Master's thesis

NTNU
Norwegian University of Science and Technology
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Dept. of Industrial Economics and Technology
Management

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How aspects of supply chains impact the supply chain strategies of manufacturing firms

Master's thesis in Project Management
Supervisor: Elsebeth Holmen
July 2020

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Kunnskap for en bedre verden

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Preface

This master's thesis has been conducted as the last part of the Master of Science in Project Management at the Norwegian University of Science and Technology (NTNU). The thesis is written in the specialization field of Industrial Engineering at the Department of Industrial Economics and Technology Management.

We would like to thank Professor Elsebeth Holmen and especially Ph.D. Candidate Leandro dos Santos for the supervision of this thesis and the opportunity to write about this topic. Thank you also to the company for the opportunity to use their product as a case in our thesis, and especially to the sourcing and procurement manager and the director of digitalization for insightful meetings and great interviews.

This thesis has been written during the COVID-19 pandemic and has been affected by this, especially in regards to data collection. The reason is that the operations, supply, and demand of the case company is impacted by COVID-19. However, we have tried to not consider this impact, and rather look at the normal operations in the case company.

Abstract

The purpose of this thesis is to examine how supply chain aspects can impact the choice of supply chain strategy. To achieve this, the supply chain aspects of product and market characteristics, decoupling point, location of inventory, transportation, and bullwhip effect are examined in relation to the supply chain for a product with the perspective of a lead firm in Scandinavia. To assess the upstream operations from the lead firm, two components that are supplied from two different suppliers are included. The relationships with these suppliers are also analyzed regarding their impact on the supply chain strategy.

Before the supply chain aspects are analyzed in a case, a narrative literature review was conducted. In this review, the suggestions from the literature are presented in terms of how the supply chain aspects impact the choice of supply chain strategy. To examine if the suggestions from the literature also apply in practice, a case study was conducted where the unit of analysis is the supply chain for a product. In this case study, data was collected through two meetings and two interviews with the lead firm in the supply chain. Also, documents provided by the lead firm and complementary data from the Internet were used to collect data. Based on these sources of data, the findings from the case study are presented, where the current supply chain of the product is described.

The main finding on the lead firm's current supply chain strategy is that they are emphasizing high efficiency and promising customers' short delivery lead time. This causes high inventory levels and overproduction for the lead firm. Another finding is that when looking at the relationships with the suppliers, their production methods and supply chain strategies do not align with the lead firm. Based on this, four supply chain strategies are proposed for the lead firm, including a preferred supply chain strategy for the suppliers following the lead firm's strategy. The four suggested strategies are the lean, agile, hybrid, and dual supply chain strategy. These are emphasizing high effectiveness and should improve the current supply chain strategy of the lead firm and the suppliers. Furthermore, some of the four suggested strategies require the suppliers to deliver with short supply lead times for the strategy to be feasible. Thus, an analysis of the customer – supplier relationships is also conducted. In this analysis, it appears that it would be more possible for the lead firm to influence one of the suppliers to change their supply chain strategy due to high interdependency in the relationship.

Sammendrag

Formålet med denne oppgaven er å undersøke hvordan forsyningskjedeaspekter kan påvirke valget av forsyningskjedestrategi. For å oppnå dette er forsyningskjedeaspektene produkt- og markedskarakteristikker, avkoblingspunkt (decoupling point), plassering av lager, transport og "bullwhip-effekt" undersøkt i forhold til forsyningskjeden for et produkt fra perspektivet til et hovedfirma i Skandinavia. For å vurdere oppstrøms operasjoner fra hovedfirmaet er to komponenter som leveres fra to forskjellige leverandører inkludert. Relasjonene til disse leverandørene er også analysert med hensyn til deres påvirkning på forsyningskjedestrategien.

Før forsyningskjedeaspektene er analysert i en reell case, gjennomføres en narrativ litteraturstudie. I denne studien presenteres forslagene fra litteraturen i forhold til hvordan forsyningskjedeaspektene påvirker valget av forsyningskjedestrategi. For å undersøke om forslagene fra litteraturen også gjelder i praksis, gjennomføres en casestudie der analyseenheten er forsyningskjeden til et produkt. I denne casestudien blir data samlet inn gjennom to møter og to intervjuer med hovedfirmaet i forsyningskjeden. I tillegg brukes dokumenter levert av hovedfirmaet og komplementær data fra Internett for å samle inn data. Basert på disse datakildene blir funnene fra casestudien presentert, der den nåværende forsyningskjeden for produktet er beskrevet.

Hovedfunnet i hovedfirmaets nåværende forsyningskjedestrategi er at de legger vekt på høy effektivitet (efficiency) og lover kundene korte leveringstider. Dette medfører høye lagernivåer og overproduksjon for hovedfirmaet. Et annet funn er at når man ser på relasjonene til leverandørene er deres produksjonsmetoder og forsyningskjedestrategier ikke i samsvar med hovedfirmaet. Basert på dette foreslås fire forsyningskjedestrategier for hovedfirmaet, inkludert en foretrukket forsyningskjedestrategi for leverandørene i samsvar med hovedfirmaets strategi. De fire foreslåtte strategiene er lean (mager), agile (smidig), hybrid og dual (dobbel) forsyningskjedestrategi. Disse legger vekt på høy effekt (effectiveness), og bør forbedre den nåværende forsyningskjedestrategien til hovedfirmaet og leverandørene. Dessuten, noen av de fire forelåtte strategiene krever at leverandørene skal levere med korte leveringstider for at strategien kan være gjennomførbar. Dermed, er det blitt gjennomført en analyse av kunde – levereandør forholdet. I denne analysen ser det ut til at det vil være mer mulig for hovedfirmaet å påvirke en av leverandørene å endre sin forsyningskjedestrategi, på grunn av høy gjensidig avhengighet i forholdet.

Abbreviations

ATO:	Assemble-to-order
BTO:	Build-to-order
DC:	Distribution center
ETO:	Engineer-to-order
FP:	Finished product
JIT:	Just-in-time
LF:	Lead firm
MTO:	Make-to-order
MTS:	Make-to-stock
SC:	Supply chain
STS:	Ship-to-stock

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1 Introduction

Manufacturing operations are about producing products from raw materials to finished products (Koren et al., 1999), in which there is rarely only one organization that produces any product from raw material to finished product (FP) in today's business environment (Beamon, 1998). As a consequence of this, organizations are dependent on other suppliers where each of many suppliers is producing parts of the FP. This stream of suppliers is what is called a supply chain (SC). SCs are becoming more complex and longer than ever (So & Sun, 2010), which further means more complexity in the number of relationships, information flow, and so on. This makes it more complicated to manage all the necessary (and unnecessary) processes to produce efficiently and to prevent producing defects or damaging products.

Moreover, manufacturing operations are not only about producing as much and as efficiently as possible, as it also has to be enough buyers (customers) to the amount of products produced. If there are none to buy it, and thus an overproduction, all cost occurring through the production will be wasted. Thus, supply and demand have to be matched, which is what can be seen as the key issue in supply chain management (Christopher, 2016; Gattorna & Jones, 1998).

To match this, organizations must have some sort of strategy to cope with the characteristics of the market and the products. Christopher (2016) suggests different broad generic SC strategies to do this, that appraise if the demand is predictable or unpredictable, and if the supply lead times are long or short. Here, demand predictability is about how stable the demand is. For example, there will be fewer buyers of skis in the summer than in the winter. Hence, this is something that the production has to consider. While supply lead times is the time it takes from an organization orders to the supplier has delivered the order. Thus, the supply lead times are longer for customized driver-seats than for bread from the bakery next door.

Two SC strategies are the lean and agile SC strategy. The former enhances efficiency in operations, while the latter has higher flexibility which enhances high effectiveness in operations. The lean SC strategy is based on one part of lean production, popularized in Womack, Jones, and Roos (1990), which is highly focused on producing with high efficiency to gain competitive advantage. This high efficiency is achieved through JIT (just-in-time) deliveries, waste reduction, kanban, VSM (value-stream mapping), etc. which reduces or eliminates processes that do not add value to the product, and that customers do not want to pay for. Especially the waste of inventory has been considered to be an important waste to improve efficiency in

operations, as organizations use high inventory levels to hide their problems (Harris, Harris, & Streeter, 2011; Nicholas, 2011). Further, a lean SC strategy requires predictable demand, which is typical for instance in precious metals products (Dyer, Furr, & Lefrandt, 2014). Through this predictable demand, this industry can know fairly certain how much they will sell over a given period of time, e.g. a month. This information can be utilized to make SC's operations as efficient as possible such as production schedules, inventory levels, and transport utilization. Thus, by producing with high efficiency, the SC members can get the most output out of their resources (input) in which can be turned into superior value.

However, as the lean SC strategy is emphasizing on producing with high efficiency, this may cause severe low effectiveness in their production in markets with unpredictable demand. Thus, it may not bring the desired benefits to use a lean SC strategy in markets with unpredictable demand. Furthermore, as product life cycles are becoming shorter and shorter, and markets more volatile than ever, it is inevitable for some SCs to avoid overproduction (Christopher, 2000). The key to survival in these markets is to develop an agile SC with high flexibility. This agile SC strategy manufactures towards demand with high effectiveness, which enables the SC to minimize inventory levels and eliminate the risk of overproduction. As this strategy focuses on high effectiveness instead of high efficiency, it can be viewed as the opposite of the lean strategy.

Furthermore, in a customer – supplier relationship might the supplier be a determinant on what SC strategy that is feasible for firms. For instance, one strategy may require high availability of components, while another may require short supply lead time. Thus, if the supplier is unable or does not want to deliver on the necessary terms, the firms' SC strategy that is desired might be infeasible. Also, by including the customer – supplier relationship in the thesis, a more holistic view can be used as the actors cannot perform their activities and utilize their resources in isolation. Thus, they are dependent on the relationship.

Moreover, it does also exist combinations of these SC strategies and different methods to use when following each of the strategies. For SC members', this is important to decide since it has major impacts on their delivery lead time, safety stock levels, degree of customization, and transport utilization. This makes the choice of SC strategy for the firms in the SC a difficult and important decision, impacting the whole SC.

1.1 Justification

In the SC literature there is a large focus on SCs, and there are many different SC aspects can be used to examine how these impact different parts of SCs (Aitken, 1998; Christopher,

2016; Eltantawy, Paulraj, Giunipero, Naslund, & Thute, 2015; So & Sun, 2010; van Weele, 2018). From the thesis perspective, the literature focuses on SC aspects which can impact the efficiency and effectiveness of SC members.

In a literature study we found that the aspects with the most focus in the SC literature are product and market characteristics (Christopher, 2016; Naylor, Naim, & Berry, 1999; Pagh & Cooper, 1998; Yang & Burns, 2003), decoupling point (Christopher, 2016; Feitzinger & Lee, 1997; Hopp & Spearman, 2004; Naylor et al., 1999; Pagh & Cooper, 1998; van Donk, 2001), location of inventory (Lin & Wang, 2011; Pagh & Cooper, 1998; Schmitt, Sun, Snyder, & Shen, 2015; Skjott-Larsen & Schary, 1996), transportation (Baumol & Vinod, 1970; Blumenfeld, Burns, Diltz, & Daganzo, 1985; Eisler, Horbal, & Koch, 2007; Ellram, Tate, & Petersen, 2013; Karlsson & Norr, 1994; Moradlou & Tate, 2018; Pan & Liao, 1989; Seth & Gupta, 2005; van Weele, 2018), and bullwhip effect (Croson & Donohue, 2006; Fuller, O'Conor, & Rawlinson, 1993; Lee, Padmanabhan, & Whang, 1997b; Metters, 1997; Sterman, 1989).

All these aspects have a large individual focus in the literature, but how they are connected together and impacting the choice of SC strategy has not to our knowledge been researched. Furthermore, there has not been conducted a case study to examine how a lead firm (LF) in Scandinavia follows what the literature suggests in the choice of SC strategy related to the different SC aspects in the literature. An LF is, in this thesis, an actor that has a greater impact on the SC of the product that is examined.

Further, the choice of SC strategy is interesting to look at in the Scandinavian environment as this environment has some typical characteristics such as high labor cost and high technological competence. Still, the SC members' do not achieve any benefits by being located close to this environment as the market is small in size and their products are often sold globally. Thus, how this environment impacts the decisions by an LF in Scandinavia, in terms of their SC strategy, is interesting to study. As the theme for the thesis has been justified, the research question for the thesis will be further presented.

1.2 Research question

Authors such as Christopher (2016), Eisler et al. (2007), and Harris et al. (2011) advocates that SCs should compete as a whole to create 'win-win'-situations. In theory, this is an excellent philosophy, however, in practice, it is not that easy because it requires that SC members have adequate capabilities, capital, and motivation to do such improvements. Hence, in practice, firms are more focused on optimizing their individual operations to lower their individual

costs. Reducing costs through reducing unit price has traditionally been common, but there are many more types of costs than just the unit price. This is why the widely used tool of the total cost of ownership (TCO) is being used to identify all costs related to products through the SC.

