supply chains, minimal lead times are required because time is perceived as waste. The lean paradigm’s driving force is cost minimization and outperformance of competitors on the basis of price in the market (Childerhouse & Towill, 2000). In lean production, the customer simply buys specific products (Mason-Jones, Naylor & Towill, 2000), as there is no requirements to purchase capacity ahead of need. This suggests that the lean paradigm principally fits standardized products. However, despite the presence of lean manufacturing facilities in the supply chain where throughput times are being dramatically reduced, customers would still experience significant delays for delivery of their orders (Fisher, 1997).

2.5.2 Agile Supply Chains

Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace (Naylor et al., 1999). Likewise, agility refers to the ability of an organization to respond rapidly to changes in demand in terms of volume and variety. Thus, agility is critical in situations where demand is highly unpredictable (Agarwal et al., 2006). In agile supply chains, minimal lead times are required to be able to service volatile consumer demands promptly and to facilitate the exploitation of new market opportunities. In the face of volatile markets, it is important for an agile supply chain to provide high levels of availability (Childerhouse & Towill, 2000). Hence, in agile pro-
duction, the customer reserves capacity that may additionally need to be made available at very short notice (Mason-Jones et al., 2000), in order to react to changes in demand. This implies that an agile approach suits customized products. Furthermore, the application of information enrichment in agile supply chains is compulsory in order to enable all supply chain members to have a clear understanding of the actual consumer demand (Childerhouse & Towill, 2000). In addition, agile supply chains must be capable to process a variety of products and achieve different goals with the same facilities, meaning that they must count with an extensive set of abilities that provide productivity, efficiency and effectiveness of activities towards the goals of the focal firm (Sharix & Zhang, 1999).

2.5.3 Leagile Supply Chains

Leagile is the combination of lean and agile paradigms within a supply chain strategy, by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream, yet providing level scheduling upstream from the marketplace (Naylor et al., 1999). The decoupling point is used to buffer the upstream players (suppliers) from the volatile market, allowing the use of lean principles upstream. On the other hand, agile principles are applied for downstream players in order to respond to the volatile customer demand. Hence, leagility features obtaining the best from both worlds in terms of efficiency and responsiveness (Childerhouse & Towill, 2000). In other words, enabling a level schedule upstream the chain allows firms to drive down costs while ensuring an agile approach downstream allows firms to respond to an unpredictable market (Mason-Jones et al., 2000).

![Figure 2.4: Supply Chain Strategies.](source: Mason-Jones et al. (2000)).

2.5.4 Production Strategies

According to Langley et al. (2009), there are four production approaches: make-to-stock (MTS), engineer-to-order (ETO), assemble-to-order (ATO) and build-to-order (BTO). The volume and product diversity determine the combination of these manufacturing methods used by firms.

Make-to-Stock (MTS) is the manufacturing method where end-products are completed before the arrival of a customer order. This enables the producers to provide their customers with shorter lead times. Likewise, the manufacturing of goods becomes more cost effective and easier to plan. Consequently, inventory management and accurate forecasting are important factors as the storage of finish products is a rule for MTS (Langley et al., 2009).

Engineer-to-order (ETO) concentrates in creating extremely customized products which require exclusive customization design. Raw materials and components are usually stocked but are not assem-
bled until the customer order arrives. Due to the rareness of the product, lead times might be long (Langley et al., 2009).

Assemble-to-order (ATO) manufacturing starts after an order has been received. The final product is often a mixture of a regular component and customized accessories. Different components may be kept in stock before the arrival of an order, but the end goods are only finished after the receipt of the customer order. Some benefits of this production practice are reduced costs due to economies of scale, lower inventory levels, enhanced response times and decreased complexity for forecasted items (Langley et al., 2009).

Build-to-order (BTO) or make-to-order (MTO) postpones assembly waiting for the receipt of an order. This approach requires an advanced degree of customization and a lower manufacturing volume. BTO is a good selection for customized products as holding inventory for them may be expensive. Subsequently, the benefit of this method is that it manages variety and fulfills customers' particular needs (Langley et al., 2009).

So far we have illustrated how customer segmentation and product classification, as well as supplier segmentation influence supply chain strategy. The supply chain strategies selected, whether it's lean, agile or leagile, determine strategies within the areas of production, distribution, information, transportation and inventory. However, our interest is to focus on inventory, particularly on issues related to inventory location.

2.6 Inventory Management

The American Production and Inventory Society (APICS) describes inventory management as the section in charge of controlling and planning inventories. Inventory management handles the product flow in a supply chain and its purpose is to provide the desired service level of product availability to customers at reasonable costs. Consequently, the cost of inventory for an item is the total inventory costs of all members in the supply chain. Therefore, the role of inventory is to act as a buffer protecting and smoothing the effects of forecast errors, demand fluctuations and supply errors (Toomey, 2000).

Firms form part of many supply chains. Hence, supply chain strategies are different for each industry sector and depend on the type of business and on the products' characteristics. This often involves a complex network and different inventory policies. In order to optimize the levels of inventory in a supply chain, the flows of information and goods must be coordinated (Emmert & Granville, 2007). Thus, local objectives must be aligned with the rest of the supply chain to prevent them from conflicting with each other. Otherwise, they will lead to the sub-optimization of the whole supply chain performance. Moreover, the lack of coordination in inventory management along the supply chain causes the bullwhip effect (Giannoccaro, Pontrandolfo, & Scozzi, 2002).

2.6.1 The Bullwhip Effect

This is defined as the demand variability amplification which moves in direction of the upstream levels in the uncoordinated supply chain (Giannoccaro et al., 2002). The distortion of the demand information has serious cost implications for the suppliers (Lee et al., 2004). According to Lee et al. (2004), there are four causes to the bullwhip effect: Demand signal processing, the rationing game, order batching and price variations.

Demand Signal Processing: The demand that is perceived at the retailer is transferred to the supplier in an amplified way. The retailer handles the demand indications, but the initial sales information is misleading and its variance intensifies as it is passed to the supplier. Additionally, long lead times from suppliers tend to worsen the distortion even more (Lee et al., 2004). Even if the forecast is accurate, delays in receiving orders from the customers and not knowing how fast their demand can be fulfilled may influence the retailers’ decision to order unnecessary amount of products to prevent shortage (Levy & Weitz, 2009).
The Rationing Game: Uncertainty or capacity limitation in production, contribute for a shortage situation in which the manufacturers might have to rationalize the supply of items to satisfy their customers’ demand. In an attempt to secure more items, each customer places an order which surpasses the amount they normally order if there was no risk for shortage (Lee et al., 2004). Thus, this over-reaction to shortage makes the suppliers to manufacture and ship more products than the customer really needs (Levy & Weitz, 2009).

Order Batching: This occurs when the customer places an order for the same amount as in the previous review cycle’s demand. There may be different ordering patterns with different variances, such as seasonal orders and random orders that contribute to the variability of demand. Also, instead of creating several small orders, the customers wait to place a larger order to diminish transportation costs. Likewise, they might be able to take advantage of discounts due to the quantities being purchased (Levy & Weitz, 2009). Hence, batching at the customer level amplifies the demand variability for the upstream level of the supply chain (Lee et al., 2004).

Price Variations: The price fluctuations that the customer experiences contribute to stock building as the suppliers have a high-low pricing practice. The customers may increase the amount of items purchased if there are discounts involved buying more products than they really need (Lee et al., 2004).

2.6.2 Supply Chain Coordination Methods

Suppliers, customers and retailers have realized that working together helps decrease the effects of the bullwhip effect and the level of inventory in the supply chain. According to Levy & Weitz (2009), there are four methods to coordinate the level of supply chain activities: Electronic Data Interchange (EDI), information sharing, Vendor-Managed Inventory (VMI) and Collaborative Planning, Forecasting & Replenishment (CPFR).

Electronic Data Interchange (EDI) enables time reduction for placing orders, receiving them and communicating delivery information related to these orders (Levy & Weitz, 2009). Therefore, the appropriate use of EDI improves the information flows along the supply chain.

Information sharing: Unnecessary inventory is built due to the lack of knowledge of what happens at different points in the supply chain. Suppliers may not know what customers need. Hence, by sharing sales information, suppliers are able to improve efficiency in their production and reduce unnecessary backup inventory (Levy & Weitz, 2009).

Vendor-Managed Inventory (VMI) is an inventory system that allows supply chains to increase their efficiency. The supplier looks after the customer’s inventory levels and once they reach the minimum point, the supplier creates an order and delivers the products to replenish inventory (Langley et al., 2009). One type of VMI is consignment stock. This occurs when the suppliers own the stock until the customer sells it. The customer only pays for the products when they are sold (Levy & Weitz, 2009).

Collaborative Planning, Forecasting & Replenishment (CPFR) takes place when different actors in the supply chain cooperate with each other sharing information, forecasts and planning in order to enhance efficiency and product fulfillment. CPFR is a more advanced practice of VMI, since it comprises revealing proprietary information, such as business strategies and new product developments (Levy & Weitz, 2009). Moreover, CPFR stresses the significance of data sharing between the different members in the supply chain (Langley et al., 2009).

Although the approaches explained above help reduce the levels of inventory, there is still a need for an integrated method that controls the inventory in the entire supply chain.

2.6.3 Supply Chain Inventory Management

Supply Chain Inventory Management (SCIM) is an integrated method to control and plan inventory throughout the supply chain. The focus is on the end-customer’s demand, as it aims to improve the customer service decreasing costs and increasing product variety (Giannoccaro et al., 2002). SCIM policies can be classified by optimization goals, control type, inventory control frequency, temporal information requirements, and spatial information requirements.
Optimization Goal: Inventory policies can have global or local objectives. Local inventory policies are established by each actor in the supply chain on its own based on local performance, while global inventory policy decisions are made to optimize the global performance of the supply chain. Nevertheless, every actor’s goal can be aligned to the supply chain by developing incentive systems such as quantity discounts and transfer pricing schemes (Giannoccaro et al., 2002). Hence, optimization instruments and goals enable supply chains to find solutions to its problems (Langley et al., 2009).

Control Type: Two different strategies can be applied for managing supply chain inventory, namely centralized and decentralized inventory management. A centralized policy tends to minimize the whole supply chain costs, but this requires a high degree of communication between the actors in the supply chain. On the contrary, a decentralized policy monitors inventory locally (Giannoccaro et al., 2002). For instance, a firm may opt for a dispersed stock model, where finished goods are held in many distribution centers, or for a central stock model, where goods are held in one main distribution center. In addition, finished goods may be shipped directly to customers from the factory (Payne & Peters, 2004).