To cope with these costs the choice of SC strategy is a major decision, as it determines the agility to how quickly output can be adjusted to match market demand, and with how lean this can be achieved to optimize resource utilization and maximizing economies of scale. What SC strategy LFs should choose can be impacted by SC aspects such as product and market characteristics, decoupling point, and transportation. Based on this, the thesis' research question is defined as follows:

"How can aspects of supply chains impact the choice of supply chain strategy of a lead firm?"

The SC aspects can impact which strategy the LF should choose. The challenge for the LF is to understand the different strategies and aspects to identify the SC strategy which fits their products. Furthermore, the efficiency and effectiveness of the LF's operations are significantly impacted by their choice of SC strategy and the SC aspects as mentioned. Two opposites strategies are the lean and agile SC strategies. Here, the lean SC strategy is emphasizing high efficiency, while the agile SC strategy is emphasizing on preventing overproduction through high effectiveness.

In this thesis, *efficiency* is used as 'doing more with less', which is about the ability to produce more output with less input. *Effectiveness* is 'doing the right thing', which is about doing what one actually should do to fulfill what the customer demand. As an illustration of these definitions, one might be highly efficient at getting from A to B. However, if one actually should have been at C, one would have low effectiveness by being in the wrong place, but high efficiency by moving to B in a short time and at a low cost. Furthermore, it is important to be aware that an improvement in efficiency and effectiveness for one SC member might result in a decrease in another SC member's efficiency and effectiveness. Thus, even though an improvement may give great benefits for the LF, this may actually decrease the efficiency or effectiveness for the supplier, and therefore be infeasible.

Moreover, as the research question has a broad scope, three sub-questions have been developed to focus on three SC concepts and how they impact the efficiency and effectiveness of SC members. These three SC concepts are production methods, the waste of inventory, and the waste of overproduction, which are important to consider in the choice of SC strategy, as they have a high impact on efficiency and effectiveness. E.g. A high waste of overproduction

can be caused by low effectiveness in production. Further, this overproduction increases inventory levels, which reduces firms' efficiency. To cope with this, a more flexible SC strategy can be used. However, by increasing flexibility, there will be difficult to operate more lean with high efficiency. Thus, to answer the research question, the three SC concepts will be used to examine how they impact efficiency and effectiveness, where the first sub-question is related to production methods and is defined as follows:

1. *"How do the production methods impact efficiency and effectiveness of supply chain members?"*

As the production method determines if the product in the SC will be produced towards customer's orders or made to stock by forecasting, the production method of the LF is related to several SC aspects. This production method will further set the premise for efficiency and effectiveness.

The last two sub-questions relate to the waste of inventory and the waste of overproduction. The reason for choosing to focus on inventory and overproduction is, as further described in section 1.3, that these have the highest focus in the SC literature of the sources of waste. Especially when looking at the sources of waste in a manufacturing SC context, they are related to several SC aspects that impact efficiency and effectiveness. Based on this, the second sub-question focuses on the waste of inventory:

2. *"How does the waste of inventory impact efficiency and effectiveness of supply chain members?"*

To achieve high efficiency in inventory, the inventory levels should be kept to a minimum, while still have sufficient components to avoid unwanted production pauses. This also enables high efficiency in production. On the other hand, to produce with high effectiveness, the inventory levels must be higher to have the required flexibility to produce towards actual demand. Thus, the different SC aspects within the waste of inventory have major impacts on the efficiency and effectiveness of SC members.

Moreover, the third sub-question is related to the waste of overproduction in an SC context, and is defined as follows:

3. *"How does the waste of overproduction impact efficiency and effectiveness of supply chain members?"*

Solely focusing on high efficiency in production increases the risk for overproduction as the

production may be more relied on producing high volume instead of considering actual customer demand. On the other hand, producing with high effectiveness emphasizes that manufactured products should have an actual demand. Thus, the risk of overproduction and obsolete products could be eliminated, or at least reduced. This shows that different SC aspects within this waste have a great impact on SC members' efficiency and effectiveness.

Furthermore, SCs consist of multiple suppliers that are dependent on each other. Then, if a firm wants to implement a change in its SC strategy with success, the suppliers should be considered. Thus, if a strategy requires something from a supplier, which will give great benefits for another SC member, this whole strategy could be inhibited because of a poor customer – supplier relationship. Thus, examining the relationship with the LF's suppliers is important to understand which SC strategies they can choose and are able to implement.

To answer the research question, a narrative literature review will be conducted to examine what the literature suggests about the three sub-questions. From this literature review, a framework will be developed which will be followed in the analysis. After this framework has been established, the research methodology will be presented, where the three sub-questions with their related SC aspects will be assessed in relation to a case firm. This analysis will follow the framework to look at the LF's current SC strategy. This analysis will be used to see how the suggestions from the literature apply to the findings on the LF's current strategy, before a discussion on alternative SC strategies for the LF will be given. This discussion will highlight how the different SC aspects should be used when the LF chooses SC strategy. Further, to set the boundaries for the thesis, the unit of analysis will be discussed.

The unit of analysis

The unit of analysis in this thesis is the SC for a product, where the perspective on the SC will be from an LF. It would be impossible to analyze the entire SC for the product, especially considering that SCs are more complex and longer than ever (So & Sun, 2010). Thus, collecting data about all components and its suppliers of the finished product would be infeasible.

To reduce this complexity, this thesis will focus on the major actor(s) in the SC, which will be referred to as *lead firms*, and tier 1 supplier(s) of this LF. Further to reduce the complexity, two components of the finished product will be chosen to analyze the upstream operations of the SC. The LF is, in this thesis, an actor that has a great impact on the SC of the product that is examined. Thus, by solely examining this product, the LF will have great influence to determine the SC strategy. However, as other suppliers in that product's SC also supplies

in many other SCs, they may not consider this SC as an important SC for them. Thus, the LF might be unable to determine the other SC members' strategy as they wish.

Analyzing the SC of an FP from the perspective of the LF reduces the complexity as our analysis will focus on the most important firm with the highest impact on creating value to the FP in the SC. By using this unit of analysis, we are able to use a holistic perspective on the SC to analyze both upstream and downstream from the LF, and the customer – supplier relationship.

Further, the background of this study, along with the main findings from our previous research will be presented.

1.3 Previous research

Previously, in Viken and Haraldstad (2019), we conducted a systematic literature review aiming to identify how the literature describes the seven sources of waste from lean in an SC context. Causes, effects, and measures to cope with these sources of waste were identified, and how this impact costs in an SC context.

The systematic search initially included 236 papers which were further reduced to 11 articles to be included in the analysis. In these articles, the waste of inventory had the highest focus as it was mentioned in eight of them. Further, another finding was that in the manufacturing industry, the waste of overproduction and inventory are highly interconnected and have the highest impact on costs in an SC context.

In the analysis, the causes for the waste of inventory from the literature were uncertainty in supply, uncertainty in demand, poor communication, play-safe tendency, different inventory management systems, unstandardized operational flow, and poor ordering terms (e.g. large bulk orders or poor contracts). These causes have different effects for the SC members as products are discarded, shortage of working space, tied-up capital, goods becoming obsolete, and obscures other problems. To cope with these causes and effects, measures that had the highest impact on reducing the waste of inventory were information sharing, developing milk-run disciplines, and placement of the decoupling point.

Regarding the waste of overproduction, Viken and Haraldstad (2019) identified the causes from the literature to be customer's demand for high availability, variety and fresh products, lack of information, poor demand forecasting, high variability in demand, and miscalculation in quantity ordered. Further, the effects of overproduction for the SC members were excess

products being discarded, lost sales of produced goods, excessive storage, and increased waste of inventory. To cope with these causes and effects, the literature suggested different measures, where information sharing and the position of the decoupling point had the highest impact on the reduction and costs related to the waste.

Furthermore, in the literature review by Viken and Haraldstad (2019), it was identified that lowering the waste of inventory often was associated with an increase in the waste of transportation. It was further identified that the waste of inventory has a significantly higher impact on costs than the waste of transportation. Thus, the literature suggested that SCs should focus on reducing the waste of inventory even though it might increase the waste of transportation.

Based on this previous research, two of this thesis' SC concepts are the waste of inventory and the waste of overproduction. The previous research has now been presented, the next section will describe the structure of this thesis, to describe briefly the content of each chapter.

1.4 Structure of the thesis

This introductory chapter has given an introduction, defined the research question for the thesis, and described previous research. The second chapter presents the theoretical background which includes a definition of SC and major concepts and aspects that are used in the thesis. Further, a literature review is conducted to examine what the literature suggests about the developed sub-questions, where a conceptual framework is developed, that is further used in the analysis. After the literature review, theory on how to conduct a case study is presented together with our methodology for the case study. This includes a description of how we collected the data about the case.

After the methodology, we present the findings from the data collection in the case study. First, it will present the finished products and its two components, before the finished product's SC is described starting upstream at the tier 1 suppliers, and moving downstream to the end-customers. The fifth chapter analyzes how the findings of the case align with what the literature suggests about the different SC aspects. While chapter six gives a discussion on alternative SC strategies that the case could choose and how the SC aspects can be utilized, according to what the literature suggests. Lastly, the conclusion is given.

2 Literature review

This chapter will first present the theoretical background for the thesis, where SC will also be defined. Further, different characteristics of business relationships are described. Followed, different SC aspects will also be related to the three SC concepts from the sub-questions. Then, a narrative literature review is conducted where the SC aspects are further examined. Lastly, a summary of this review is made where a conceptual framework is developed, which is further used in the analysis.

2.1 Theoretical background

This section will provide the definition for SC and present a theoretical background on business relationships. Further, the three SC concepts of production method, the waste of inventory, and the waste of overproduction will be described. These concepts will also be related to the SC aspects.

2.1.1 Supply chain

In this section, a discussion and definition of SC will be given. There exist many different definitions of SC in the literature. Aitken (1998, p. 2) defines SC as "a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users". In this definition, the word 'network' is applied in an attempt to replace the word 'chain' as they argue that there will normally be multiple suppliers, these suppliers' suppliers and so on, to be included in the total system. However, in this thesis, we do not want to introduce this replacement. Another somewhat more comprehensive definition, which also specifies activities, is given by Mentzer et al. (2001, p. 4) as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer". This definition tries to grasp a broad range by including a minimum number of entities (also only individuals) and not being specific by beginning from a 'source'. Thus, this definition is considered too unspecific.

A third definition is "a series of companies (links) in which the consecutive stages of production of an economic product take place, from primary producer to final consumer" by van Weele (2018, p. 56). This definition does not include suppliers but only the 'primary producer', and is therefore not used in this thesis.

On the other hand, the definition by Sabri and Beamon (2000) will be used as the definition of SC in this thesis, as it includes the unambiguous definition of production from raw material to consumption, and it also includes important concepts for the thesis such as inventory and distribution. The authors' definition is as follows:

> A supply chain is a set of facilities, supplies, customers, products, and methods of controlling inventory, purchasing, and distribution. The chain links suppliers and customers, beginning with the production of raw material by a supplier, and ending with the consumption of a product by the customer (Sabri & Beamon, 2000).

As the definition of SC has been given, the next section will give a theoretical background on business relationships, as SCs consist of and are dependent on many business relationships. This will be used later in the analysis of the thesis.

2.1.2 Characteristics of business relationships

This section will present a theoretical background which can be used to analyze business relationships in SCs. The reason for considering business relationships is that the market performance of firms is dependent on the functioning of its relationships with others. Further suppliers are also an important part of an SC strategy, as the relationship can determine what SC strategy that is feasible for the LF.

Thus, the relationships between the SC members' are important to consider to understand how they are interconnected. To understand and analyze business relationships, Håkansson and Snehota's (1995) structural and process characteristics will be presented.

Håkansson and Snehota (1995) describe characteristics of a business relationship in their book, and how to utilize the two characteristics of *structural* and *process*, where the structural describes how relationships between two companies are in terms of importance, age and so on. The process part can tell us more about the nature of the interaction processes within the relationship, what effects they have on the actors, and how they develop and decay.

Structural characteristics

Looking at the former characteristics by Håkansson and Snehota (1995), they further divide these into four features:

- *Continuity.* A relationship is an investment and lasts on average 10-20 years. Thus, having continuity in the relationship is of high importance as the relationship is devel-

oped successively and gradually.

- *Complexity.* The complexity of a relationship may vary largely for several reasons both within and between the relationship. These complexities are determined for reasons such as the interrelations of people involved and the complexity of the product, processes, range of product offering, organization, information, and so on. These complexities may further lead to coordinating technical, logistics, administrative and economical issues.
- *Symmetry.* Relationships are seldom symmetrical, but an imbalance in one dimension may offset the imbalance in another dimension. The balance does also vary with the general state of the economy making short-term versus long-term gains/losses to be an issue.
- *Informality.* All relations do contain uncertainty, and, as there are too many aspects to cover and unexpected events that might occur, it is pointless to formulate agreements that are meant to cover everything. Hence, the relationship will have inherent informality where the relationship develops trust over time and reciprocal learning processes, and there will be important with different types of social situations.