Inventory Control Frequency: A periodic-review control occurs when the inventory level is reviewed on a continuous time interval at every stage. A continuous-review control requires that a replenishment order is issued when the inventory level falls below the predetermined level. A hybrid-review control uses both periodic and continuous-review controls (Giannoccaro et al., 2002). Thus, inventory control enhances appropriate inventory levels and inventory precision (Langley et al., 2009).

Temporal Information Requirements: This describes whether inventory planning should adopt a proactive approach or a reactive approach. A proactive approach necessitates future demand information in form of forecast or customer orders. A proactive approach necessitates future demand information in form of forecast or customer orders, while a reactive approach is based on the actual consumption of stock (Giannoccaro et al., 2002).

Spatial Information Requirements: These are characterized by the way inventory position in the supply chain is measured. Inventory can be handled locally or in different locations in the supply chain (Giannoccaro et al., 2002).

In order to achieve an integrated control and planning of inventory, firms must differentiate the factors that can affect the wellbeing of the whole supply chain. One of them is the degree of uncertainty present in each supply chain.

2.6.4 Uncertainty

Inventory exists as insurance against the uncertainty that comprises the suppliers’ performance, the trustworthiness of the manufacturing process, the changing of customers’ desires and transportation processes. In order to control uncertainty, a firm must understand the impact of the different sources of uncertainty along the supply chain and try to reduce the impact they have (Davis, 1993). According to Davis (1993), there are three causes of uncertainty in the supply chain: customers, suppliers and manufacturers.

Customers’ Demand: This is the main cause of uncertainty in supply chains. Irregular purchase orders may occur depending on the factory’s location, unexpected demand from other customers and the fulfillment of inventory orders. These irregular orders increase the level of uncertainty in the supply chain due to their variability, which makes it difficult for suppliers to have the required stock level. The average demand and its variability help managers to set inventory goals according to customers’ needs (Davis, 1993).

Suppliers’ Performance: Many unforeseen events can occur such as longer lead times than quoted from other suppliers, force majeure incidents and machinery breakdowns. The suppliers’ on-time delivery, incongruence or late deliveries can be registered throughout time. This data can help characterize each supplier and determine the stock that must be held in order to avoid shortages (Davis, 1993).

Manufacturers’ Performance: Examples of variability in the manufacturing process include a new order with high priority transmitted to the factory, a machinery breakdown or a computer failure. Measur-
ing the entire process performance using key metrics, such as frequency of downtime, repair time and variation of repair time, can help managers to find out the reliability in their production and to take appropriate actions to improve customer service (Davis, 1993).

The three major causes of uncertainty addressed by Davis (1993) still remain important in inventory management. Nonetheless, in recent studies, authors mention product uncertainty as a significant source of uncertainty in the supply chains. As previously mentioned, product uncertainty represents the demand uncertainty that is connected to the predictability of the items’ demand (Lee, 2002). Given that uncertainty is present in all supply chains, strategies must address it. A natural strategic response to uncertainty is postponement (Boone, Craighead & Hanna, 2007).

### 2.6.5 Postponement

Postponement represents the concept of delaying activities in the supply chain until a demand has been recognized (Boone et al., 2007). The logic behind this concept is that uncertainty costs and risks are connected to the differentiation of items which occurs during production (time, place and form) and logistics operations (Pagh & Cooper, 1998). Authors propose that postponement can decrease the costs of inventory, transportation, storage and obsolescence while increasing the responsiveness of the supply chain (Boone et al., 2007).

The level of postponement is defined by the type of product the supply chain carries and by the customers’ needs. This dictates the appropriate supply chain strategies since postponed activities might be placed closer to the time and place of consumption (Yang et al., 2007).

A major principle of postponement is to gather actual information to describe and interpret customers’ requirements into a specific service or item (Yang et al., 2007). This decreases inventory in the supply chain and at the same time enhances the response time to customers (Yang et al., 2004). According to the condition of the inventory, four categories of postponement are suggested: Logistics postponement, production postponement, purchasing postponement and production development postponement (Yang et al., 2007).

Logistics postponement pursues delay opportunities that concern finish goods such as postponing inventory location to the suppliers until customer demand has been received (Yang et al., 2007). However, sometimes postponement in logistics needs express deliveries, which increases transportation costs. Therefore, the greatest advantage of using this approach is when a product needs to be tailored before delivery (Yang et al., 2004), such as single packaging.

**Production Postponement (Work-In-Process):** Semi-finished items can be maintained undifferentiated as long as the demand allows it. This enables the firm to be more flexible to satisfy the variations in customers’ needs. By maintaining undifferentiated inventory, firms can decrease supply chain costs (Yang et al., 2007) as it is possible to reduce obsolete inventory (Yang et al., 2004).

**Purchasing Postponement:** The purchase of raw materials or parts can be delayed until the receipt of an order. Thus, obsolete stock risk is minimized as firms are prevented from building unnecessary inventory. Vendor-managed inventory (VMI) practices can be applied at the same time as purchasing postponement (Yang et al., 2007).

**Product Development Postponement:** High risk projects with long lead time usually get more assets assigned while low risk sub-projects can be postponed so that every part of the project occurs simultaneously. In order to decrease integration risks, low risks sub-projects must consider the latest information of high risk projects, customers, manufacturers and other members of the supply chain (Yang et al., 2007).

Postponement facilitates actions to be performed on real time and real market demand. Therefore, it is essential to collaborate along the supply chain in order to implement postponement. For instance, purchasing and production postponement should be used to decrease inventory levels along the whole supply chain instead of shifting inventory responsibilities to lower levels. The downstream members of the supply chain must be aware of the potential order fulfillment difficulties in the upstream levels. This occurs because downstream members may experience a lack of flexibility when
placing an order at an early phase. On the other hand, suppliers may not have the possibility to plan manufacturing and logistics, thus decreasing the performance of the entire supply chain (Yang et al., 2007).

Postponement might provide the strategy of using a centralized approach in the upstream parts of the supply chain and a decentralized approach in the downstream parts of the supply chain. Defining a proper level of postponement relies on the customers’ needs and on the capacities of the firm. Moreover, postponement may be intended as a substitute for additional inventory investment (Yang et al., 2007).

The following figure describes postponement strategies and suggests the decoupling point to be based on the type of product the supply chain carries. The level of postponement can be connected to the choice of customer order decoupling point. For instance, the manufacturing method of engineering to order (ETO) entails a full postponement strategy. The dotted line in the figure reveals where in the supply chain the customers’ demand is registered. This differentiates order controlled and forecast activities (Yang et al., 2007).

Figure 2.5: Postponement Strategies & Decoupling Points.

Source: Yang et al. (2007).

2.6.6 Inventory Location: The Decoupling Point

The customer order decoupling point (CODP), or order penetration point (OPP), delimits the point in the supply chain where an item is connected to a customer order. The OPP is the last place in the supply chain where inventory is maintained. Likewise, the location of the OPP is determined by the product strategy adopted by the firm, such as make-to-stock (forecast driven), make-to-order (order driven), assemble-to-order (ATO) and engineer-to-order. The market, items and manufacturing aspects also affect the location of the OPP and its shifting along the supply chain (Olhager, 2003).

The OPP separates the manufacturing phases that are forecast controlled in the upstream level from the customer controlled phases in the downstream level (Olhager, 2003). Both information and material flows have their decoupling point. Hence, differentiating and placing strategically the OPP for both flows enhances the supply chain performance. Also, postponement theory can be applied when handling the material flow penetration point. The strategic location of the material penetration point
depends on the type of product, customer demand and the selected supply chain strategy. In contrast, the information flow penetration point should be placed as close to the suppliers as possible to provide all the members of the supply chain with accurate information (Mason-Jones & Towill, 1999).

Any change of the OPP requires a strategic motivation which enforces a competitive advantage such as lead time reduction. Thus, a company can maintain the OPP at its actual location or shift it forwards or backwards depending on the strategy approach (Olhager, 2003).

Forward shifting: The reduction of the lead time and the improvement of production efficiency are two important factors for shifting forward the OPP. The competitive advantages achieved by using this approach are prompt deliveries and better prices to the customers due to the supply chain efficiency. However, using this approach requires a higher reliability on forecast which may contribute to stock obsolescence. Also, this approach decreases the item customization to keep inventory levels and enlarges the level of pre-fabrication. Furthermore, it increases the work-in-process since more products need to be forecasted (Olhager, 2003).

Backward shifting: The reduction of forecast reliability, inventory levels and the risk for stock obsolescence while increasing the level of product customization, contributes to the competitive advantages of product range, product mix flexibility and quality. Nonetheless, by using this approach, lead times become longer and the delivery reliability may be affected if manufacturing lead times are not decreased. Also, the efficiency in production may be diminished since the possibilities for optimizing the process are reduced. Excessive backward shifting locates the company in an ETO-condition while excessive forward shifting positions the company in a MTS-condition (Olhager, 2003).

Although the strategy of postponement may well be used successfully for many products, there is another strategy that may have better results for other kind of products. This strategy is called speculation.

2.6.7 Speculation

This approach represents the contrary of postponement. Speculation supports that the changes in products and inventory movements must be made as soon as possible in order to decrease costs for the whole supply chain. The advantages include economies of scale in logistics and manufacturing processes as well as shortage risk minimization (Pagh & Cooper, 1998). Therefore, the manufacturing method of make-to-stock (MTS) entails a full speculation strategy. Bucklin (1965) extended the concept of postponement and discussed that speculation ends where postponement begin and vice versa. The idea of speculation is that the differences in form must be made as soon as possible in order to reduce costs. Likewise, it prevents lost sales for not having products in stock and decreases uncertainty in the supply chain (Bucklin, 1965). Transport costs can also be decreased as products can be sent with regular transports without using express deliveries.

2.7 Summary

The literature suggests that companies should be customer-oriented in order to ensure their competitiveness and profitability. Thus, supply chain management practices should center on customer satisfaction. As a result, firms are encouraged to offer more customized products and services delivered by innovative supply chains. This is possible through customer segmentation and product classification schemes.

Products can be classified according to their characteristics as well as by demand and supply factors. The most relevant variables in terms of product characteristics include design, lifecycle, value and obsolescence rate. In terms of demand, the most significant variables are uncertainty and delivery lead time, along with demand volume, frequency and variety. In addition, supply uncertainty and replenishment lead time are equally important.

Both supply side and demand side risks exist. Supply side risks vary according to supplier reliability, while demand side risks depend mostly on forecasting errors. Therefore, companies should engage
in supplier segmentation in order to manage supply uncertainty and optimize value through exchange, by minimizing opportunism and developing close relationships with few suppliers.