Process characteristics

The second characteristics of Håkansson and Snehota (1995) are process characteristics in which they divide into these four features:

- *Adaptations.* If a company adapts in a relationship it means that the supplier in the relationship will be treated uniquely. The reason for doing adaptations is to take advantage of the unique attributes of the supplier. As cited in Håkansson and Snehota (1995), Hallén, Seyed Mohamed, and Johanson (1989) have found over time that mutual adaptations of some kind are generally a prerequisite of the development and continued existence of a relationship between two companies. The two companies tend to modify and adapt, more or less continuously, the products exchanged as well as the routines and rules of conduct to function better *vis-a-vis* each other.
- *Cooperation and conflict.* In a relationship, there is an inherent conflict about the division of benefits, but other conflicts can also arise over time. There could be a need for some amount of conflicts to keep the relationship healthy. Still, it will always be a concern with cooperation and value-creating that a relationship becomes a zero-sum game. The relationship must be worthwhile for both actors involved.
- *Social interaction.* Business relationships are essentially about business-specific behav-

iors, subjective values, personal bonds, and convictions are always present and play an important role. The social exchange process where the individuals involved become committed beyond strictly the task at hand is generally where business relationships develop. Personal relationships tend to be a condition for the development of inter-organizational ties between two companies in which trust becomes one of the most important factors in the relationship.

- *Routinization.* Over time business relationships tend to become institutionalized. Routines, explicit and implied rules of behavior, and rituals in conduct emerge over time in the more important relationships that a company maintains with the customers and suppliers. These routines mitigate costs of transaction in a relationship and coping with the complex needs to coordinate the individual activities within the relationship.

Different characteristics of business relationships have now been described. Further, four SC strategies will be presented, as the research question of the thesis aims to examine the choice of SC strategy of a lead firm.

2.1.3 Supply chain strategies

This section will introduce four generic SC strategies. How these strategies impact the production method and the waste of inventory and the waste of overproduction will also be described. A major part of firms' supply chain management is the determination of their individual SC strategies. Here, a strategy is about making choices in which it should answer what one will do, and what one will not do, to create a competitive advantage (Lafley, Martin, & Riel, 2013). Moreover, no one strategy suits all SC members, and the strategy should be determined by characteristics such as supply, demand, product, and production (Christopher, 2016; Naylor et al., 1999; Pagh & Cooper, 1998). Christopher (2016) applies four broad generic SC strategies; *kanban, lean, agile*, and *hybrid*. These depend on the combination of supply and demand characteristics for each product, and they will further be described.

1. *Kanban.* A kanban strategy is suggested when there are predictable demand and short supply lead times. This strategy relies on the continuous replenishment of products that have been sold or used.
2. *Lean.* A lean strategy is suggested with predictable demand and long supply lead times. This strategy enables firms to order necessary supplies ahead of demand, where manufacturing and transportation can be planned and optimized to be as efficient as possible in terms of cost and asset utilization.

3. *Agile.* In the opposite situation, of the lean strategy, with unpredictable demand and short supply lead times, the agile strategy is suggested. This strategy is concerned with SC members' effectiveness by enabling a 'quick response' solution to deliver multiple products (often customized) for smaller market segments in response to actual demand.
4. *Hybrid.* When the demand is unpredictable and the supply lead time is long, a combination of the lean and agile strategy is proposed as a hybrid strategy. This strategy is termed 'leagility' by Naylor et al. (1999) and 'the full postponement strategy' by Pagh and Cooper (1998). This SC strategy requires that the SC is decoupled by holding strategic inventory in a generic or unfinished form, where the final configuration is completed rapidly once real demand is known.

Moreover, following Christopher (2016), the lean strategy is emphasizing high efficiency through reducing inventory and unnecessary processes. While the agile strategy is emphasizing on preventing overproduction through high effectiveness and is therefore not as concerned with high efficiency. As market demand may be unpredictable, this latter strategy may be feasible as it will reduce unsold and obsolete products, and still be able to deliver what customers demand.

Firm's SC strategies are directing their choice of production method, which is how they choose to manufacture their products. For instance, demand characteristics of some products require that the product is available at the exact time the customers want them such as food products in supermarkets. According to Corsten and Gruen (2004), if these food products are not available at that time, 26% of customers will substitute the product with another brand. This is why Proctor and Gamble (P&G) have long focused on improving their product availability on the shelf (Christopher, 2016). For other products, customers may be willing to wait for a longer period of time so that they can get the exact specified, customized product that they want such as customized offshore oil platforms and supply ships. Hence, the choice of production method is of high significance to SC members' effectiveness and efficiency.

Moreover, the SC strategy will have a significant impact on the sources of waste, such as inventory and overproduction, as the strategy determines what is produced by forecast and what is produced by actual orders. These sources of waste must be reduced or eliminated by SC members to optimize their efficiency and effectiveness of operations, which is impacted by the SC strategy.

Nevertheless, some SC members may be unable to reduce waste as they may lack the capability and capital for such improvements. On the other hand, some individual firms may

very much be enabled to reduce waste but may lack motivation because it will not have any significant impact on their profits. There may also be firms in the SC that are in such a powerful position that they can determine all waste reduction measures to their best interest, in which the rest of the SC members will have to comply.

In an SC context with such SC members, this may cause higher purchasing prices for downstream suppliers, and ultimately customers. Such higher sales prices do, all else equal, lead to lower sales volume and thus lower profits for the individual firms. Also, lack of waste reduction by one or a few SC members may impact the rest of the SC members as this may reduce their flexibility to rapidly respond to changes in demand, or to improve operational efficiencies. Furthermore, some SC members may also inhibit waste reduction measures such as milk-run disciplines, to reduce the waste of inventory, as of their incapability or lack of motivation.

The four SC strategies and how they impact the production method and the waste of inventory and the waste of overproduction has now been established. Further, these SC concepts will be related to different SC aspects.

2.1.4 Supply chain concepts

This section will describe the three SC concepts from the sub-questions in section 1.2, which will be examined further in the literature review. Further, to identify how these SC concepts impact efficiency and effectiveness of SC members, different SC aspects will be related to the concepts. Thus, in this section the following question will be answered:

What aspects of supply chains relate to production methods and the waste of inventory and the waste of overproduction?

This question will guide a literature review in section 2.3, about SC aspects and their impact on production methods and the waste of inventory and overproduction, where they will be reviewed more in-depth to identify what the literature suggests about them.

Production methods

Both Naylor et al. (1999) and Bozarth and Chapman (1996) have a similar differentiation between the same production methods that most manufacturing firms use. Further, these production methods are briefly described including their significant differences in their impact on inventory, overproduction, and lead times.

- *Buy-To-Order (BTO) and Engineer-To-Order (ETO).* This method is suitable if the

products produced are unique, such as in innovative projects, and when they do not necessarily contain the same raw materials. Here, the demand will be highly variable, and the customer must accept long delivery lead times, where *delivery lead time* is used to describe the time it takes from a customer order until the customer receives the product. For the SC members, they will not have any uncertainty of obsolete inventory, and of overstocking caused by a product not succeeding in the market. On the other hand, they will not be able to take advantage of new markets as quickly.

- *Make-To-Order (MTO).* Firms are here able to change between different products, as long as they are made by the same raw materials. By utilizing this strategy, the production lead time will be shorter (as the product does not have to be designed), but customers will still have to expect considerable long delivery lead times. Here, the *production lead time* is used to describe how long it takes to produce (assemble) the product or component. However, the only uncertainty that the SC members are exposed to is the inventory of raw materials and components.
- *Assemble-To-Order or Finish-To-Order (ATO).* With this method, a postponement strategy can be used so that the customization of products is postponed until as late as possible. The SC members are then able to respond to a variable product mix within a range of products. Compared to the aforementioned two methods, this method will have a considerably shorter delivery lead time and will depend on where in the SC the final assembly is located. The uncertainty of overstocking or understocking increases slightly, but its value is still not as high as if the products were complete, fully assembled products.
- *Make-To-Stock (MTS).* This method requires standard products and a steady demand to be able to forecast accurately. It can also cope with varied locations, and deliver with short lead time. However, there is uncertainty in how accurate the SC members' forecasts are to avoid overproduction and to hold the correct inventory levels to minimize the risk of overstocking and stock-outs of components.
- *Ship-To-Stock (STS).* Like the previous method, this method requires standard products and a steady demand to be able to forecast accurately. However, since this method ships the products to fixed locations before they are ordered, the demand for all locations is forced to be forecasted. Hence, this method is even more dependent on accurate forecasting than any of the other production methods, and thus has the highest risk of overstocking and stock-outs of components and finished products. Moreover, this method can deliver with a very short lead time.

Furthermore, some special cases such as the production of electrical energy can also determine what production method will be applied. This electrical energy is difficult to stock, and thus must be consumed as it is produced. Also, food products such as vegetables and fruits can only be stored for a short period before they must be consumed. However, the focus of the thesis is towards physically manufactured products without fast degradation, and thus not such special cases or service activities.

The different production methods of the individual firms in the SC are affecting other aspects of the SC, concerning this, the aspects of *product and market characteristics, the decoupling point, location of inventory* and *transportation* will be briefly introduced below, which will be further discussed later in this chapter.

The *product and market characteristics* are an important aspect to consider when deciding on a production method as these must align with customers' willingness to wait and pay. These characteristics may include volume per variant, variability, and predictability in demand and supply lead times (Christopher, 2016).

The decision of the individual firm's production method will further determine the location of the *decoupling point*. Upstream from the decoupling point, the operations are forecast driven, while downstream is operated based on actual customer's orders (Christopher, 2016; Naylor et al., 1999). E.g. in the production of automobiles, most of the components to the car will be produced by forecasts but, at some point in the SC, the car will be customized and assembled according to a specific order. Upstream from that point in the SC, the components will be forecast driven, while downstream they will be produced demand-driven. This point may vary largely by what production method that is used. For instance, a BTO production method will have a decoupling point further upstream in the SC than an MTS production method.

Another aspect of supply chain management is the *location of inventory*, which is wherein the SC inventory is held, and if it is kept centralized or decentralized. Centralized inventory is inventory kept in a central location to reduce the total inventory investment, while decentralized inventory is smaller warehouses closer to the customer's location which reduces the delivery lead time (Christopher, 2016). The decision on the location of inventory is dependent on the supply and demand characteristics, which makes it important to consider and align with the decision of firms' production methods (Lin & Wang, 2011; Schmitt et al., 2015).

Moreover, *transportation* is another aspect to be considered with the choice of production method. Short supply lead times increase the production's flexibility to produce according to

customer's orders, while long supply lead times may lead to high inventory levels. In addition, there is also the transportation that occurs internally and downstream in the SC to the final customer. High effectiveness in transportation can be achieved by transporting directly to customers, while high efficiency can be achieved through optimized transport utilization.

This section has presented the different production methods and related SC aspects to this concept. Further, a theoretical background on the sources of waste will be presented, where the focus will be on the waste of inventory and the waste of overproduction.

Sources of waste

In SCs, reducing the sources of waste is an excellent tool to improve efficiency as it reduces activities that do not add value to the product in the SC. This will further reduce delivery lead times to customers and lower the costs for SC members. However, it is not an easy task to reduce inter-organizational waste, because often firms are still able to sell their products with waste, making the motivation to reduce waste unclear. It is often viewed by firms as a tool that consumes a lot of resources, while the benefits realized are difficult to see and understand. Further, the sources of waste will be described, where the waste of inventory and overproduction will be used as SC concepts in this thesis, as these were identified to have the strongest impact on costs in a manufacturing SC context in Viken and Haraldstad (2019) as described in section 1.3.

Reducing the sources of waste is used as a tool in the lean philosophy to do continuous improvements. In lean, organizations are encouraged to increase their value-added activities and eliminate or reduce waste (Nicholas, 2011; Womack & Jones, 1996). Further, in Nicholas (2011, p. 60), the author state that Toyota defines waste as "anything other than the minimum amount of materials, equipment, parts, space, or time that are essential to add value to the product." To gain a competitive advantage by eliminating waste, Toyota created the now-famous Toyota Production System (TPS), which introduced seven sources of waste in which should be focused on to increase customer value and reduce cost (Hines & Rich, 1997; Nicholas, 2011). These seven sources of waste are (1) overproduction, (2) waiting, (3) transporting, (4) processing, (5) inventory, (6) defects, and (7) motion.

Traditionally, waste is viewed from the perspective of a single firm (Harris et al., 2011; Nicholas, 2011; Womack & Jones, 1996). However, as advocated by Christopher (2016) and Harris et al. (2011), improving internal operations is not enough in the competitive market. Thus, reducing waste should be considered as an opportunity to create a competitive advantage for all SC members. Moreover, inter-organizational waste emerges in SCs when

firms cooperate ineffectively and thus, create waste. However, as an SC involves activities spanning multiple functions and organizations, Eltantawy et al. (2015) state that to achieve superior performance in such a complex setting, firms need to effectively coordinate between the firms in the SC to achieve higher efficiency and effectiveness.

Furthermore, waste reduction or elimination in an SC context is more complex and difficult than for a single company. However, as the studies by Eltantawy et al. (2015), Seth and Gupta (2005), and Shamah (2013) shows, reducing waste can provide benefits for every firm involved. In Viken and Haraldstad (2019), two of the most common effects of reducing inter-organizational waste were reduced costs and lead times.

When reviewing the different sources of waste in an SC context in Viken and Haraldstad (2019), it was found that inventory was the waste with the highest focus in the literature. This is not surprising as costs related to high inventory levels are interconnected with several of the other sources of waste (Kumar, 2004; Machado Guimarães, de Carvalho, & Maia, 2013). In addition to inventory, Monden (1998) and Liker (2004) argue that overproduction is the worst of the seven sources of waste from TPS. Both inventory and overproduction were also identified to have the highest impact on the cost level for the SC members (Viken & Haraldstad, 2019).

Considering these findings, this thesis will further describe the SC concepts of the waste of inventory and the waste of overproduction applied in its original manufacturing environment in an SC context.

The waste of inventory

The waste of *inventory* creates costs as holding stock requires space, products become obsolete, pilferage, and it increases insurance costs (Harris et al., 2011; Nicholas, 2011). Moreover, the goods may never be sold (caused by overproduction) and tie-up capital (Womack & Jones, 1996). Tied-up capital has an opportunity cost, as the capital cannot be invested in other activities that could further increase profits. In addition, tied-up capital increases the value of the capital employed in which reduces the SC members' return on investment (ROI).

The placement of *the decoupling point* is important to ensure the optimal balance between efficiency and effectiveness to avoid high inventory levels (Hopp & Spearman, 2004). The reason for this is that before the decoupling point, inventory is needed as the production will be forecast driven. While after this point, as the production is driven by demand, inventory is not needed. Thus, this point is also often strongly connected with the decision regarding the *location of inventory*.

However, inventory levels and the location of inventory also impact the aspect of *transportation* in the SC (Eisler et al., 2007; Kumar, 2004; Machado Guimarães et al., 2013; Savino, Mazza, & Marchetti, 2014; Wee & Wu, 2009). Low inventory levels often require high transport frequency, as to avoid running out-of-stock, deliveries must be shipped more frequently. This will also increase transportation costs (Eisler et al., 2007). However, in Viken and Haraldstad (2019) it was found that the waste of inventory has a greater negative impact on the SC than the waste of transport, making it more important to reduce inventory levels than optimizing transport utilization and costs.

Moreover, it is common that suppliers have their own safety stocks because of poor communication and a play-safe tendency caused by the *bullwhip effect* (Christopher, 2016; Eltantawy et al., 2015; Savino et al., 2014; Seth & Gupta, 2005), and to cope with uncertainties in supply and demand (De Steur, Wesana, Dora, Pearce, & Gellynck, 2016; Savino et al., 2014). With these safety stocks (inventory), SC members can obscure their problems, and thus, to do continuous improvements, the inventory levels should be reduced to be able to identify and correct these problems (Harris et al., 2011; Hines & Rich, 1997; Nicholas, 2011). This is why inventory is regarded as 'the root of all evil' by Toyota (Nicholas, 2011). In addition, inventory is often a hidden cost for the SC members as it does not have a direct impact on the unit price of the products.

The waste of overproduction

The waste of *overproduction* is about producing more goods or services than what there is actual demand for (Womack & Jones, 1996). This is regarded as the worst waste as it consumes direct labor and materials in which SC members have to sell their products at a reduced price or scrap them as they can become obsolete (Harris et al., 2011; Hines & Rich, 1997; Nicholas, 2011).

In SCs, the placement of the *decoupling point* has a major impact on overproduction as this point decides where the SC members start to produce toward actual demand instead of using forecasts. Further, overproduction can occur because individual firms in the SC emphasize to produce with high efficiency. Emphasizing high efficiency in production can be to inhibit idle time on machines and employees. However, this may lead to lower efficiency of inventory, as it could increase safety stock levels due to overproduction, which may also cause artificial pressure on workload (Harris et al., 2011; Nicholas, 2011). Furthermore, overproduction at one supplier can lead to pressure on subsequent suppliers to also overproduce, and it is also likely to inhibit quality, effectiveness, and productivity (Harris et al., 2011; Hines & Rich, 1997; Nicholas, 2011). Besides, it tends to lead to excessive storage and longer lead times

lowering the efficiency for the SC members, which subsequent suppliers and end-customers may suffer from (Harris et al., 2011; Hines & Rich, 1997).

One of the most common causes of overproduction is the *bullwhip effect* (Chen, Drezner, Ryan, & Simchi-Levi, 2000; Eltantawy et al., 2015; Lee, Padmanabhan, & Whang, 1997a; Metters, 1997). Lee et al. (1997b) state that the bullwhip effect occurs when the demand order variabilities in the SC are amplified as they move upstream in the SC. This effect will lead to ripple effects by upstream suppliers producing even more than the previous supplier, greatly decreasing the effectiveness upstream in the SC. E.g. if a retailer keeps 100 six-packs of one soda brand in stock, and normally sells 20 six-packs a day. This means it would order 20 six-packs from the distributor every day to keep the stock level at 100. However, one day the retailer sells 70 six-packs and assumes customers will start to buy more products, which results in the retailer ordering 100 six-packs to meet this higher forecasted demand. The distributor may then respond by ordering double, 200 six-packs, from their manufacturer to ensure their stock level. This leads to the manufacturer producing 250 six-packs as a play safe tendency which creates the bullwhip effect, where the increased demand got amplified through the SC from 100 six-packs at the customer level to 250 six-packs at the manufacturer.

Table 1 gives an overview of which SC aspects that are related to which SC concept. Moreover, these are also interconnected. As shown in the table, production method and inventory are related to all the SC aspects expect bullwhip effect for production method and product and market characteristics for inventory. Overproduction is related to the SC aspects of the decoupling point and bullwhip effect.

Table 1. Overview of supply chain concepts and related aspects

Supply chain aspects	**Production method**	**Inventory**	**Overproduction**
Product and market characteristics	X		
Decoupling point	X	X	X
Location of inventory	X	X	
Transportation	X	X	
Bullwhip effect		X	X

Further, these SC aspects will be examined in a narrative literature review in section 2.3, to see what the literature suggests. First, our methodology for the narrative literature review

will be presented.

2.2 Narrative literature review

Before the literature review is presented, the literature review's methodology will be discussed (narrative literature review). The methodology for the literature review is described here as it provides information on how it was conducted. Thus, it should ease the reading of the literature review as to how the literature was searched for, the structure of the review, and an overview of the included papers and books are presented in advance. In addition, this allows the methodology chapter to only deal with the main methodology for this research. Moreover, before this narrative review is presented, a theoretical background will be described briefly.

According to Bryman (2016), narrative literature reviews seek to arrive at an overview of a field of study through a reasonably comprehensive assessment and critical interpretation of the literature. Thus, the review summarizes what is already known in a research area which is our purpose of this review. Bryman (2016) also states that narrative reviews are difficult to reproduce as it is usually described without a standard procedure on how to perform it.

In our literature review, when searching for literature regarding the SC aspects, mainly Google Scholar and Scopus databases were used. In searching for relevant literature, term 1 from table 2 was used to ensure that the literature was connected with the research question of an SC context, and thus not only on individual firms. Term 2 was added to reflect the concepts of each sub-question and searched by connecting them with their related aspects (term 3) following table 1. In appendix A, an overview is provided of the literature which is included in the review. This overview gives a totality of the literature included and is placed in the appendix due to the large number of papers and books included.

Table 2. Search terms

Term 1	Term 2	Term 3
"Supply chain", inter-organizational	Production, manufactur*, inventory, overproduction	Product, market, decoupling, postpon*, location of inventory, bullwhip, transport*, JIT, sourc*

From our literature search, 31 papers and three books were found which was included in our literature review. The overview in appendix A gives information in regard to the published year, the methodology used, and geographical area and aspect(s) studied. Looking at the published year, there is a large difference as the first paper was published in 1970, while the

last one, which is a book was published in 2018. Further, 76% of the included papers and books have been published in the last 25 years, and 41% in the last 15 years. This shows that the field of SC and manufacturing has not received attention in the literature over a large period of time.

Further, when assessing the methodology, mainly conceptual and mathematical models are used in the literature included. This is not surprising as we aim to identify what the literature suggests about the different SC aspects in regard to theory, and not how they can be implemented in practice. Thus, the papers with these two methods do not study a particular geographical area as they study to develop models using theory. Regarding the SC aspects, it appears that most of the literature only studies one SC aspect in which only five out of the 34 included papers and books were identified to study more than one SC aspect.

The methodology and literature have been described in this section. Further, this will be used in the next section to examine the literature and its suggestions regarding the SC aspects related to three concepts.

2.3 The literature review

This section will present relevant literature on the concepts of production methods and the waste of inventory and the waste of overproduction and their related SC aspects of product and market characteristics, decoupling point, location of inventory, transportation, and bullwhip effect as illustrated in table 1. This literature will be used to support the research question from section 1.2, which is defined as follows:

"How can aspects of supply chains impact the choice of supply chain strategy of a lead firm?"

Further, to find relevant literature which can be used to answer this research question, the three sub-questions developed in section 1.2 will be examined separately.

2.3.1 Production methods

An important concept in SCs is the SC members' production methods, which can be STS, MTS, ATO, MTO, and BTO as described in section 2.1.4. These will be utilized to research the first sub-question:

1. *"How do the production methods impact efficiency and effectiveness of supply chain members?"*

LFs' production method has a key role in enhancing efficiency and effectiveness in production and other operations, resulting in changes in performance measures such as costs, lead time, flexibility, and customer satisfaction (Sha & Che, 2006). Further, the literature on the SC aspects related to SC members' production methods, will be reviewed in this section. These SC aspects are the *product and market characteristics*, *decoupling point*, *location of inventory*, and *transportation*.

Product and market characteristics

To decide upon a production method to enhance efficiency and effectiveness, the product and market characteristics must be analyzed and considered (Christopher, 2016; Naylor et al., 1999; Pagh & Cooper, 1998; Yang & Burns, 2003).

In a market where the product's demand is predictable, the production method should focus on enhancing efficiency (Christopher, 2016). This predictable demand lowers the uncertainty of forecasting in which operations' efficiency can be optimized. If the volume per variant is high and the variety of product mix is low, an STS or MTS production method will be preferred to gain high efficiency. These methods result in short delivery lead times to customers and low cost, but with low flexibility to respond to market changes (Christopher, 2016; Naylor et al., 1999).

On the other hand, if the demand is unpredictable with low volume per variant and high variability in product mix, the production method should be focused on producing with high effectiveness (Christopher, 2016). The production method will then be more oriented towards BTO, ETO, or MTO, as these are produced by customer's actual orders. Furthermore, an ATO method can also be employed, especially in combination with a postponement of production or logistics operations, as proposed by Pagh and Cooper (1998). This will be described later in this section.

Moreover, the production method must also align with the uncertainty of supply. A product that can be produced with standard components with short lead time, will require another method than products that need specific, customized components with long lead times (Bozarth & Chapman, 1996; Christopher, 2016; Naylor et al., 1999).

Decoupling point

The decoupling point is the location in the SC where upstream operations are driven by forecast, while downstream operations are driven according to customer's actual demand. Naylor et al. (1999) and Christopher (2016) argue that a postponement strategy is desirable to use on the decoupling point when combining a lean and agile SC strategy. A postponement

strategy is used to postpone parts of production and logistics operations until the final customer's commitment is obtained. This enhances firms' effectiveness as it reduces or even eliminates the risk of unsold products (Pagh & Cooper, 1998). With this strategy, SC members seek to design products using common platforms, components, or modules, but where final assembly or customization does not take place until the final market destination and/or customer's requirement is known (Christopher, 2016; Naylor et al., 1999).

This strategy has been used increasingly by firms, as part of their SC strategy, as it can be used to cope with the risk of high inventory levels of MTS and with the long delivering lead times of MTO (Feitzinger & Lee, 1997). By using this strategy, the final differentiation of the product can be postponed to the latest possible point in which makes it especially feasible with an ATO production method (Naylor et al., 1999).