Once products are classified and customers segments are identified, it is possible to define supply chain strategies for each product category. A supply chain strategy, whether it features lean, agile or leagile characteristics, determines the strategy in other areas including inventory management. In leagile supply chains, the decoupling point sets the boundary between the lean and agile approaches. Within a manufacturing firm, strategic stocking points are dictated by the production strategy in place, such as make-to-stock or engineered-to-order.

Despite the fact supply chain strategies may help determine inventory locations by identifying decoupling points, there are many factors that influence these decisions. The problem is that companies face a lot of uncertainty not only from market demand fluctuations, but also from manufacturers and suppliers. Thus, firms are forced to adopt speculation strategies and rely on forecasts. Hence, they must deal with the bullwhip effect. On the other hand, postponement strategies require supply chain collaboration and integration. This implies that supply chain inventory policies are seldom effective, unless a high degree of integration exists. In addition, firms usually belong to a bigger supply chain network, where different supply chains overlap. This situation adds further complexity and thus, appropriate inventory locations are difficult to identify.

Most of the models for supply chain strategy selection found in the literature suggest which supply chains are appropriate for a product. However, Huemer (2006) advises that the question originally formulated by Fisher (1997) “what is the right supply chain for your product?” should be reversed to “what is the right product for your supply chain or supply network?” In practice, many companies are forced to adapt to their actual operational settings and few are capable to control their entire supply chain network. Finally, this leads to our research question: How to determine appropriate inventory locations according to the current structure of the supply chain?
3 Methodology

This chapter outlines the methodology approach selected to carry out the research. The first part introduces the case study research approach, followed by a discussion of our case study design, where we argue the reasons behind our methodology selection, including the data collection methods that were used. Finally, we present the data analysis approach and we close the chapter with a discussion on the credibility of the research.

3.1 Case Study Research

Case study research is used in management disciplines (Voss, Tsikriktsis & Frohlich, 2002) as it is appropriate for business research (Ellram, 1996). Some authors have identified a trend toward greater application of this method in logistics research (Frankel, Naslund & Bolumole, 2005). Moreover, case studies focus on holistic conditions in real life contexts and have boundaries of interest, such as an organization (Voss et al., 2002). In general, case studies are good at investigating how and why questions, and are mostly suitable for developing new theory and ideas (Voss et al., 2002). The advantage of this approach is the close collaboration between the researcher and the participants, who are able to describe their views of reality and this enables the researcher to understand the participants’ actions (Baxter & Jack, 2008).

The methodologies within case studies can be classified according to the type of data and the type of analysis. The type of data can be empirical data or modeled data. Empirical data is data to be analyzed gathered from the real world, whereas modeled data is hypothetical data to be manipulated by a model. On the other hand, the type of analysis can consist of either quantitative or qualitative research methods (Ellram, 1996). The emphasis in quantitative research is on numerical data, thus it can be quantified and the results expressed in statistical terms. Conversely, qualitative research seeks to understand phenomena in context-specific settings, where the researcher does not attempt to manipulate the phenomenon of interest. A qualitative researcher searches for illumination, understanding, and extrapolation to similar situations (Golafshani, 2003).

Although research methods may be combined, it is preferable to use a quantitative approach if the goal is to understand an incidence. However, qualitative methods are preferred when the objective is to explain a phenomenon. One disadvantage of the empirical method is that significant efforts may be expended without achieving meaningful results. Nonetheless, the empirical method includes real world data, thus improving the research relevance (Ellram, 1996).

Case studies are used for various research purposes, such as exploration, theory building, theory testing and theory refinement (Voss et al., 2002). Likewise, Ellram (1996) discusses that case study methodology can be utilized to answer research questions which are exploratory, explanatory, descriptive or predictive. In exploratory research, which characterizes our study, the focus is how or why is something being done or happening (Ellram, 1996). Thus, exploration entails the development of further research ideas and questions (Voss et al., 2002).

3.2 Case Study Design

Our research is best described as a single case study. A single case offers the possibility to investigate subunits situated within a larger case (Baxter & Jack, 2008). Likewise, our study is mainly exploratory and explanatory in nature and is designed to extend earlier conceptual work. A case study methodology was chosen because this research proposes to examine how appropriate inventory locations are determined considering the current supply chain structure of a firm. The purpose of the study is to obtain depth of understanding of supply chain management practices, particularly issues concerning inventory location through product classification. Frankel et al. (2005) stresses the importance of spending time in organizations, observing and communicating with professionals performing logistics in action, in order to benefit logistics research. By being in the “real world”, it is possible to collect first-hand information.
We believe that this research methodology is correct for our purpose as it focuses on holistic conditions in real life situations and it is suitable at investigating “how” questions. In addition, it provides the ability to explore and understand the interrelationships of concepts. Moreover, the phenomenon can be investigated in its natural context and thus meaningful knowledge can be created by observing actual practice (Voss et al., 2002).

This research is mainly conducted within the planning and procurement departments at SCM Germany. The decisions taken in these areas have a significant impact on the selection of supply chain strategies, product classification, supplier relationships and inventory management. In addition, in order to have a better understanding of SCM Germany’s supply chain, interviews to different group suppliers and sales companies in different countries were carried out.

We utilized qualitative methods for our data collection. Quantitative methods were not possible to use as our access to the company’s database to gather figures was limited. We now explain the data collection method in detail.

3.3 Data Collection

Frankel et al. (2005) identify data collection methods used in logistics research, such as surveys, interviews, observations and content analysis of documents and archival records. However, they emphasize that no single source has a total advantage over the others. Rather, they suggest that these sources could be well complementary to each other (Frankel et al., 2005). The data collection methods to be used are in part determined by the methodology research. The main source of data in case study research is often structured and semi-structured interviews backed up by unstructured ones. Other sources comprise observations, attendance to meetings, surveys and archival review (Voss et al., 2002). Quantitative methods have prevailed in many business disciplines including logistics, operations management, marketing and general management. However, qualitative methods have gained both recognition and acceptance as viable and valuable alternatives (Ellram, 1996).

Data sources can be distinguished as being primary or secondary. Primary data is gathered directly through fieldwork by the researcher, whereas secondary data refers to information collected by previous authors who utilized it for another purpose (Bailey, 2007). Within this study, a great portion of primary data was collected through interviews, informal conversations and direct observations. Secondary data was also obtained but to a lesser extent due to confidentiality matters. This includes documents and presentations provided by the firm as well as data retrieved from the company’s intranet, such as procurement guidelines, product classification and general company information.

A fundamental principle in collection of data in case study research is triangulation (Voss et al., 2002). This refers to the use of different techniques to study the same phenomenon. Three key qualitative techniques that can be used are direct observation, recordings and interviews (Ellram, 1996). Likewise, Voss et al. (2002) suggest questionnaires and archival research. Researchers recognize the importance of a multi-method application in logistics research. This is evidenced by the trend for its increased use (Frankel et al., 2005).

Structured interviews feature questions which are set out ahead of time and have a guide that is closely followed. In contrast, semi-structured interviews feature a set of prepared questions but leave room for dialogue between the interviewer and the interviewee, while unstructured or informal interviews offer a great degree of flexibility and enable the interviewer to obtain the most information (Bailey, 2007). In this research, we conducted semi-structured and unstructured interviews at the firm’s SCM offices and one sales company, as we had a chance to schedule these interviews ahead of time and visit the company’s premises in Germany. On average, these interviews took between 1 and 2 hours. On the other hand, a questionnaire was formulated to gather data from suppliers and another sales company due to time limitations and geographical barriers. Structured interview questions were e-mailed to different suppliers located in different countries and to a sales company in Sweden.
Table 3.1: Schedule of Interviews.

<table>
<thead>
<tr>
<th>Company</th>
<th>Interview</th>
<th>Interviewee’s Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM Germany</td>
<td>Unstructured</td>
<td>Director - Global Planning &amp; Procurement</td>
<td>20-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Semi-structured</td>
<td>Business Analyst</td>
<td>20-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Semi-structured</td>
<td>Buyer Procurement – Aerospace Europe</td>
<td>20-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Semi-structured</td>
<td>Business Analyst</td>
<td>21-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Semi-structured</td>
<td>Buyer Procurement – Automotive Europe</td>
<td>21-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Semi-structured</td>
<td>Project Purchaser - European Purchasing</td>
<td>21-Mar-2012</td>
</tr>
<tr>
<td>Sales Germany</td>
<td>Semi-structured</td>
<td>Sales Manager</td>
<td>21-Mar-2012</td>
</tr>
<tr>
<td>SCM Germany</td>
<td>Unstructured</td>
<td>Business Analyst - Global Planning</td>
<td>22-Mar-2012</td>
</tr>
<tr>
<td>Sales Sweden</td>
<td>Structured</td>
<td>Sales &amp; Technical Support</td>
<td>27-Mar-2012</td>
</tr>
<tr>
<td>Group Supplier Malta</td>
<td>Structured</td>
<td>Operations Manager</td>
<td>27-Mar-2012</td>
</tr>
<tr>
<td>Group Supplier Italy</td>
<td>Structured</td>
<td>Supply Chain Manager</td>
<td>27-Mar-2012</td>
</tr>
<tr>
<td>Group Supplier Poland</td>
<td>Structured</td>
<td>Logistics Manager</td>
<td>28-Mar-2012</td>
</tr>
<tr>
<td>Group Supplier UK</td>
<td>Structured</td>
<td>Production Support Manager</td>
<td>30-Mar-2012</td>
</tr>
<tr>
<td>Sales Sweden</td>
<td>Structured</td>
<td>Sales Engineer</td>
<td>30-Mar-2012</td>
</tr>
</tbody>
</table>

Interviews are criticized for their propensity to encourage the interviewer and respondent bias (Frankel et al., 2005), but on the other hand, interviews can provide much richer information. Likewise, unstructured interviews allow flexibility for questioning so further data can be gathered (Williamson, 2002). The observations in our study involve recording the pattern of objects and events. These are based both on personal views and content analysis. The content analysis of documents, websites and archival records provide a relatively stable review process which is unobtrusive and can provide a wide coverage of data over an extended time period. Yet, one of the drawbacks associated with this form of data collection is the inherent researcher bias in source selection and reporting (Frankel et al., 2005).

3.4 Data Analysis

The process of analyzing qualitative data involves breaking down the study components and interpreting its meaning (Bailey, 2007). This entails categorizing data into meaningful groups; unitizing data or attaching bits to the data relevant to the established categories; and identifying relationships or searching for patterns, where new categories are developed (Saunders, Lewis & Thornhill, 2003).

The empirical data was analyzed following the three-step process suggested by Miles and Huberman (1994): data reduction, data display and conclusion drawing. Data reduction is a form of analysis that sorts, focuses, discards and organizes data. It also concerns data codification (Miles & Huberman, 1994). First, the field notes taken during the interviews at the firm’s SCM offices were gathered together and placed under a same document for easier interpretation and analysis. The same process was performed with the data collected from the sales company in Germany. These notes included additional comments and discussions that emerged from semi-structured interviews and informal conversations. In addition, redundant notes were minimized. A similar process was followed with the data collected from the questionnaires sent out to suppliers and sales companies. In the latter case, the answers provided were placed under two separate files: one file containing supplier information and the other holding data from sales companies. Data collected from the German sales company
was then placed under the file containing other marketing companies’ data. Hence, we were able to isolate the data into three main groups, namely, supply chain management, suppliers and sales companies. The first part of the process allowed us to summarize data and to observe similarities and differences among the different bodies of data in a simplistic way.

Following the data analysis process, we continued to break down the information by establishing links between the different bodies of data, that is, the connection between suppliers, the SCM unit and sales companies. This was possible by displaying the data into charts and tables. Thus, we were able to identify patterns in these relationships. Data display helps us understand a phenomenon and enhances qualitative analysis validity. In contrast, utilizing only extended text can be cumbersome and make the researcher jump to partial, unsupported conclusions (Miles & Huberman, 1994). Subsequently, conclusions were drawn once these connections were established.

3.5 Research Credibility

A good research design requires construct validity, internal validity, external validity and reliability (Ellram, 1996). Reliability is the extent to which results are constant over time and to which they can be reproduced utilizing a similar methodology (Golafshani, 2003). In other words, this refers to the extent to which a research study can be repeated and achieve the same results (Voss et al., 2002). In contrast, validity verifies whether the research actually measures that which it was intended to measure or how truthful the study’s results are (Golafshani, 2003). Both reliability and validity can be enhanced by developing a protocol (Ellram, 1996). A protocol contains the research instruments that should be used, outlines the subjects to be covered and indicates the specific data required (Voss et al., 2002). Appendix A, B and C includes the interview questions prepared for the planning and procurement departments at SCM Germany, sales companies and group suppliers.

Construct validity addresses the establishment of proper operational measures for the concepts being studied (Ellram, 1996). It can be tested by observing whether predictions about the relationships to other variables are confirmed using multiple sources of data and by verifying if a construct as measured can be differentiated from another (Voss et al., 2002). In addition, construct validity can be tested by having key informants review the research (Ellram, 1996). In order to ensure construct validity, interview notes were reviewed by the Director of Global Planning & Procurement, who corroborated that the facts addressed were accurate. Moreover, all of the questions directed to SCM Germany were first reviewed by our key informant before the interviews were carried. He suggested which persons were suitable to answer each set of questions according to the subject. Thus, we ensure validity by interviewing the right people.

Internal validity refers to the extent to which a causal relationship can be established, whereby certain conditions are shown to lead to other conditions (Voss et al., 2002). In addition, internal validity involves making proper inferences from the data collected (Ellram, 1996). Conversely, external validity is the ability to reflect how accurately the results represent the topic studied and to generalize the results (Ellram, 1996). The number of persons interviewed, who work in different positions and areas, increases the validity of our study. In terms of external validity, the research problem does not tackle specific issues of the firm but rather the problems associated with inventory location in many industries.

Triangulation features the combination of methodologies in a study of the same phenomenon (Jick, 1979), thereby enhancing research validity (Baxter & Jack, 2008). This entails the use of multiple sources of data (Voss et al., 2002). Multiple indicators produce more stable and reliable results (Baxter & Jack, 2008). In addition, triangulation is used to examine the same phenomenon from multiple perspectives (Jick, 1979). Thus, by combining multiple observers, theories and methods, intrinsic biases can be overcome. Our research is built on multiple data sources, thus enhancing its credibility. Some of the interview questions conducted at SCM Germany were answered by more than one person in order to mitigate bias. In addition, there were two observers involved: an internal and external one. The internal observer is currently employed by the firm. The advantage of having an external observer participating in this study is the avoidance of bias as different points of view are brought together.
4 Empirical Findings

This chapter presents the results of the empirical study, where the outcomes of the interviews as well as information retrieved from documents obtained from the company are displayed. First we provide a brief description of the firm and its supply chain, followed by the product classification and customer classification methods developed by SCM Germany. Then we summarize the information collected from sales companies. Subsequently, we present the supplier segmentation method carried by the firm, followed by a summary of the data collected from group suppliers. Finally, we exhibit information about inventory management and lead times, and we close the chapter by discussing supply chain management and supply chain coordination. The outcome from the interviews is presented in text, figures and tables.

4.1 Company Background

SCM Germany is part of a leading global corporation founded in 1905. Today, the corporation employs 20,000 people in more than 40 countries and has more than 120 manufacturing plants. The group comprises four different business areas, including Sealing Materials (Sealing Materials, 2012). The present study is conducted at the supply chain management offices of the Sealing Materials business area in Europe. The products sold include a wide range of sealing products which are applied across different industries. A centralized, regional warehouse was established in 2003 near the SCM offices in Germany.

The Sealing Materials business area mainly comprises group suppliers, supply chain management (SCM) and sales companies.

Group Suppliers: These are factories that supply all kinds of seals and o-rings for the main company. They are located in different parts of the world.

Supply Chain Management (SCM): This is where the offices for supply chain management are located. It includes the areas of procurement and planning.

Sales Companies: These firms take care of their regional markets, which are usually divided by countries. They register their customers’ orders in a common system, from where SCM can observe the demand and place in some cases consolidated purchase orders. The final products are mainly sent from the suppliers to the regional warehouse and subsequently to the customers.

4.2 Product Classification

SCM Germany considers important to classify its products in order to ensure availability, order economic quantities, maximize margins under economic restrictions and minimize financial risk (Sealing Materials, 2011). This classification is used as a guideline to purchase the products.

SCM Germany classifies its products into four main groups: MTS (Make-To-Stock), MTO (Make-To-Order), MTC (Make-To-Customer) and SMS-Items (Supplier Managed Stock). The criteria for the product classification are: frequency (the number of sales picks), risk (the customer share on the sales of the item), volatility (the number of months with sales) and the date of last transaction. The reclassification is done at least once per year (Sealing Materials, 2011).

4.2.1 Make-To-Stock (MTS) Products

The items that fall into this category are the ones that fulfill the following requirements:
Table 4.1: MTS Classification Criteria.

<table>
<thead>
<tr>
<th>MTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ They must have been picked from the warehouse more than 9 times during the last 12 months</td>
</tr>
<tr>
<td>▪ The biggest customers’ purchases account for less than 70 percent of sales</td>
</tr>
<tr>
<td>▪ They have more than 5 months with sales picks</td>
</tr>
<tr>
<td>▪ They have been sold within the last 3 months</td>
</tr>
</tbody>
</table>

These items have an automatic forecast generated by a system called “Demand Solution”. This program takes into consideration history and statistical forecasts, utilizing sales history from the last 14 months. In addition, there is a safety stock calculated manually and updated continuously based on sales history, volatility, lead time and service level (Sealing Materials, 2011). This has the purpose to cover the risk of wrong forecasts.

The company distinguishes between MTS runners, MTS repeaters and MTS replacements, but there is no difference on how parts are replenished in reality. The main reasons to have several MTS classifications are information purposes, sales history, to monitor parts movements and risk minimization. MTS products can be classified into MTC, MTO and vice versa. The stock level for 3 percent of MTS items is below 2 weeks demand and a safety stock is held for 95 percent of the MTS items.

4.2.2 Make-To-Order (MTO) Products

MTO items are sub-classified into MTO 6-, MTO “_” and MTO 10+ (Sealing Materials, 2011).

Table 4.2: MTO Classification Criteria.

<table>
<thead>
<tr>
<th>MTO 6-</th>
<th>MTO “_”</th>
<th>MTO 10+</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTO product classification is updated daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 6 sales picks in the last 12 months</td>
<td>7 to 9 sales picks in the last 12 months</td>
<td>10 or more sales picks in the last 12 months</td>
</tr>
<tr>
<td>Minimum Order Values (MOV) &amp; Minimum Order Quantities (MOQ) are considered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Order Values (MOV) Optimized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchasers are only allowed to buy the same amount as in the customers’ orders</td>
<td>Order quantity based on sales history, price structure and demand</td>
<td></td>
</tr>
</tbody>
</table>

The products are sub-classified according to the number of sales picks in the last 12 months, as shown on the table above. In addition, some purchasing rules apply for each sub-classification, such as minimum order values (MOVs) and minimum order quantities (MOQs).

4.2.3 Make-To-Customer (MTC) Products

MTC items are sub-classified into MTC 4 and MTC 9, according to the principles described in the table below (Sealing Materials, 2011).
### Table 4.3: MTC Classification Criteria.

<table>
<thead>
<tr>
<th>MTC 4</th>
<th>MTC 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products comply with MTS criteria, but the customer share of the biggest customer exceeds 70% of sales</td>
<td>Products promoted by sales</td>
</tr>
<tr>
<td>High value purchase order quantities have to be confirmed by the biggest customer</td>
<td>MTO “_” order rules apply</td>
</tr>
<tr>
<td>Products reclassified at least once per year</td>
<td>Classification possible for G, A and B customers</td>
</tr>
<tr>
<td>Order quantities based on actual demand of biggest customers and demand of other customers</td>
<td>Requires a minimum purchase order value per year (set by the firm)</td>
</tr>
</tbody>
</table>

#### 4.2.4 Supplier Managed Stock (SMS) Products

The supplier managed stock items are planned and ordered by the supplier and their prices are prefixed, independent of the delivered quantity (Sealing Materials, 2011). These items are not reclassified regularly and they maintain their classification as long as SCM Germany decides. There is only one valid price. However, a minimum and maximum stock level is defined and it is the supplier’s task to keep the stock level within that range.

#### 4.2.5 MTS, MTO and MTC Figures

Between March 2011 and February 2012, the percentages of sold products were: MTS 8%, MTO 73%; and MTC 19%. MTS items represented 20% of the total stock value, while MTO and MTC accounted for 24% and 56% respectively (Figure 4.1 & Figure 4.2). The average transaction on each group was 55 times per year for MTS, 16 times for MTC and 3 times for MTO.

![Figure 4.1: Percentage of Products Sold](image1)

![Figure 4.2: Percentage of Total Stock Value](image2)

#### 4.3 Customer Classification

All sales companies classify their customers according to the monetary amount they buy per year, into A, B, C, D and G customers. This customer classification determines the service level each customer receives (Sealing Materials, 2007).