Christopher (2016) advocates that the decoupling point should be pushed upstream in the SC by SC members postponing their production to produce with as high effectiveness (pull) as possible, without exceeding customers' willingness to wait. By locating this point upstream in the SC, the production method will be oriented more towards BTO, ETO, and MTO. With these methods, Christopher (2016) argues that when used correctly, SC members can achieve benefits of lower inventory levels and uncertainty (as there is less or no need to forecast), better flexibility, and high customer satisfaction.

On the other hand, Naylor et al. (1999) advocate locating the decoupling point as far downstream as possible, by postponing the differentiation with an ATO production method. Following this strategy, firms' production can be optimized to be as efficient as possible to reduce cost and delivery lead time.

Furthermore, Pagh and Cooper (1998) argue that one can have a manufacturing postponement strategy in which the authors describe can fit with an MTO production method. But, seen from an SC perspective, what these authors describe is actually an ATO strategy where the final differentiation, such as color, is finalized according to customer's demand. Further, they describe an MTS production method with a decentralized inventory (described later in this section) to not fit with a postponement method. The authors have named it 'the full speculation strategy', where it is named speculation as it relies on forecasts of coming demand. This production method (and logistics) is what Naylor et al. (1999) and Bozarth and Chapman (1996) names an STS production method, as it is shipped to be stocked at decentralized locations.

In addition to the different manufacturing postponement strategies, Pagh and Cooper (1998)

add a logistical postponement strategy in which can be combined either with or without a manufacturing strategy in which is about centralized or decentralized inventory. This will be described later in this section.

Another perspective on the decoupling point is described in Hopp and Spearman (2004). Here, they use the term 'inventory/order interface', which they describe as the point in the production process where the stimulus for work movement shifts from MTS to MTO. The location of this interface decides the production method for the SC members, thus locating it at finished goods emerge an MTS production method, where having products in stock reduces the delivery lead time. The trade-off for SC members, according to Hopp and Spearman (2011), is between high costs related to inventory, low flexibility, and low delivery lead times or low costs related to inventory, high flexibility, and higher delivery lead times.

Furthermore, firms can also have a decoupling point in their internal production. A well-illustrated example of this is the company McDonald's, described in Hopp and Spearman (2004). During rush hours in McDonald's production, there are specified targets for the warming table where finished products are being stored. This warming table acts as a decoupling point, as the production up to this point is MTS, and production beyond this point is MTO. The finished products on the warming table are then kept in inventory until a customer orders them. McDonald's does this to increase their efficiency in operations to this point. This enhances customer satisfaction as McDonald's are delivering with short delivery lead times to customers, which keeps the queue as short as possible. In this situation, the production schedules determine how much stock is at the warming table (forecasting), which is based on information from previous rush hours' sales. The major risk with this is that the demand may suddenly decrease or increase one day in which can cause the products to become obsolete, and McDonald's could be forced to discard them (Hopp & Spearman, 2004), or loss of sales due to unsatisfied customers.

Moreover, as Yang and Burns (2003) argue, product type, market, process, and stock characteristics should be considered when deciding where to locate the decoupling point, and thus cannot be generalized without considering these. Moreover, as pointed out by Yang and Burns (2003), the postponement location and the decoupling point does not have to be located at the same location in the SC. But, as Heskett (1977) states, a postponement strategy, and the decoupling point are closely linked.

Location of inventory

As Christopher (2016) points out, the location of inventory is important to consider as this

is a major factor when looking at the supply lead times. The author states that long supply lead times would enhance SC members' to have an efficient lean SC strategy with production methods such as STS and MTS. Further, he states that when the supply lead times are short, the production method can be emphasized on high effectiveness, such as MTO, BTO, and ETO.

Furthermore, the location of inventory is also about SC members' decision of centralized or decentralized inventory, named logistical system by Pagh and Cooper (1998), which further impacts their choice of production method. Thus, it will affect the SC members' efficiency and effectiveness in operations, and they should, therefore, be considered concerning one another (Pagh & Cooper, 1998). Centralized inventory is inventory that is kept in a centralized location and allocated locally at demand. This will lower the firm's inventory levels as safety stocks can be lowered. Decentralized inventories, on the other hand, are inventories that are located in several smaller warehouses closer to customers. This will lead to reduced delivery lead times, but higher inventory levels for the SC members (Christopher, 2016).

In the study by Schmitt et al. (2015), it was found that the location of inventory should be assessed related to the market characteristics. Centralized inventory was found to be optimal when supply has low variability and demand is unstable. This implies that a centralized inventory can be implemented when following an ATO or MTO production method.

When market characteristics are so that supply may be disrupted and there is low variability in product demand, Schmitt et al. (2015) advocates combining decentralized inventory with a BTO, ETO, MTS, or STS production method. In addition, the authors found that when the supply can be disrupted, and the demand is unstable, risk-averse SC members should choose decentralized inventory to maintain customer's satisfaction.

Lin and Wang (2011) aim to utilize a BTO production method in a market characterized by uncertainties in supply and demand. In this paper, one of the mitigation strategies to cope with these uncertainties is through centralized or decentralized inventories. The authors state that through centralized inventory, the level of inventory and repositioning costs can be reduced, however, economies of scale in production must be sacrificed. Further, they suggest that a centralized inventory with direct demand fulfillment with the BTO production method reduces the overall operating cost.

Transportation

When deciding on what production method to apply, transportation should be considered. As stated by Christopher (2016), long supply lead times results in lower flexibility to cope

with changes in production, but the frequency and size of each transportation can be optimized, resulting in high efficiency. Thus, this will be especially feasible with an MTS or STS production method. With short supply lead times, the author argues that the production can be more agile to produce with high effectiveness, but this may result in lower efficiency as more frequent and smaller deliveries may be required. Thus, this is more feasible with an MTO, BTO, and ETO production method, as the necessity to hold high inventory levels will be low due to the short replenishment times. This is also aligned with what Naylor et al. (1999) suggest.

In Karlsson and Norr (1994), just-in-time (JIT) was implemented in an SC in the automobile industry in which it was identified that there were clear possibilities for the SC members' to achieve higher effectiveness. JIT is about materials and products being delivered at the exact time when they are needed, thus not earlier or later, and with the correct quantity (van Weele, 2018). Related to the production method, JIT implies that nothing should be produced if there is no demand and emphasizes the importance of short supply lead times. This makes the production more agile, and thus enhances the option of producing with the high effectiveness of an MTO production method instead of MTS.

Moreover, the decision of sourcing locally or globally (reshoring or offshoring) has received a great deal of recent attention from authors such as Christopher (2016), Ellram et al. (2013), and van Weele (2018), which greatly impact transportation. This decision is about sourcing from a global supplier, which has longer supply lead times due to greater distances, compared to sourcing from a local supplier with shorter supply lead times. As identified in Moradlou and Tate (2018), local sourcing generally leads to higher flexibility (better responsiveness) and enhances an MTO production with its high effectiveness, while global sourcing promotes to produce with high efficiency through an MTS production method in low-cost countries and large bulk quantities (van Weele, 2018).

2.3.2 The waste of inventory

The waste of inventory with its related SC aspects has a large impact on efficiency and effectiveness for SC members. Based on that, this literature review will present literature related to the second sub-question:

2. *"How does the waste of inventory impact efficiency and effectiveness of supply chain members?"*

Further, the literature on the SC aspects identified in section 2.1.4, related to the waste

of inventory, will be presented in this section. These SC aspects are the *decoupling point*, *location of inventory*, *transportation*, and *bullwhip effect*.

Decoupling point

The placement of the decoupling point has a great impact on the waste of inventory for the individual firms in the SC, as this point is often where the strategic inventory is held (Naylor et al., 1999). In SCs, Christopher (2016) describes and applies the decoupling point in which has a high impact on the waste of inventory. This point is where inventory is held in a generic form as possible, and, according to Christopher (2016), this point should be as far upstream in the SC as possible. The reason for this is that the SC members should operate with high effectiveness, and only produce or differentiate products when there is a known demand from the market, avoiding high inventory levels due to obsolete products. Thus, if the decoupling point is far upstream in the SC, the SC members downstream of the point can operate with high effectiveness and low inventory levels. However, this could force the SC members upstream of the point to hold higher inventory levels, to enable the high effectiveness downstream of the point (Christopher, 2016).

One strategy strongly connected with the decoupling point is the postponement strategy proposed by Pagh and Cooper (1998). This strategy can, together with the decoupling point, be used to reduce the waste of inventory and increase effectiveness for SC members. If the SC members postpone the product differentiation until the customer's commitment is obtained, high inventory levels and waste will be avoided due to fewer products becoming obsolete in production, and thus the necessity to keep high stock levels (Pagh & Cooper, 1998). This postponement can be achieved by moving the decoupling point upstream in the SC to keep operations as 'pull' as possible, as suggested by Christopher (2016). This will reduce the need for keeping finished products in inventory, as the products can be directly shipped to the customer when they are finished avoiding unnecessary inventory. This increases the flexibility for SC members, as only raw materials or semi-manufactured products need to be kept in inventory. The cost level for the individual firms in the SC also decreases due to lower inventory levels and waste, as there is less tied-up capital, and fewer or no products will be discarded due to loss of sale, which increases the effectiveness (Harris et al., 2011; Nicholas, 2011).

In the case study by van Donk (2001), the impact of the decoupling point is well illustrated. Here, the author observed three possible decoupling points; the stock of raw materials, the stock of semi-finished products, and the stock of finished products. Further, van Donk (2001) identified that the main issue for the case company was that too many finished products were

kept in stock due to the location of the decoupling point. This caused problems with inventory control and shelf life of products. Further, over time, this also leads to low effectiveness and poor customer service. However, by moving the location of the decoupling point upstream in the SC for different products, the effectiveness increased which reduced the time products had to be stored. Based on this, van Donk (2001) observed that the customer service level increased and that the previously high inventory waste was reduced.

Location of inventory

The location of inventory has a great impact on the waste of inventory and further the efficiency and effectiveness of SC members. For SC members, where the location of inventory is located, will impact transport activities. However, the literature on this issue will mainly be presented in the next SC aspect, transportation. Thus, for this aspect of the location of inventory, the decision of a centralized or decentralized inventory will be focused on (Lin & Wang, 2011; Schmitt et al., 2015).

A centralized inventory location is about having one or a few locations to stock products, as is aligned with what Pagh and Cooper (1998) refer to as speculating or postponing logistics. A centralized inventory, and postponement of logistics, makes SC members more flexible to meet unstable demand from customers, but with somewhat longer delivery lead times than with a decentralized inventory. Thus, with centralized inventory, SC members can operate with high effectiveness and avoid obsolete products being stored reducing the waste of inventory. Moreover, in Schmitt et al.'s (2015) study, it was found that a centralized inventory reduces costs, as individual firms in the SC can utilize economies of scale in inventory (Schmitt et al., 2015). Furthermore, according to Christopher (2016), the products will rather be shipped with express delivery from the centralized inventory location to the customer.

On the other hand, a decentralized inventory is about having several local warehouses where the products can be kept as generic as possible to enable SC members to deliver with very short lead times (Schmitt et al., 2015). This follows Pagh and Cooper (1998) in which state that a decentralized inventory can be used when logistics is based on speculation, as the products are shipped to warehouses through forecasting. This results in significantly higher inventory levels, but it has the benefit of very short delivery lead times. Thus, the total inventory levels in a decentralized strategy are higher than in a centralized location of inventory, as the smaller warehouses need more products in total in stock to meet the different requirements from the market. This results in low effectiveness, and this makes SC members operate with high safety stock levels, which results in low efficiency.

Furthermore, Christopher (2016) proposes a combination of the two inventory management choices, namely a 'virtual' or 'electronic' inventory. Here, the inventory will be physically located decentralized but managed centrally. This means that all, or groups, of warehouses, utilize each other's inventories to respond to customers' demand. Thus, the delivery lead times can be held low, as the products are physically located close to the customers. At the same time, there will be no need for individual safety stock levels at every decentralized location as they are managed centrally and thus can be distributed in-between the locations. This will increase the effectiveness as the risk for obsolete products will decrease by lowering safety stock levels. However, as Christopher (2016) states, this combination will typically lead to higher transportation costs, as the products will travel greater distances, and may sometimes require high-cost express deliveries by air to ensure short delivery lead times.

Transportation

As mentioned in section 1.3, the waste of inventory has a significantly higher impact on costs for SC members than the waste of transportation. Thus, transportation is assessed as an SC aspect in this literature review instead of a source of waste as inventory and overproduction are. Nevertheless, transportation has a great impact on the waste of inventory, especially considering that SC is becoming longer than ever with the increased globalization (So & Sun, 2010). The trade-off for SC members is typically high inventory levels with high efficiency transport or low inventory levels with high effectiveness transport.

Further, transportation and inventory are highly interconnected as when SC members want to increase their flexibility, they reduce inventory levels by increasing the transport frequency and lowering the delivery size, which was the case in the article by Eisler et al. (2007). Thus, as transport utilization is not optimized, the efficiency decreases. However, products are stored for a shorter time increasing the efficiency in inventory for the SC members. The reason for this is that instead of having products kept in inventory, they are shipped JIT to the customer. JIT increases the effectiveness of transport as there are more frequent deliveries with smaller quantities, delivering only what there is actual demand for. This also reduces SC members' need for inventory. Moreover, Blumenfeld et al. (1985) identified that JIT is most optimal when the customer is located close to the production of the finished product. Another view on JIT is studied by Pan and Liao (1989), where they state that an JIT inventory system should be used when production schedules are relatively stable and long term purchasing agreements are possible.

SCs are dependent on transportation to distribute goods to and from suppliers and customers. When goods are transported, Baumol and Vinod (1970) consider them to be 'inventory

on wheels' calling it transit inventory. This means that goods being transported can be considered to be the same as goods being kept in inventory. Thus, if the transport distances are long the inventory in transport will tie-up much capital, resulting in low efficiency in operations. This is illustrated in the article by Seth and Gupta (2005) where the product had to kept three days in inventory due to inefficient transport routes and utilization. By implementing milk-run disciplines for the transport, the SC members were able to reduce the time spent in inventory from three days to only half a day.

The term transit inventory from Baumol and Vinod (1970) is highly relevant when studying the issue of local or global sourcing (reshoring or offshoring). If firms use global sourcing, the amount of transit inventory will generally increase due to long supply lead time, because of the greater distances the goods must be shipped (Holweg, Reichhart, & Hong, 2011). According to Han, Dresner, and Windle (2008), these long supply lead times caused by global sourcing, creates less dependable supply from upstream suppliers, requiring the LF to maintain higher safety stock levels, which decreases the LF's efficiency. In a study conducted by Handfield (1994), when using global suppliers, long supply lead times and high costs related to inventory are among the top five experienced problems. However, Christopher, Mena, Khan, and Yurt (2011) states that in global sourcing, transport utilization can be optimized with bulk orders to achieve high efficiency. On the other hand, with local sourcing firms may have the option of short supply lead times, which can be utilized to have more frequent deliveries. This will lower the transport efficiency, but it will enable lower safety stock levels and increase flexibility. To keep the inventory levels low with local sourcing, the focus for transportation, according to Holweg et al. (2011), should be on having more frequent deliveries with high effectiveness.

Bullwhip effect

From section 2.1.4, it is clear that this SC aspect is related to the waste of inventory. Mainly the bullwhip effect, which is the distortion of inventory through SCs, will increase inventory levels for SC members due to the demand amplification causing suppliers to produce excess products (overproduction) through the SC (Eltantawy et al., 2015; Lee et al., 1997b). Thus, these excess products are produced without an actual demand, making them obsolete which further decreases the effectiveness for the SC members. Further, when studying the bullwhip effect, Lee et al. (1997a) identified that increased variability in the demand data upstream in SCs is one of the main causes of increased inventory waste. They state that distortion in demand information will mislead the manufacturer, who only observes its immediate order data, with amplified demand patterns (bullwhip effect). This increases the waste of inventory and costs for the individual firms in the SC, as it creates different implications, for example,

excess of raw materials due to the unplanned purchase of suppliers, additional manufacturing expenses created by overproduction, inefficient resource utilization, overtime, excess warehousing expenses, and additional transportation costs due to inefficient scheduling and premium shipping rates (Lee et al., 1997a). All of these implications impacts SC members' efficiency and effectiveness.

To illustrate how the bullwhip effect and high inventory levels can impact efficiency for SC members, an example is presented in the study by Fuller et al. (1993). They found that inefficiencies caused by the bullwhip effect were partly responsible for the $75 billion to $100 billion worth of inventory which the various members have in the $300 billion (annual) grocery industry. These numbers show the potential gains achievable by increasing effectiveness to reduce inventory levels caused by the bullwhip effect.

In research of an inventory management experimental context, Sterman (1989) reports evidence of the bullwhip effect in the 'Beer distribution game'. The experiment involves an SC with four firms that make independent inventory decisions without communicating with other SC members, relying only on orders from the tier 1 supplier or customer as the sole source of communication. Sterman (1989) found that the variances of orders amplify as one moves up one tier in the SC, increasing the inventory levels and confirming the bullwhip effect. He interprets the phenomenon as a consequence of firms' systematic irrational behavior, or as he calls it, 'misperceptions of feedback'. This experiment by Sterman (1989) shows that communication with only the tier 1 suppliers or customers can create a bullwhip effect through the SC which will increase the waste of inventory, and further decrease effectiveness. The findings by Sterman (1989) also shows that it can be the people making the decisions about orders in the firm, which creates the bullwhip effect as they lack the necessary information to make the right decisions.

2.3.3 The waste of overproduction

In a manufacturing SC context, the waste of overproduction has one of the largest impacts on the lead time, costs, and flexibility for SC members. Overproduction by SC members will directly impact their effectiveness, as products can become obsolete, and in the worst case be scrapped. To further understand how this waste and its related SC aspects impact SC members' efficiency and effectiveness, the third sub-question will be examined:

3. *"How does the waste of overproduction impact efficiency and effectiveness of supply chain members?"*

Further, the literature on the SC aspects identified in section 2.1.4, related to the waste of overproduction will be presented in this section. These SC aspects are the *decoupling point* and *bullwhip effect*.

Decoupling point

The decoupling point has great impacts on the waste of overproduction, because this point, according to Christopher and Towill (2000), is the point in the SC where the market demand meets upstream forecasting. Naylor et al. (1999) describe the demand side to have a fluctuating demand which suits an agile SC strategy well with high effectiveness and the forecasting side to suit a lean SC strategy with high efficiency, as the production has leveled schedules. Thus, the decoupling point determines where the operations are driven by forecast and where they are based on actual customer demand. Hence, it has a great impact on the waste of overproduction, as everything that is forecasted for could have high uncertainty in demand.

As previously mentioned, the postponement strategy is highly connected to the decoupling point. This strategy aims to produce according to actual demand to avoid overproduction, and thus with high effectiveness. The manufacturing postponement strategy, proposed by Pagh and Cooper (1998), combined with an understanding of the decoupling point, can be used to reduce the waste of overproduction. This strategy involves keeping the product in a neutral and non-committed status as long as possible in the SC. Thus, the final differentiation of the product is postponed until the final customer's commitment is obtained, avoiding the waste of overproduction (Pagh & Cooper, 1998). This principle is the same as Christopher (2016) proposes by moving the decoupling point as far upstream as possible to produce with as high effectiveness as possible for all SC members. Using this strategy will reduce the risk of overproduction, which further increases the effectiveness for SC members, as by keeping the products generic they have higher flexibility towards the market, making it possible to assemble and finish them towards actual demand. However, by reducing the waste of overproduction, the delivery lead time can increase, as the products will not be kept in stock at the time of order.

Bullwhip effect

One of the main causes for the waste of overproduction for SC members is the bullwhip effect (Chen et al., 2000; Eltantawy et al., 2015; Lee et al., 1997a, 1997b; Metters, 1997). In the study by Lee et al. (1997b), they identified different causes for the bullwhip effect through SCs which will be further described. When a bullwhip effect occurs through the SC, the waste of overproduction will increase and it is difficult for SC members to achieve high effectiveness until the effect is coped with.

Demand forecast updating, according to Lee et al. (1997b), happens when a downstream operation places an order, and the upstream manager applies this information to readjusts his or her demand forecasts to be safe and, in turn, the orders placed with the suppliers. If the SC members have long supply lead times, this forecast updating gets delayed and leads to the waste of overproduction and excess products being placed in safety stocks. This delayed forecast updating combined with a play-safe tendency of the SC members when they order will create a bullwhip effect through the SC increasing inventory levels. The authors found that it is not uncommon for SC members to have weeks of safety stocks (inventory) which harms their efficiency.

Further, Lee et al. (1997b) found that when firms in the SC place orders weekly or monthly instead of ordering frequently, order batching happens. If a firm order once a month from its supplier, the supplier faces a highly unpredictable stream of orders. Thus, this periodic ordering increases the variability for the demand, which gets amplified through the SC as a bullwhip effect.

Lee et al. (1997b) also found in their study that when product demand exceeds supply, manufacturers often ration its product to customers. Often the manufacturer allocates the amount in proportion to the amount ordered. Further, Lee et al. (1997b) state that the customers know this and then exaggerate their real needs when they order and, when demand reduces, orders will suddenly disappear, and cancellations pour in. Lee et al. (1997b) state that the effect of this is that the customers' orders give the supplier little information on the product's real demand, and this leads the supplier to overproduce which further creates a bullwhip effect and increased waste for firms in the SC.

Moreover, Lee et al. (1997b) identified 'forward buying' as another reason for the bullwhip effect, which is caused due to price fluctuations in the marketplace, especially when looking at the grocery industry. Forward buying happens when goods are bought in advance of requirements, usually because of a manufacturer's attractive price offer. Thus, the customers' buying pattern will have high variability which can further lead to overproduction.

Literature on the three SC concepts and their related SC aspects have now been reviewed. Further, this will be summarized to develop a conceptual framework that will be used in the analysis in the case study. This framework is developed to show which main elements of the SC aspects we want to examine in the case.

2.4 Conceptual framework

The literature review has examined the SC aspects related to each sub-question in which forms the conceptual framework in figure 1. This framework will be used to analyze a finished product, its component, and the customer – supplier relationship among the LF and the suppliers. This will be analyzed in relation to how the SC aspects can impact the efficiency and effectiveness of the LF and the suppliers. Further, a short summary of the literature review of each SC aspect is given.

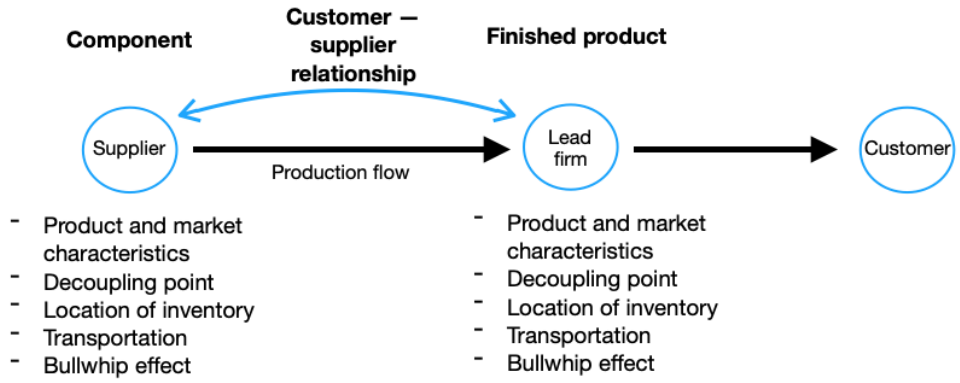

Figure 1. Conceptual framework

When looking at the *market characteristics*, the production method should focus on enhancing efficiency in a predictable market. While in an unpredictable market the production method should focus on producing with high effectiveness. Regarding the *product characteristics*, products with high volume and low product mix should be produced STS or MTS, while low volume and high product mix a BTO, ETO, ATO, or MTO production method should be preferred.

Further, looking at *the decoupling point*, this point is often where strategic inventory is held, thus locating this point upstream in the SC enables a BTO, ETO, or MTO production with high effectiveness. While locating it far downstream in the SC increases the need for forecasting, which further increases the risk for high inventory levels and overproduction. Together with the decoupling point, a postponement strategy can be used when combining a lean and agile SC strategy, where downstream from the decoupling point an agile SC strategy should be used, while upstream suits a lean SC strategy.

For the *location of inventory*, the decision to locate inventory centralized or decentralized is important. Centralized inventory is optimal when supply has low variability and demand is unstable, however, the delivery lead times can be high. Decentralized inventory should

be used when supply may be disrupted and there is low variability in product demand. Decentralized can also deliver with very short lead times, however, the safety stock levels will be high.

Moreover, looking at *transportation*, the trade-off for SC members is typically high inventory levels with high efficiency transport or low inventory levels with low efficiency transport. It is also important to be aware that goods being transported can be viewed as 'inventory on wheels', called transit inventory which will tie-up capital. Further, using global sourcing creates long supply times where firms should be focused on producing with high efficiency. On the other hand, local sourcing enables short supply lead times, where firms are enabled to produce more agile with the high effective production methods of MTO, BTO, or ETO, while still keeping inventory levels low. High effectiveness in transportation can be achieved by transporting directly to the product's designated location, thus without being transported to multiple locations before it ends up at the designated location.

The bullwhip effect is the distortion of inventory through SCs, where a demand amplification can create a bullwhip effect which further leads to overproduction and high inventory levels. Further, solely communicating with the tier 1 supplier can increase the risk of a bullwhip effect occurring through the SC.