A and G are target customers who receive full service. This means that these customers are given priority (e.g. customized service) in order to satisfy their needs. G customers have even greater priority and their classification is exclusively authorized by top management. Their turnover should be higher than a certain amount per year. These customers account for 80 percent of the European turnover. Conversely, B customers receive standard service. Their turnover should be higher than a certain amount per year. These customers account for 18 percent of European sales turnover. C customers receive limited service. Their turnover is less than a given amount per year and they are
supposed to be handled by distributors. These customers account for the remaining 2 percent of the European sales turnover. Lastly, D customers are distributors and they are treated as A customers (Sealing Materials, 2012).

### Table 4.4: Customer Groups.

<table>
<thead>
<tr>
<th>Customer Group</th>
<th>Service Level</th>
<th>Priority</th>
<th>Stock Building Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, G</td>
<td>Full Service</td>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>Standard Service</td>
<td>Medium</td>
<td>Sometimes</td>
</tr>
<tr>
<td>C</td>
<td>Limited Service</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>D</td>
<td>Full Service</td>
<td>High</td>
<td>Sometimes</td>
</tr>
</tbody>
</table>

Customers are normally reclassified on a yearly basis (Sealing Materials, 2007). A, G and D customers are highly important for the firm. Likewise, B customers are relevant but to a lesser extent, while C customers are not that important, but they are nonetheless maintained because they have the potential to become B, A or G customers. In general, requests for stock building are demanded by A and G customers and sometimes from B customers.

**Figure 4.3: Percentage of Sales Turnover according to Customer Type.**

The company uses the ABC analysis tool to classify customers, based on sales volume and historical data.

### 4.4 Sales Companies

Every sales company manages independently its regional market according to the particular needs of their customers. The data was collected from two different sales companies.

#### 4.4.1 Sales Germany

According to the manager of the sales company in Germany, customers would ideally like SCM to have everything in stock although this is not feasible. In addition, customers do not want to assume risks of carrying stock. The majority accept a lead time between 4 and 6 weeks. There are customers that provide them with forecasts while others don’t. Their customers are classified according to the industry they belong to (e.g. Sanitary, Medical, Food & Beverage). However, they believe that customer classification has nothing to do with the product classification. The most important factor that influences the customer classification is the quality approvals that every customer requires.

Sales Germany’s customers are located in the south and west part of Germany and since the central warehouse is located in the same country, the stock is located very close to the customers compared to other sales companies in other countries. The percentage of total sales per item is 30% for
MTS, 30% for MTC and 40% for catalogue parts, which comprises both MTC and MTO products. Sales Germany has a good and frequent communication with its customers.

Sales Germany has consignment stock for three customers. The stock level is checked once a year. They normally have 3-4 months demand in the consignment stock. Information on the consumption is received on a monthly basis. They might even get orders earlier from the customer. Web EDI is used to communicate with two customers. This is a form of vendor managed inventory (VMI) that allows Sales Germany to have real time information from customers. Sales Germany, together with the customer, sets the minimum and maximum stock level. A person monitors the stock changes for the different customers’ plants. When the stock reaches the lowest level, a customer order is placed. As a result, the items are replenished the next day to the customer. This allows Sales Germany to place consolidated orders. Sales Germany reviews inventory physically once a year, and has never scrapped an item from the consignment stock, because these are items that are constantly being bought (runners). Also, some of the items they sell are delivered directly from the group suppliers to their customers.

4.4.2 Sales Sweden

Sales Sweden segments their markets into automotive, aerospace and industrial categories, as well as into G, A, B, C and D customer groups. This helps them to prioritize customers in terms of service. Sales Sweden is aware of the customers’ needs for the different sectors, because the actual product applications are discussed before the proper seal is suggested. Furthermore, Sales Sweden’s customers want good prices which are not necessarily the lowest, but the most reasonable prices that involve quality, technical support, technical knowledge, flexibility and service. The seasonal demand changes depend on the industry the customers belong to. Sales Sweden considers that the customer classification influence the product classification due to special design requirements and quality approvals. The factors that influence the customer classification are the turnovers and the customers’ potential. The higher the turnover, the higher the customer is ranked in the classification. Approximately 60 percent of the items sold are MTC, while the rest comprise MTO and MTS items. The sales person responsible knows the products that are produced by their customers in order to suggest proper seals. Sales Sweden suggests that there should be a closer relationship between the sales companies and the production plants, since they considered this a key to work as a group. In addition, Sales Sweden considers that SCM Germany classifies the customers properly.

The changes in the classification of items affect the quotes given to customers. Sales Sweden works hard to lead the customer to purchase stock items instead of non-stock items. However, there is a trend among some customers who have adapted the lean production system. Due to the high freight costs and bigger focus on the environment, these customers request new alternatives for stock keeping such as suppliers with local stock or suppliers with the ability to arrange consignment stocks. In addition, the customers perceive the lead time as too long.

4.5 Supplier Segmentation

SCM Germany selects third party suppliers through an external firm, which performs a pre-selection. Then, SCM Germany provides potential suppliers with a questionnaire in order to decide their suitability. This questionnaire includes information regarding the supplier’s manufacturing sites, work flows, finances, products, sales, purchasing, material management (e.g. where raw materials are sourced), production capabilities, engineering capabilities, quality management system, and business relationships with the Sealing Materials business group and competitors.

Suppliers are classified into two main groups: strategic and non-strategic. All group suppliers are considered strategic as it is a group strategy to prefer own production plants when sourcing. Strategic suppliers must have top performance in terms of quality, costing and on-time delivery. The nomination of the strategic suppliers is reviewed at the beginning of each year. The decision on this status, include the input from the market segments on existing and upcoming needs. Thus, new suppli-
ers could be nominated “strategic” solely due to its special importance for the growth or strategic plans of sales companies.

Strategic suppliers are a preferred choice when considering new sourcing needs. Hence, the company sources according to the importance of the supplier. Different business relationships are established with suppliers depending on the nature of the parts sourced. For instance, in a partnership, the goal is to achieve a win-win output. However, if there is competition among suppliers, an arm’s length relationship is established, thus there is a possibility to bargain.

The main suppliers are ranked every 3 months in order to monitor their performance. These are divided into three segments: automotive, aerospace and industrial. One quarter of the supply base is composed by third party suppliers, while the rest is composed only by group suppliers. Supplier reliability is measured according to KPIs, on-time delivery (OTD), backlog, direct shipments, orders placed, orders received, stock level forecast, rejected parts (complaints) and order inquiries.

SCM Germany can normally influence and establish a better negotiation with third party suppliers compared to group suppliers. The problem is that certain diplomacy must exist when dealing with group suppliers due to the organizational structure of the company.

4.6 Group Suppliers

Suppliers from four different countries were interviewed. These are located in Italy, Malta, Poland and the UK. According to these group suppliers, the lead times they acknowledge against the actual delivery lead time were reliable or very reliable. In order to improve lead times, the suppliers need more reliable customer forecasts and more visibility, since the current view in demand does not allow enough time to react to peaks in demand. In addition, they suggest that SCM should consider capacity issues when ordering, such as the number of tool cavities per item (productivity) and variable fluctuation of the different production department (booking), and not just lead time per item for any quantity and unbalanced distribution of the portfolio. On average, the on-time delivery for these suppliers ranges from 75 to 98 percent. However, two of them reported 75 percent OTD. The main causes for delayed orders include unpredictable technical issues during the production process, bad quality at the end line, tooling issues, capacity issues and late material deliveries.

The suppliers classify their products differently. For instance, one supplier classifies their items into runners, repeaters and strangers, which is the frequency products are being sold. Other suppliers classify their items according to the application of the product, such as automotive or industrial. Also, the items could be classified according to their compounds or product type. The majority of the suppliers agree that the product classification is connected to delivery reliability. Two out of four suppliers are aware of SCM Germany’s product classification. Long term information regarding customers’ needs and lead time is lacking even though group suppliers have access to SCM Germany’s system. Also, sometimes customer request information is missing right from the beginning. Three of the suppliers share information about their production plans with SCM Germany in full details.

The group suppliers suggest that both SCM and suppliers should adapt to each other’s standard procedures and service expectations. Also, they consider important to analyze the time each process takes, from the final customer order receipt, until the product delivery to the final customer. In addition, they consider necessary to improve forward visibility and forecasting.

The level of communication between group suppliers and their suppliers is in general good, and mostly depends on their reliability and the importance of material deliveries. Some of the group suppliers experience delays on delivery of raw material from their suppliers, which affect the on-time delivery towards SCM Germany. These group suppliers do not have stock for final products. Therefore, their production strategy is make-to-order.
4.7 Inventory Management

For SCM Germany, inventory management is the function of understanding the stock mix of the company and the different demands on their stock. The demands are influenced by both external factors (e.g. forecast and sales orders) and internal factors (e.g. service levels and lead times), and are balanced by the creation of purchase orders proposals (Sealing Materials, 2012).

The way SCM Germany manages its stock is directly related to the product classification. MTS items are planned mostly centrally due to the fact that there are customers in different countries who buy the same products. These items are stored in the central warehouse. In regards to MTO and MTC items, each sales company is allowed to plan and register in their systems the planning figures. These companies are held liable in case the stock is not sold.

At the end of the year, the items are revised by SCM Germany in order to inform each sales company about the products that have not been sold, to both scrap the items and charge sales or to maintain them in stock in case they will be needed. Lists of stock are handled regularly to sales so that they can get an overview of what they have in stock. Also, a list of obsolete items warning is sent to each sales company to inform them about the products that have not been sold during the last months.

Stock and stock rotation is monitored regularly in order to identify changes. In total, 85 percent of the products, including MTS, MTO and MTC items, are delivered from the central warehouse. Nearly all MTS products are delivered from this location (98 percent). MTO and MTC products are sometimes shipped directly to the customer from the supplier. Besides consignment stocks, local stock is available in some markets like in the UK, France and Norway. However, local stock is not very common and the amount is usually minimal. Consignment stocks are available in the following markets: Belgium, Czech Republic, Denmark, Norway, Spain and the UK. Consignment stock and vendor managed inventory represent 4.44% of the total sales for all sales companies in Europe.

Inventory policies are local. Thus, no supply chain inventory policies are followed. Business units operate independently.

One of the inventory strategies SCM Germany utilizes is to calculate the normal optimal cost by considering the stock keepings fixed cost against the best price. Best cost is the best benefit for the company. Thus, they continuously search for optimal purchasing prices. The safety stock in place should cover the fluctuation of the item and its forecast. SCM Germany is also responsible for managing stock for USA and Asia. Centralized warehouses are also located in Japan, China and the USA.