Lastly, looking at the *customer – supplier relationships*, this is an important element to consider in an SC strategy, as relationships with suppliers can determine what SC strategies that are feasible for other SC members. A customer – supplier relationship can be described using structural and process characteristics. The structural characteristics describe how relationships between two companies are in terms of importance, age, and so on. While the process characteristics tell more about the nature of the interaction processes within the relationship, what effects they have on the actors, and how they develop and decay.

This chapter has established the theoretical foundation for the thesis by defining important terms and presenting the SC concepts used in the thesis. The terms and concepts presented are chosen based on their impact on SC strategies. The final part of this chapter ends with developing a conceptual framework, which summarizes the main elements from the theory and literature review. This framework will be used later in the analysis chapter. Further, the next chapter will present the main methodology of the thesis.

3 Methodology

This chapter will present theory on case study research, and how we will implement this theory into the methodology for our case study. Further, theory on data collection will be described, followed by how we collected data about the case. Thus, the methodology for the case study will be presented in this chapter.

3.1 Case study research

This section will give a definition of case study research, followed by why we have chosen case study as our methodology in this thesis.

A twofold definition of case study research is used by Yin (2018). Here, the first part is about the *scope* of a case study. Yin (2018, p. 15) defines it as: "a case study is an empirical method that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident." Hence, a case study can be employed because the researcher wants to understand a real-world case and to assume that it is likely to involve relevant contextual conditions in the case.

Moreover, the second part of the definition is about the *features* of a case study, as these are not always clearly distinguishable from real-world situations. The author defines this second part as:

> A case study copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result benefits from the prior development of theoretical propositions to guide design, data collection, and analysis, and as another result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion (Yin, 2018, p. 15).

This twofold definition shows that case study research has its own logic of design, data collection techniques, and specific approaches to data analysis (Yin, 2018).

The methodology in this thesis is a case study, as we examine a company (case) in-depth and within a real-world context. The reason for using case study as the research methodology was to see if a real company uses the suggestions by the theory from the literature review in chapter 2. Thus, a case study allowed us to go more in-depth to collect the necessary data in order to analyze if the theory was implemented in practice. Further, our case study will use the theory from the literature review presented in chapter 2. Moreover, to ensure that

the results from the study have strong validity and reliability, we will rely on multiple data sources to triangulate the data collected. These data sources will be further described in section 3.2.1.

As we have chosen case study as our methodology, the next section will present theory on how feasible this research method is, and discuss how feasible it is for our thesis.

3.1.1 Feasibility of the research method

According to Yin (2018), three conditions determine if case study research is a feasible research method to use. For the first condition, the form of question should be "how?" or "why?"-questions to favor case study as these imply more thorough in-depth research, compared to other forms such as "who", "what", "where", "how many" and "how much" (Yin, 2018). The second condition considers if it is required to have control over behavioral events in which would imply an experimental research design.

The third condition is about the focus on contemporary events, which is the recent past and the present (not just the present), as opposed to an entire historical event. Contemporary would normally mean that one would be able to collect data by direct observation of events and interviews of persons still involved in the events. Compared to a historical study design which does not usually have these sources of data available.

These three conditions that determine what kind of research methods to use are in accordance with our research design as a case study. The research question, as presented in section 1.2, is a "how?" question. As the study is about an SC with its inherent great complexity, an experimental research design with control over behavioral events is impossible. Furthermore, our study involved observing how a company operates in regards to established theory within the field. Lastly, interviews were to be conducted with people currently working in the case company. This made us able to analyze their current situation and not a historic event. Thus, all three conditions suggested by Yin (2018) were fulfilled which makes our use of case study a feasible research methodology.

Case study as the methodology has been established as a feasible research method. Further, different types of cases will be presented, including which type of case we will study.

3.1.2 Types of case

There are different types of cases in which Yin (2018) distinguishes between five types:

1. *The critical case.* In this type, the researcher has a well-developed theory and a case is chosen which allows a better understanding of the circumstances in which the theory/hypothesis will or will not hold.
2. *The extreme or unique case.* Researchers call their case extreme or unique when they believe that the circumstances for their case are not found in any other case. Thus, the research is about finding out why these circumstances exist or how these circumstances affect the environment or people in the case.
3. *The representative or typical case.* Yin (2018) also call this an exemplifying case. In this kind of case, the purpose is to find and capture the circumstances and conditions of an everyday or common situation. Researchers often choose these types of cases because they exemplify a broader category of cases or provide a suitable context for their research questions, and not because they are extreme or unusual in some sort of way. Another reason for choosing exemplifying cases is that they allow the researcher to examine key social processes, as the context in these cases often represents common social situations.
4. *The revelatory case.* This type of case exists when a researcher has the opportunity to observe and analyze an event previously inaccessible for research. These cases can occur due to new technology being developed or discoveries in other research areas.
5. *The longitudinal case.* A longitudinal case can be studied over time. In a longitudinal case, the researcher is often a member of an organization or community for many months or years. This type of case can also be any of the previously mentioned types if they are studied over a longer period of time. Yin (2018) suggests that a longitudinal case often offers the opportunity for research at two or more junctures. Another way of conducting a longitudinal case study is to study a previous case study at a later place in time. This can provide new perspectives or derive new results that were not discovered during the first study.

Further, within each of these different types of cases, Yin (2018) describes three different ways of doing case study research; explanatory, exploratory, and descriptive. In an explanatory case study, the author states that the primary objective is the construction and testing of an explanation for why specific events have occurred. According to Ogawa and Malen (1991), the primary purpose of an exploratory case study is to extend our understanding of complex social phenomena. Further, a descriptive case study according to Zainal (2007), describes the natural phenomena which occur within the data in question, for instance, what different strategies are used by a reader and how the reader applies them. The goal, in a descriptive

case study, set by the researcher is to describe the data as they occur.

In our research, the type of case is a combination of a unique and typical case by being one of a few, that is a manufacturing company in Scandinavia while at the same time does not operate in a traditional manufacturing industry, such as the car industry as there already exists a lot of literature on this industry. Our case study research will be explanatory as we aim to test if what the theory suggests in the literature review applies in the same manner in the SC of the FP.

This section has described which type of case we will study and our way of doing case study research. Further, the unit of analysis within the case will be described based on theory on different case study research designs.

3.1.3 Case study research designs

Case study research did traditionally not use formal designs, as is often used in surveys or experimental research (Yin, 2018). However, following a formal case study research design can make the case study stronger, and possibly, be easier to do. Yin (2018) has identified two categories of case study research design, single- and multiple-case study, which includes four different types of research designs. These four types are single-case (holistic) designs, single-case (embedded) designs, multiple-case (holistic) designs, and multiple-case (embedded) designs

As our unit of analysis in the case study is an SC for a product, the case study research design will be a single-case (holistic) design. The reason for a holistic design is that no logical sub-units were identified within the FP's SC due to its complexity. Further, using a holistic perspective enables us to study one SC in-depth and assess different aspects within the same SC. The holistic perspective also enables us to include the tier 1 suppliers upstream from the LF and downstream from the LF towards the customers, the internal operations of the LF, and the customer – supplier relationship.

The previous sections have described our case study research in terms of feasibility of the research method, the type of case we will study, and our unit of analysis within the case. Further, theory on data collection and different attributes a case study researcher should possess is presented.

3.2 Data collection

In case studies, the data collection procedures are not standardized or routinized, thus Yin (2018) argues that a case study does demand much from the researcher's intellect, ego, and emotions than any other research method. To conduct a high-quality case study, the author argues that a well-trained and experienced researcher is needed due to the continuous interaction between the issues being studied and the data collected. Still, Yin (2018) has not found any tests for being a good case study researcher, however, he has identified a basic list of attributes which the researcher should possess:

- Ask good questions and interpret the answers fairly
- Be a good 'listener', not trapped by existing ideologies or preconceptions.
- Stay adaptive, so that newly encountered situations can be seen as opportunities, not threats.
- Have a firm grasp of the issues being studied, even when in exploratory mode.
- Conduct research ethically, from a professional standpoint but also by being sensitive to contrary evidence.

Through the process of developing this study, we have gained experience in conducting research which makes us better prepared for the process of data collection. Moreover, in the research process, the attributes developed by Yin (2018) were considered to ensure high quality for the data collection in our case study.

Theory on how to collect data with high quality has been presented. The next section will present different sources of data and which sources of data we have used in our case study.

3.2.1 Sources of data

When starting to collect the actual data for the case study, the complete list of sources of data can be quite extensive, therefore Yin (2018) has identified six major sources of data: *documentation, archival records, interviews, direct observations, participant-observation*, and *physical artifacts*. Further, he argues that it is important to mention that none of the sources have a complete advantage over all the other, most of them are highly complementary, and a good case study relies on as many sources as possible. Later in this chapter, interview and documentation will be explained further as these will be the main sources of data used in this thesis.

In our case study, we used multiple sources of data to collect information about the SC of

the FP. Some data are also collected using sources not included in Yin's (2018) six major sources of data. Initially, we wanted to visit the case company to be able to directly observe the case (direct observations). However, due to circumstances above our control, only virtual meetings and interviews were possible to conduct. To cope with lacking this source of data, in addition to using documents provided by the case company, searching the Internet for complementary data was conducted. Based on this, our sources of data in the case study are a case presentation, an information meeting, interviews, documents from the case company, and complementary data from the Internet.

Figure 2 shows the timeframe for our data collection process, where mainly the data collection was conducted in May. The reason for this is that it was difficult to establish communication with the case company, mainly due to the impact on the case company by the COVID-19 outbreak.

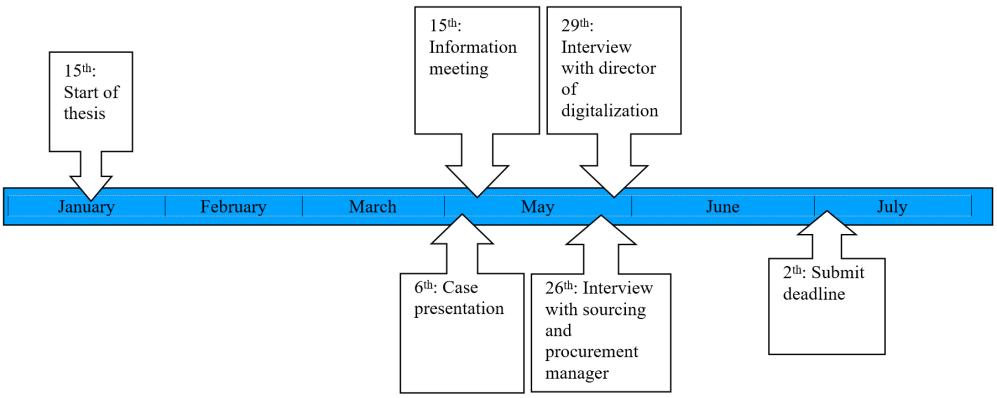

Figure 2. Timeframe for our data collection process

Further, each of the sources of data described in this section will be presented, including our methodology on how we used the different sources to collect the data.

3.2.2 Interview

An interview is probably the most widely employed method in qualitative research where mainly two types of interviews are employed: the *unstructured interview* and *semi-structured interview* (Bryman, 2016). In an unstructured interview, the interviewer usually only has a list of topics or issues, that are to be covered (Bryman, 2016). During the interview, the style of questioning is usually informal, where the phrasing and sequencing of questions will vary from interview to interview. Bryman (2016) states that semi-structured interviews

typically refers to a context in which the interviewer has a series of questions in the form of an interview guide but can vary the sequence of the questions. The interviewer usually also has the freedom to ask further questions in response to what is seen as significant replies.

In case studies, interviews are one of the most important sources of evidence, according to Yin (2018). They can especially help to suggest explanations of key events, as well as the insights reflecting participants' relativists perspectives. Case study interviews will resemble guided conversations rather than structured queries. Although the researcher will pursue a consistent line of inquiry, the actual stream of questions in a case study interview is likely to be fluid rather than rigid. This could lead to well-informed interviewees helping to identify other relevant sources of evidence for the case study.

In our case study, two interviews were conducted with employees from the case company. The travel restrictions applied to refrain the COVID-19 pandemic forced us to have the interviews virtual, where we used Microsoft Teams software. Further, the interviews were semi-structured, where we prepared an interview guide for each interview. Due to the interview guides' large size, these are attached in the appendix as Appendix B and Appendix C. The interview guides are made based on the theory with a series of questions in which were shared in advance. This was done so that the interviewees could prepare for the interviews to be able to provide in-depth information about the SC of the FP that we were interested in. The interview guide also makes our data collection more transparent and easier to replicate which are two typical criticism identified by Bryman (2016) against case study research. Further, a description of each person that was interviewed will be given, in addition to the theme for the respective interviews and how it was conducted. All findings from the interviews that were evaluated as valuable for the case study are presented in chapter 4.

Interview with sourcing and procurement manager

The first interview was conducted with the LF's sourcing and procurement manager. She has worked for the LF for 15 years, where she started as a senior procurement engineer. Her educational background is as an engineer in telecommunication, and later she has continued her education by studying business and administration for one year and is certified as a purchaser.