SCM Germany scraps regularly the items they do not use regularly. The main reasons for scrapping items include lack of demand, customers switching supplier, excessive amount of products in stock due to the MOQs, obsolesce of the compound and quality issues. SCM Germany’s scrap costs due to shelf life obsolescence represent 0.8% of the total amount they scrap per year. They have an excel file showing the maximum shelf life per compound.

Lead times are also important for inventory management, since SCM Germany has many suppliers with short and long lead times. A big task is to create a stable lead time range that can be trustworthy along the supply chain.

4.8 Lead Times

The lead time in the company’s system takes into consideration the production time, the freight and a buffer of 3 days for warehouse handling and errors. The orders are placed 2 weeks before they actually need to be ordered. Normally, SCM Germany sets the lead times per supplier, product group and compound. Moreover, for some suppliers, it is set on item level because of the size of the product. Lead times are changed because of external factors such as summer shutdowns and supplier capacity issues. Also, the suppliers inform SCM Germany about their average lead time. Furthermore,
SCM Germany informs the sales companies when the lead time changes are reduced or increased due to seasonal changes.

According to SCM Germany, the delays from suppliers include production capacity limitations or simply lack of capacity, quality problems (shipments delayed), new machinery (capacity restricted), new compounds, transfer of machinery and wrong lead times. At the moment, the company is building a table in the data warehouse which registers all changes of lead times on item level. This will eventually help to build a scheme for supplier reliability.

The on-time inbound delivery in February 2012 was 79% for MTC, 77% for MTO and 81% for MTS (Figure 4.3). The on-time outbound delivery in February 2012 was 92% for MTC, 85% for MTO and 93% for MTS (Figure 4.4).

![Figure 4.4: Inbound OTD](image)

![Figure 4.5: Outbound OTD](image)

**4.9 Supply Chain Strategy**

The company claims to be customer-oriented and thus, they attempt to focus on customer demands. The goals are decided by top management, which are then transmitted to SCM, and subsequently to the group suppliers and sales companies. SCM Germany is a cost center, thus, they focus on cost minimization. On the other hand, profitability goals are stressed at sales companies since they have close contact with customers. The profit margin improvement project is directed to sales. In addition, the management strategy is adjusted according to the changes in the industry and the economy.

**4.10 Supply Chain Coordination**

According to SCM Germany, they are not receiving enough information from the sales companies in regards to MTC and MTO products. SCM has normally problems communicating with the sales companies, as sales/marketing people work and think differently from the people in planning and procurement departments at SCM. Likewise, it is also challenging to communicate effectively with suppliers. SCM Germany suggests that the communication with suppliers could be enhanced by visiting suppliers and exchanging more information. In addition, they suggest that good ordering systems could improve lead time reliability. According to SCM, some suppliers are self-interested and do not collaborate. The group suppliers usually don’t share their margins, which indicate a lack of transparency. For instance, suppliers would lower their costs only if they are threatened to lose the business. This problem even exists with group suppliers.

The information transmitted along the supply chain is usually done through EDI, e-mail and telephone. Product classification is informed to suppliers in the purchase orders and by e-mail. Also, suppliers can only see demand when the orders are placed within lead time. There is a certain level of transparency between SCM and some third party suppliers since it is possible for SCM and the sales companies to see if a third party supplier has stock available through their IT system.
5 Analysis

This chapter analyzes the empirical findings, where the outcome of the study is compared with the theory presented in the literature review. First, we look at product classification, customer segmentation and supplier segmentation, where we make some suggestions and address the managerial implications involved. Then we determine whether a relation exists between product classification, customer and supplier segmentation and supply chain strategy. Finally, we explore the issues related to supply chain coordination and inventory location.

Research Question: How to determine appropriate inventory locations according to the current structure of the supply chain?

Determining appropriate inventory locations along the supply chain is a challenging task due to the fact that there are many managerial actions required. First, it is necessary to differentiate the products and segment both the customer and supplier base, in order to respond to demand effectively and manage financial risks. Second, this entails the selection of a supply chain strategy, which in turn suggests the most appropriate inventory strategy. However, based on the study conducted at SCM Germany, we find out that a firm is forced to manage its supply chains within the existing context as suggested by Selldin and Ollhager (2007). Therefore, the establishment of supply chain strategies does not seem practical.

The literature suggests that firms should be more customer-oriented in order to generate higher profits. This is precisely what SCM Germany attempts to do by focusing on improving customer lead times and ensuring stock availability. Therefore, decisions on inventory location are relevant. Now we will examine the managerial tasks discussed in more detail.

5.1 Product Classification

The purpose of product classification is to enable SCM Germany to replenish inventory properly. This has an impact on inventory location decisions, because it determines whether products should be stocked or not. For instance, MTS items are finished products stored in the central warehouse, while MTC and MTO items are only stocked if required by important customers, thus, they are produced against an order. It seems that SCM Germany has a well-grounded product classification system as it considers both, how to respond successfully to customer demands, and the economic constraints involved. For example, they consider minimum and maximum order quantities and order values. In general, the literature hardly ever considers financial limitations in product classification schemes. Yet, any product classification model is far from perfect.

SCM Germany focuses on market and demand factors (volatility, customer share, months with sales and sales line out of the warehouse) in order to classify their products, by utilizing production strategy labels. Most classification models found in the literature consider mainly product characteristics and neglect demand factors. In this case, we find the opposite. Therefore, SCM Germany should also include product characteristic factors such as monetary value, order line weight and physical volume in their classification scheme. Sub-classifications could be created to incorporate these new variables. Value influences profitability: the higher the cost, the higher the impact on the supply chain. On the contrary, weight and physical volume impact transportation costs. In addition, SCM Germany could also add another category such as ETO to further differentiate items by type or design. For instance, they currently classify their innovative products as MTC, but MTC could also comprise standard items. Table 5.1 shows the proposed product classification.
Table 5.1: Proposed product classification.

<table>
<thead>
<tr>
<th></th>
<th>MTS</th>
<th>MTO</th>
<th>MTC</th>
<th><strong>ETO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Level</td>
<td>High</td>
<td>Low/Medium</td>
<td>Low/Medium</td>
<td>Low/Medium</td>
</tr>
<tr>
<td>Delivery Frequency</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>No. of Customers</td>
<td>Many customers</td>
<td>Limited number of customers</td>
<td>One main customer</td>
<td>One main customer</td>
</tr>
<tr>
<td>Demand Uncertainty</td>
<td>Low</td>
<td>High</td>
<td>Medium/High</td>
<td>Medium/High</td>
</tr>
<tr>
<td>*Monetary Value</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
</tr>
<tr>
<td>*Order line weight</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
</tr>
<tr>
<td>*Order line Physical Volume (dimension)</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
<td>Low/Medium/High</td>
</tr>
<tr>
<td>*Product Type</td>
<td>Standard</td>
<td>Standard</td>
<td>Standard/Innovative</td>
<td>Innovative</td>
</tr>
</tbody>
</table>

*Suggested product classification variables; **New product classification.

Based on this example, we realize that it is difficult to determine which factors are more relevant than others. Thus, even though the firm has a sound product classification scheme, they are probably not categorizing their products correctly. What we find important is that the classification should not only include demand factors, but also product characteristics. Likewise, in some cases source factors should also be considered. In the end, the way in which products are categorized will not only impact inventory location, but also transportation and storage costs.

Another issue is the frequency of product reclassification. This has an impact on the downstream section of the supply chain, because of the changes in lead time. For instance, if a MTS product is reclassified as MTO, the customers would be affected since the lead time for a MTO item is higher than for a MTS item. The reason is that MTO products are bought according to suppliers’ lead time while MTS items should always be in stock. The impact of product reclassification could be diminished by informing the sales companies at least 3 months in advance about which items will be reclassified. This would give sales companies the opportunity to build stock, to remove stock or to inform their customers about the new lead time.

Furthermore, product classification is considered by group suppliers to be connected to delivery reliability. SCM Germany should be aware of the product classification their suppliers utilize in order to have a better understanding of the lead time fluctuations. This would enhance their cooperation, improve OTD and even improve SCM Germany’s price negotiations, since a “runner” product at the supplier may be produced in bigger quantities for other customers, thus SCM would benefit from the economies of scale this generates as costs would decrease.

5.2 Customer Segmentation

Another significant factor that influences inventory decisions is customer segmentation. SCM Germany and the sales companies follow a multi-segment approach, as they target different market segments, such as aerospace, automotive and industrial. Thus, they differentiate their markets by product application. In addition, customers are segmented according to the volumes they purchase. Managerial tools such as ABC analysis have proven to be useful for customer segmentation at SCM Germany. Both forms of differentiation are very effective. Likewise, quality approvals are considered in customer classification to identify the minimum standard requirements demanded by each customer.
An important customer who buys large amounts of stock might have special requirements on stock availability for certain items and demand special inventory management arrangements such as VMI or consignment stocks. Customers who receive this special service could fall under a different category due to the level of integration required. Based on Sales Germany’s experience, this is an efficient way of managing inventory since not a single item has to be scrapped. At the same time, VMI allows the firm to respond to the customers’ needs very effectively. However, not all customers are capable or willing to engage in this sort of arrangement.

On the other hand, there are local stocks held at some sales companies. However, this should be minimal since the company’s approach is to have a centralized stock where all sales companies can benefit, and at the same time, where economies of scale can be generated. Thus, customers may receive a better purchasing price and service. In addition, maintaining local stock may not justify the costs involved, unless the customer demanding it ranks high.

Another customer classification factor that could be considered is the production strategy employed by each customer. For instance, according to Sales Sweden, some customers are adopting a lean production system. As a result, these particular customers are demanding special stock arrangements with their suppliers. This classification could probably be used to further segment A and G customers, as these types of services entail a high level of customization.

The guidelines followed by SCM Germany to purchase items are affected by customer classification, since the customer share, among other demand factors, is considered when classifying products. Another factor that could be considered is demand location and dispersion. Yet, in the case of SCM Germany this is not that relevant, because each sales company targets the market in the country where they operate.

5.3 Supplier Segmentation

Supplier segmentation is important in order to manage supply uncertainty. This can also impact inventory management decisions. The company has had pre-established group suppliers and third party suppliers for many years. However, when sourcing new suppliers, an external firm performs a pre-selection. We consider that SCM Germany selects and categorizes its suppliers properly. Nevertheless, some improvements can be made when monitoring the reliability of the suppliers. For instance, a table can be created to show the OTD of each supplier in every month in order to create a pattern that illustrates the changes in delivery performance throughout the year. This would allow SCM Germany to rank their suppliers into reliable and less reliable groups. Also, this would allow the firm to identify seasonal delivery changes for every supplier and product. Furthermore, this would enable SCM Germany to find out average lead times that would be reliable for longer periods.

The Kraljic’s matrix may help SCM Germany to classify their suppliers according to supply risk and financial impact. This would enable purchasers to identify better sources of supply by mitigating risks to ensure better on-time deliveries. The following matrix (Figure 5.1) is an adaptation of the supplier classification method suggested by Guo and Xu (2007) and Kraljic (1983). In addition, it is possible to locate the different product categories created by SCM Germany in each quadrant. For example, demands for new products such as some MTC items are sourced to strategic suppliers (Type IV) as they feature both high value and risk.
Among the causes of late deliveries is the lack of raw material at the suppliers’ production line. Thus, we consider important that group suppliers actively engage in supplier segmentation in order to better monitor the performance of their suppliers and avoid the risk of raw material stock outs. For other companies, it might be necessary to request a supplier to have finished goods in stock. SCM Germany might require this from their third party suppliers. However, this is not applicable to group suppliers since they are part of the corporation, thus, the stock value would impact the group as a whole regardless of the stock location.

5.4 Supply Chain Strategy

SCM Germany does not have an established supply chain strategy. However, we notice that the company attempts to follow a lean strategy towards suppliers and an agile approach towards customers. The SCM unit is a cost center and thus it focuses its efforts on cost minimization and waste elimination. Time is perceived as waste, so minimal lead times are expected. Yet, the average inbound OTD during February 2012 was 79 percent. Some suppliers reported to have an OTD of as low as 75 percent. This suggests that SCM Germany must work harder with suppliers in order to improve inbound OTD. On the other hand, the company aims at responding effectively to customer demands. This involves ensuring high product availability and minimal lead times. In addition, there are marketability costs involved. In this case, SCM Germany also needs to improve outbound OTD, especially for MTO items, where only 85 percent were delivered on-time during February 2012.

Based on our observations, SCM Germany attempts to follow a “leagile” supply chain strategy. The decoupling point is located at the central warehouse, where all the customer orders from different sales companies are received. In this sense, the same supply chain strategy applies for all the products carried by SCM Germany. The only difference between the product categories is the units stocked for each type of product at the central warehouse. Figure 5.2 illustrates the supply chain management approach. Yet, we can still argue that a lean approach is consistent with MTO and MTC products which are not stocked, where the inventory strategy aim is to minimize stocks. On the other hand, we can argue that an agile approach is consistent with MTS items, where the inventory approach is to deploy stocks to ensure availability.
Although a formal supply chain strategy has not been established, we can still observe a relationship between product classification and inventory management strategy. Customer segmentation also plays an important role since it influences the product classification. However, in this case supplier segmentation does not seem to impact inventory strategy even though it should be considered, as we have discussed.

5.5 Inventory Management

5.5.1 Supply Chain Coordination

Without proper communication between supply chain participants, it becomes challenging to agree on inventory management decisions, including inventory locations. Also, the lack of information creates unnecessary stock building. The lack of communication is a common issue in many supply chains and the SCM Germany’s case is not the exception. Suppliers, sales people and staff from the SCM offices, including purchasers and planners, all agree that there is a communication issue between them. Thus, there is a need for better coordination and information sharing between group suppliers, SCM offices and sales companies.

Sales companies play an important role as they have direct contact with the customers. Thus, they have easier access to customer demand information and forecasts. This information must be transmitted backwards along the supply chain effectively. However, not all sales companies are able to obtain enough information from their customers and forecasts are not always shared. This eventually leads to the bullwhip effect. Several reasons can be attributed to this problem. In this case, we believe that lead times uncertainty is a possible cause for the amplification of demand. Another cause might be order batching. The customers’ inability to know how fast their demands can be fulfilled may lead to order unnecessary stock.

SCM Germany claims that they are not receiving enough information from sales companies. This suggests that sales companies should try to achieve greater integration towards their customers. In addition, both group suppliers and the SCM unit, demand more information from each other. SCM should be more aware of the production capacity issues and work closer with group suppliers. Furthermore, there needs to be better cooperation between sales companies and suppliers. Information could flow more direct between sales and the production lines. Suppliers demand more visibility and better customer forecasts to react effectively to changes in demand.

Problems with communication and coordination persist, despite the fact that information is being shared through EDI and a common platform. Third party suppliers provide some transparency as it is possible for SCM Germany to view stock availability through an integrated IT-tool. Yet, there is a need and a desire for greater supply chain integration. Some suppliers suggest that they could adapt to SCM Germany’s procedures and vice-versa. No problems with communication were acknowledged between group suppliers and their suppliers. However, this could be the case in other companies.

5.5.2 Inventory Location

The following diagram (Figure 5.3) illustrates the supply chain of the Sealing Materials business and the location of inventory. According to the empirical findings, group suppliers do not carry stock of finished items. Thus, production is triggered once an order is received from SCM Germany. Nevertheless, third party suppliers do carry some stock. Most products are delivered to the regional warehouse in Germany and subsequently distributed to the customers in different European countries. Some items are delivered to the sales companies, which sometimes also carry stock. Based on this information, we notice that the company adopts a central stock model. This supply chain inventory strategy requires a high level of communication and coordination, as addressed previously.
The following diagram (Figure 5.4) shows the postponement strategies implemented along the supply chain of the Sealing Materials business. A logistics postponement strategy is adopted for MTS products, since these are stocked in the central warehouse and distributed when a customer order is received. Thus, MTS items are produced based on speculation; SCM Germany relies on forecasts and sales history to determine how much to stock. On the other hand, a production postponement strategy is adopted for MTO and MTC items, since manufacturing is triggered when a customer order is received. In some cases, even purchasing postponement is applied as group suppliers might not always have raw materials in stock. Furthermore, we suggest that some MTC items could be classified as ETO. In this case, product development postponement could be adopted.

Figure 5.4: Postponement strategies applied at the Sealing Materials business.

As we pointed out, the decoupling point at SCM Germany is located at the central warehouse, where the customer orders are received. Nevertheless, a supply chain features many decoupling points. For instance, the decoupling point for group suppliers is located at the beginning of their production lines, since their entire manufacturing process is postponed. Hence, these are purely order-driven production strategies. This indicates that group suppliers stock raw material to be prepared to produce once an order is received, although it may be the case that raw materials are purchased once they receive an order (purchasing postponement), as previously addressed. The problems associated with pushing the decoupling point as far back as possible in the supply chain as in this case, include longer lead times and less reliable delivery times. This explains why SCM Germany is currently working towards a project to improve on-time deliveries. Also, according to Sales Sweden, many customers perceive that the lead times are too long. On the other hand, there seems to be no
real motivation or logical reason to move forward the decoupling point in production. This would entail group suppliers to carry more stock and thus, inventory costs would increase as well as the risk of stock obsolescence.

In this case study, due to the nature of the products, there is no need for assembly in manufacturing. However, in other companies, it may be optimal to locate the decoupling point somewhere along the manufacturing process, either at an assembly point or before packaging, as shown on Figure 5.4.

5.5.3 Postponement vs. Speculation

The amount of MTS items sold during the last year only accounted for 8 percent, while MTO and MTC items accounted for the rest. In addition, both Sales Germany and Sales Sweden report that most of their sales comprised MTO and MTC products. This indicates that the company engages a high degree of postponement. Hence, when it comes to inventory location in the supply chain, SCM Germany should concentrate on its suppliers and suppliers’ suppliers to guarantee the availability of raw material, even though the reasons for poor on-time delivery are mostly associated with capacity and machinery issues. SCM Germany, like many other companies, must be able to balance the level of postponement against speculation in order to manage financial risks and satisfy customers’ demands successfully. A high level of postponement requires further supply chain integration and collaboration, as we discussed earlier.

5.5.4 Product Classification & Inventory Location Issues

Given the significance of product classification in determining appropriate inventory locations in the supply chain, we further discuss this subject by proving an example. As already addressed, SCM Germany might not be focusing on the right products when it comes to stockholding. There are products with long lead times that force SCM Germany and its customers to build unnecessary stock. These items might not even be relevant for the whole supply chain. Hence, product classification is very important when determining inventory locations. SCM Germany classifies their products into MTS, MTO and MTC, focusing on demand factors, which prevents item obsolescence and enhances economies of scale. We consider this classification to be customer-oriented and could be used externally, by both suppliers and sales companies.

However, an internal item classification that takes into consideration product characteristics, specifically value, weight and physical volume could be implemented, as previously mentioned. This means that this classification guideline would only be used by SCM Germany. This would help decrease transportation and storage costs as well as decrease the stock value. In SCM Germany’s case, the scrap costs related to stock obsolescence are low. Therefore, the product life cycle is not considered a relevant classification factor. This internal classification could categorize products into three distinct groups. A monetary value to each parameter could be assigned considering what is high, medium and low. These parameters may differ between companies. The outcome is a series of possible combinations, as shown in Table 5.2.
Table 5.2: Internal product classification proposal

<table>
<thead>
<tr>
<th>Group A: High-value items</th>
<th>Group B: Medium-value items</th>
<th>Group C: Low-value items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value</strong></td>
<td><strong>Weight</strong></td>
<td><strong>Vol.</strong></td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

Item Monetary Value - H: High; M: Medium; and L: Low.

*For simplification purposes, we refer to weight and physical volume as being High or Low, instead of Large or Small.

The items in group A should be given greater attention due to the financial impact they could have on the company. For instance, an item with a high value, weight and physical volume, should be bought only against the receipt of a customer order. In this case, a purchasing postponement or product postponement strategy would apply. This means that a “HHH” item would be handled as a MTO or MTC product.

Products classified as MTS which feature high value, weight and physical volume could be shipped directly to the customers. These items could be managed by group suppliers. On the contrary, if an item is classified as MTS and features a low value, weight and physical volume (“LLL”) it could be stored at the central warehouse. In this case, a logistics postponement strategy would apply and speculation principles would be followed. Thus, it would be handled the way all MTS items are treated currently.

By classifying the products according to value, weight and physical volume, it is possible to determine appropriate inventory locations in the supply chain. This would enhance lead time stability and decrease uncertainty in the supply chain. The lack of stock, which contributes to the bullwhip effect, would also be prevented by classifying the products properly and placing them accordingly in the supply chain.

However, companies operate in complex and changing environments. In addition, other factors must be considered, including customer demands and supplier capabilities. For instance, customers might require SCM Germany to have “HHH” items in stock. Likewise, suppliers might not have the capability to stock finished products. This suggests that even though maximum efficiency is desirable, capacity limits and customer requirements call for flexibility. Therefore, despite storing a “HHH” item is economically unfeasible, it must still be stored if an important customer demands it. However, if these items are stored, they must be monitored constantly, and in case they are not sold within a period of time, they should be invoiced and sent to the customer. Consequently, it can be impractical to satisfy all customers’ requirements. Therefore, it is necessary to segment customers according to their value for the company in terms of sales. Only those customers who contribute significantly to the firm’s profitability should be prioritized.
6 Conclusion

Research Question: How to determine appropriate inventory locations according to the current structure of the supply chain?

Determining appropriate inventory locations is not an easy task as different factors have to be balanced. For instance, customers’ demands must be balanced against economic constraints. All customers wish their suppliers have stock availability 24/7, although this is not economically feasible. Thus, a firm engages in customer segmentation in order to identify valuable customers and satisfy their requirements according to their significance to the company. As a result, stock might be kept at locations close to the customer and in some cases consignment stock or vendor-managed inventory might be required.

In addition, products must be categorized according to demand variables as well as physical characteristics, as shown in the example provided in the Analysis. This allows a company to identify which products should be stored in the warehouse and which ones should be ordered upon customer requests. This way demand risk can be managed as unnecessary stock building is avoided. The selection of product classification variables is challenging since it is hard to determine which factors have more relevance. We believe that this depends on the company’s objectives and the nature of the products and the industry. Overall, we find that product classification is a key determinant for inventory location.

Another factor that must be taken into consideration is supply risk. Therefore, a firm engages in supplier segmentation in order to identify which suppliers are more reliable. The nature of the product should be considered in the classification scheme, as suggested. Suppliers which follow a make-to-order production strategy may face issues with lack of raw material availability. Thus, it is also important that suppliers monitor their suppliers in order to mitigate the risk of stock out. In other cases, a company might find necessary to request a supplier to hold finished goods in stock.

The literature suggests that the way products are classified as well as customer and supplier factors, can help determine supply chain strategies. However, the case study reveals that in reality it is not possible to establish such strategies. On the contrary, a company is forced to adapt within its current supply chain structures. Thus, products must be reclassified every certain amount of time. The same is required for customers and suppliers. For example, a customer with low profit contribution in the present may become an important client in the future, or a supplier with a poor qualification may actually improve and become a reliable supplier. As a result, it is not possible to establish a different, long-term supply chain strategy for each product category. What seems logic is that a company should adopt a lean strategy towards suppliers and an agile approach towards customers for certain products. This way it is possible to focus both on cost minimization and profit maximization by allocating resources effectively.

Due to the complexity of supply chains and changing circumstances, it is essential to maintain a good level of communication along the chain, particularly in a firm which adopts a centralized inventory policy and adopts a high level of postponement, as in the case study. Hence, supply chain coordination plays a significant role. This is especially important in order to respond effectively to customer requirements. Likewise, both supplier and demand uncertainty can be minimized through enhanced information exchange. Moreover, lead times could be reduced through better communication as solutions to the problems are more likely to be solved in cooperation with other supply chain participants.

To summarize, appropriate inventory locations can be determined by classifying products and segmenting customers and suppliers every certain period, although product classification has a much greater influence. This way a firm is able to minimize supply and demand risk and at the same time ensure stock availability. By locating stock at the right place, it is possible to respond in a timely manner to customer requests and simultaneously lower costs. As a result, profit margins can be improved. Thus, the purpose of this thesis has been addressed.
7 Future Research

A future study could analyze the factors determining inventory location from the perspective of a manufacturing company. In that case, it would be possible to analyze appropriate locations for the decoupling point within the production process. In addition, it would be possible to study the impact of postponement at the manufacturing stage along the supply chain.

Another area that deems to be investigated is the positioning of the information decoupling point. This research only considers the location of the material decoupling point since it addresses inventory location. However, the information decoupling point could be located independently from the material decoupling point. The strategic positioning of information decoupling points can considerably enhance the information flow along the supply chain and as a result, diminish the level of uncertainty and speculation. Moreover, this would enable supply chain participants to plan and coordinate better their activities, including the identification of suitable locations for stock.

On the other hand, researchers should reflect on economic constraints when developing product classification schemes. The case study illustrates the importance of incorporating financial restrictions when classifying products. Therefore, future studies should also consider these limitations, especially order values.
References


Appendix A

Interview Questions for Sales Companies (Structured)

1. How do you segment your customers?
2. Do you know what the customer needs are for different sectors?
3. Do you experience seasonal changes in the demand for certain articles? Do you know which items? Please specify.
4. Does the customer classification influence the product classification?
5. What factors influence the customer classification?
6. Where are your customers located?
7. What percentage of customers buys each of your product categories?
8. How much information do you have about the customers that buy the different kinds of products?
9. Is it feasible to have stock located closer to some customers?
10. How can (company name), subsidiaries and suppliers, improve their services to the customers?
11. What do customers think about the company’s lead times?
12. What do customers think about the company’s on-time delivery (OTD)?
13. What do customers think about product availability for each of your product categories?
14. What percentage of each of your product categories do your customers buy?
15. What do you think about how the company classifies their customers?
16. What do you think about how the company classify classifies their products?
17. Are there any other comments or observations you would like to add?

Interview Questions for Sales Company in Germany (Semi-structured)

1. Do you know what the customer needs for the different sectors?
2. Do you experience seasonal changes in the demand for certain articles? Do you know which articles? Please specify.
3. Does the customer classification influence the article classification?
4. What factors influence the customer classification?
5. Where are your customers located?
6. What percentage of customers buys each of your product categories?
7. How much information do you have about the customers that buy the different kinds of products?
8. How critical is to have stock located near the customer in the different markets?
9. Is it feasible to have stock located closer to some customers?
10. Do you manage consignment stocks and/or vendor-managed inventory? If so, how?
11. Are parts occasionally delivered directly from the suppliers to the customers?
Appendix B

Interview Questions for Group Suppliers (Structured)

1. How reliable are the lead times you acknowledge against the actual delivery lead times?
   A) Very Reliable; B) Reliable; or C) Not Reliable
2. What kind of information would you like to receive in order to improve the reliability of your lead times?
3. In percentage, how many orders do you deliver on-time to (company name) every month and how many orders are delayed?
4. What are the causes for delaying the orders?
5. Do you classify the products you manufacture into different groups? If yes, which are they?
6. Do you think that this product classification is connected to your delivery reliability in some way?
7. Are you aware of the product classification that (company name) follows?
8. Do you follow the same product classification?
9. Do you think you receive enough information from (company name) regarding customers’ needs and lead time?
10. Do you share information about your production plans with (company name)?
11. What is the level of communication between you and your suppliers?
12. Do you have problems with deliveries from your suppliers which ultimately impact your OTD with (company name)?
13. Do you start production when orders from (company name) are received or do you stock items?
14. Any suggestions that you would like to make in order to improve your lead time and service towards (company name) and its customers?

Appendix C

Interviews at SCM Germany (Semi-structured)

Product Classification

1. How many levels of runners/ Make-To-Stock (MTS) items do you have?
2. Which criteria do you use to classify the different types of runners/MTS items?
3. How often do you classify them?
4. How do you plan runners/MTS items?
5. How often do you update their safety stock?
6. How do you calculate the safety stock for runners/MTS items?
7. Do you have safety stock for all runners/MTS items?
8. Do you inform the people at the sales companies when you make the item reclassification?
9. Do you classify a runner/MTS item into other categories?
10. Do you reclassify the items within the same category often?
11. Do you handle supplier managed stock? If so, how often do you classify these items?
12. How often do you have shortage for runners/MTS items?
13. What is the percentage of each of your product categories that you sell/manage?
14. What is the value of the different stock in percentage for each of your product categories and their different sub-classifications (if any)?
15. Do you stock different products that can substitute each other? If yes, why?

**On-time delivery (OTD)**
1. What is the inbound OTD for each of your product categories?
2. What is the outbound OTD for each of your product categories?
3. How do you measure the suppliers’ OTD?
4. Is your goal to improve OTD only towards customers or does it also include suppliers?

**Lead time**
1. How do you set the lead times in the system?
2. How often do you change them?
3. Do you have a register that shows how often the suppliers change their lead times and their lead times variation in days?

**Supplier Relationship Management**
1. What do you think are the causes for delays from the suppliers?
2. Do you have a tool that measures every supplier’s reliability?
3. Do you use EDI for transmitting you orders to the suppliers?
4. What kind of tools do you have in order to receive and transfer information between customers and suppliers?
5. How long in time can the supplier see your demand?
6. Is your product classification communicated to your suppliers?
7. Do you have different relationships with suppliers?
8. Do you classify your suppliers? How?
9. Do you source according to the importance of the supplier?

**Information Flows**
1. Do you receive enough information from sales companies/subsidiaries regarding each of your product categories (e.g. Make-To-Order or Make-To-Customer items)?
2. What do you think the customers’ needs are?
3. What do you think the suppliers’ needs are?
4. How can you improve your communication with the suppliers?
5. How can you improve the communication with the sales companies?
6. What kind of information do you need from your suppliers?
7. Do you face any challenges in terms of information sharing with your suppliers?
8. What kind of information do you need from the sales companies?
9. Do you face any challenges in terms of information sharing with sales companies?
10. What do you think it can be done to improve lead time reliability?

**Obsolete Material Handling**
1. Do you have a register of material durability? Is this an important variable when purchasing products that are not MTS?
2. How often does each of your product categories become obsolete?
3. Do you have records regarding how often you scrap each of your product categories due to material obsolescence?
4. How often do you scrap articles?
5. What is the classification of the articles you normally scrap?
6. What are the main causes for scrapping the articles?
7. Which marketing companies scrap most articles?
8. Are you using any method to prevent the same article to be scrapped again?

**Inventory Management**
1. How often do you check what you have in stock and the stock rotation?
2. What is the percentage of articles that are delivered from your centralized warehouse?
3. Do you always deliver the runners/MTS items from your centralized warehouse?
4. How do you mostly deliver other product categories that are not runners/MTS, from your centralized warehouse?
5. Have you considered locating stock at other locations (supplier side)?
6. Do you have agreements with your suppliers about where to have stock available?
7. Are your inventory policies local?
8. Do you have supply chain inventory policies?
9. Do you manage VMI and/or consignment stock? If so, what is the percentage of customers who have VMI and consignment stock?

**Supply Chain Management**
1. In general, how important is customer satisfaction for the firm?
2. Where do you focus more when trying to improve your supply chain, on the supply side or the demand side of the chain?