Before this interview, we developed the first interview guide (Appendix B) with questions about the two components and its suppliers, which was chosen as the topic since she is a procurement manager and should, therefore, have more than sufficient knowledge on this. We also shared the interview guide to let her prepare herself for the interview. The interview

lasted about one and a half hours, where she shared in-depth information and knowledge about the two components and its suppliers.

Interview with director of digitalization

The second interview was with the LF's director of digitalization for SC & manufacturing. He has worked for the LF for about two years, where he is responsible for the digitalization of the end-to-end SC, from suppliers to end-customers. His educational background is a master's in business and administration (MBA) in production, logistics, and supply chain management.

Looking at his background of supply chain management, production, and logistics, this interview was highly focused on the LF's supply chain from suppliers to end-customers, and their production method. Before the interview, the second interview guide (Appendix C) was developed and shared with him so that he could prepare for the interview. Also, this interview lasted for about one and a half hours, where he was able to answer with in-depth knowledge about the SC of the FP.

3.2.3 Documentation

Yin (2018) states that keeping records of various information has become a norm for people and organizations today. This means that documentary information (paper or electronic) is likely to be relevant for every case study topic. There exist many different types of documentation, and the availability of these is increasing through Internet searches. In case study research, the most important use of documentation is to confirm and augment evidence from other sources (Yin, 2018). However, it is important for the researcher that if the documentary evidence is contradictory rather than corroboratory, the researcher must find the reason by inquiring further into the topic.

Yin (2018) argues that there is no doubt that documentation has great value and can play a prominent role in any data collection in doing case study research. Still, researchers can become overreliant on documentation in case study research. He states the importance of understanding, when reviewing any document, that it was written for some specific purpose and some specific audience other than those conducting the case study. Another issue is that researchers may get lost in reviewing documents and waste a lot of time due to the increased amount of material available. To cope with this issue, Yin (2018) argues the importance of having a strong sense of the case study's inquiry and focus on the most pertinent information when reviewing documents.

In our case study, when using documentation as a data source, mainly documents from the case company were used. These were used to collect more data about the case and could confirm or augment evidence from other data sources such as the interviews. Further, it was important to assess the relevance of the complementary data collected to avoid spending to much time looking for documents on the Internet. Further, the documents from the Internet were used to provide new perspectives on topics talked about in the interviews and the case.

After the two meetings with the case company, we were given documents with additional information about their SC setup, the components, the FP, and the suppliers. This information was used to triangulate the information already established in the meetings and interviews. During this data triangulation, it was discovered that some of the information in the documents was outdated, where the interviews provided us with the correct and updated information. An example of this was their SC setup which had changed in the last year, thus making the provided document describing their SC setup outdated.

3.2.4 Additional data collection

Moreover, in our case study, we used additional data sources in which is not included in Yin's (2018) six major sources of data. These sources were two background meetings with the case company before the interviews, where we were presented with general information about the company. Both meetings were conducted virtually as we did not have the opportunity to visit the company. These two meetings are further described where the first meeting was a case presentation and the second an information meeting.

Case presentation

The first meeting was the first time we directly talked with the case company. This meeting consisted of us, our supervisor, the sourcing and procurement manager, and the director of digitalization from the case company. The purpose of this meeting was to get a presentation of the company, where we were presented the case for us to study. This case included the FP and component B (transport protector) which we received much information about. We also had the opportunity to ask some basic questions to clarify the information about the company and the case, and we asked for one additional component of the FP to be studied. In addition, beforehand, we sent our problem statement to the case company in which also was discussed at the end of the presentation, so that both parties had a similar understanding.

Information meeting

The information meeting consisted of the same individuals as in the case presentation. In this information meeting, we received more information about the FP and information about

component A (the cable). Furthermore, we asked some follow-up questions from the case presentation and the current information meeting, to clarify some information. Based on this, we had sufficient information to prepare for the upcoming interviews.

The sources of data and our data collection has now been described. Further, to ensure that this is high quality data, we will discuss our methodology following four principles presented by Yin (2018).

3.2.5 Quality of data collection

To assess the quality of the data collected in our case study, Yin (2018) describes four principles which have been commonly used to establish the quality of most empirical social research. These principles are important to ensure that the methodology used in the research is of high-quality. The principles are also a good way of checking if the data collection has been done in a good manner (Yin, 2018). As case studies are considered to be part of empirical social research, the principles are also relevant to assess case study research. The four principles are:

- *Construct validity.* Identifying correct operational measures for the concepts being studied.
- *Internal validity.* Seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships.
- *External validity.* Showing whether and how a case study's findings can be generalized.
- *Reliability.* Demonstrating that the operations of a study, such as its data collection procedures, can be repeated with the same results.

Further, to maximize the benefits from the six major sources of data and strengthen the different types of validity and reliability of the study, Yin (2018) has developed four principles of data collection. The four principles are:

1. Use multiple sources of evidence
2. Create a case study database
3. Maintain a chain of evidence
4. Exercise care when using data from social media sources

In our data collection, we used multiple sources of evidence to triangulate our data. This triangulation was done by collecting data from different sources, which included interviews, doc-

umentation, meetings, and complementary sources on the Internet. These different sources are used to examine the same issue in the SC of the FP, which strengthens the *construct validity* of our study. Further, the procedures for how this data was collected has been described in this chapter, thus increasing the *reliability* of our study.

All data collected in the case study were stored in a case study database in the cloud. This included recordings and transcriptions of the interviews, all documents provided by the case company, and notes taken during the meetings. The complementary sources from the Internet are already stored there, however, the information collected from these sources was also added to the database. This database enabled us to have the data in a retrievable form, which increases the *reliability* of the case study.

Moreover, to maintain a chain of evidence in the case study, we present the findings from the case study in the next chapter. Further, the analysis is based on these findings where we tried to identify causal relationships in the SC of the FP through building explanations to strengthen the *internal validity*. Furthermore, to strengthen the *external validity*, we use the case study to examine if the suggestions from the literature can be applied in practice. Thus, maintaining the chain of evidence is important to be able to examine if these suggestions actually apply.

Furthermore, Yin (2018) states that most of the six sources of data can be represented by social media. In our case study, we used social media as a secondary data source, as we searched for additional data on the SC of the FP. However, we exercised care to avoid decreasing the *construct validity* and *reliability* of the study. This was done by asking for the same information in the interviews and meetings with the case company, as we had collected from the Internet.

This chapter has described case study research and our methodology for the case study which is an explanatory case study. This includes our sources of data and how we have used them to collect data about the case. The quality of our data has also been discussed. Further, the next chapter will present the findings from the case study based on the data we have collected.

4 Case study findings

This chapter will present the findings from the data collected in the case study. The findings are based on one company presentation, one information meeting, and two interviews with the case company, as described in chapter 3. Further, documents provided by the case company and complementary sources of data found on the internet have been used to support these findings. The case will first be presented, where the FP and both components are given a brief description. Further, the FP's SC will be presented, where upstream, internal, and downstream operations are described.

4.1 Presenting the case

The case chosen in the thesis is the SC of an FP, which will be looked at from the perspective of the LF. This LF is an international technology and manufacturing company that produces equipment for the health sector. The FP is produced at the LF's headquarter in Scandinavia, where it is sold globally, where the United States (US) is the largest market.

One of the LF's most important products for healthcare training will be looked at as the FP in this thesis. The FP is a product used for healthcare training with many different functionalities, which is produced in three different colors which the customer can decide when they order. The FP is also highly complex as it consists of more than 1500 different components.

Further, the FP will be described, before the two components will be presented. These two components are used to analyze the upstream SC of the LF, where the suppliers of the components will also be looked at.

4.1.1 The finished product

The LF started producing this product in 2008, which is now produced in 18 different versions. Between these 18 versions, the main differences are different functionalities and differentiations by three different colors. There are three versions that cover about 80% of the demand, while the other 15 versions are only covering 20% of the demand. The price for the different versions of the FP range from 20 000 USD to 50 000 USD. This large price range is due to which functionalities the customer wants. In addition, the customer can order a broad range of other accessories with the FP, which also contributes to the large price range. The FP is not produced at any other manufacturing site than the factory in Scandinavia and, according to the sourcing and procurement manager, the FP's lifetime is about five to ten

years depending on its usage.

All of the components are used in the production of the FP, which are assembled at the LF's facility in Scandinavia. The reason for having the assembly located in Scandinavia is that the LF has its highest competence and expertise in Scandinavia. As the labor cost is not the main cost of the FP, the effect of high wages in Scandinavia is low for the LF. Moreover, the reason for the high price of the FP is the large number of complex components and high assembly costs. Thus, it is not because of high prices of individual components, but rather the accumulated total.

4.1.2 Component A (cable)

One of the components of the FP is a cable which is one of many cables used in the FP. The unit price for one cable is considered to be low compared to the high price of the FPs, in which one unit is equal to the amount required to produce one FP. The cable is customized for the FP's design, but they are standardized to be used for all the different versions of the FP. Thus, this component is specified by the LF and thus not an on-the-shelf component. This makes one unit of the cable equals to what is required to produce one FP.

4.1.3 Component B (transport protector)

Another component of the FP is a transport protector. This component is customized for the LF, where it can be used for all the different versions of the FP. The price for one component is low compared to the high total price for the FPs, in which one unit is equal to the amount required to produce one FP. The component's application is to protect the FP from any damages during transportation. Thus, the component is not used in the actual production of the FP.

4.2 The supply chain of the finished product

The headquarter of the LF has always been located in Scandinavia. A simplified model of the FP's SC is illustrated in figure 3, to show that the perspective on the SC in this thesis will be from the LF's perspective. In the FP's SC, the LF has many suppliers in which supplies to their manufacturing sites in Scandinavia and other facilities in the world. At these facilities, the LF produces the FP which is further distributed to their 12 distribution centers (DC) located around the globe. From these DCs, the product is sold through their globally spread sales offices to their customers.

The LF's main product development is still located at their headquarters in Scandinavia as their competence is highest there, however, some product development is also done in Asia and the US.

Figure 3. Simplified generic supply chain

Figure 3 shows a simplified generic SC. This includes the production flow between the main actors of the SC; upstream suppliers, internal LF, and downstream customers. All these actors are highly interconnected as the boundaries between them are not rigid. Further, the findings will focus on how the FP moves through the SC. The two components will be used to describe the upstream part of the SC (suppliers). Internally in the LF, the components will be assembled into the FP, and downstream to the customers the FP will be looked at.

4.2.1 Upstream from the lead firm in Scandinavia

When looking upstream of the LF, the findings will be separated into Component A and Component B, where the focus will be on the suppliers for both components.

Component A

The cable is globally sourced from a Chinese supplier, which has been the LF's supplier of the component for about 5-6 years. Further, this supplier will be referred to as Supplier A. Initially, Supplier A was used as a test supplier to increase the LF's emphasis on global sourcing to determine their skills in cable production. Through the years, these skills have proved to be high, and the supplier has thus become more and more important as their product mix and delivery volume have increased. Today, Supplier A delivers components to all of the LFs manufacturing sites and is considered to be a strategic partner of the LF. Moreover, the sourcing and procurement manager stated that there are significant product and process developments that have to be developed if the LF switches to a new supplier.

Supplier A does not produce finished products of the cables before they receive an actual order from the LF. They usually have some of the needed raw materials in-stock as their ordering sizes do not align with the exact number that the LF orders. Mainly, it is the LF that determines the specifications of the component, such as to improve quality, but Supplier

A does also have the possibility to suggest adjustments to lower costs such as in materials and operations. The production lead time for the component is four weeks, and they are normally transported through air shipments which takes about two weeks. This results in a lead time of about six weeks, equal to 42 days. The LF does also have the option to transport them by sea, which takes approximately six to eight weeks. However, air shipments are normally used as the cables are small in size and light-weighted. In addition, the sourcing and procurement manager argued that they would rather receive them faster through air shipments than risking running out-of-stock if they are stuck on a slow sea shipment.

As for the communication between Supplier A and the LF, this is mainly done through email in which the LF has one purchasing manager as liaison from each manufacturing site. Moreover, from time to time, Supplier A and the LF do have collaborations on R&D projects together in which there are more people involved in the communication. In addition, the LF uses its facility in China as a resource when local issues in China are arising.

The sourcing and procurement manager said that there has not developed any new significant routines and informal agreements with Supplier A through these years, that she knows of. Supplier A and the LF have had a gathering with their teams at the supplier's site in China. Moreover, the LF has also had a supplier-day at their facility in China, where Supplier A attended, which included price awards and events in the evening.

Furthermore, as of what the sourcing and procurement manager can remember, there has not been any conflicts regarding this component with Supplier A. However, there was one episode in 2019 with another cable that Supplier A supplies the LF. Here, Supplier A had switched the connector in the cable without asking or even telling the LF, as this was a cheaper material. This was not received with appreciation by the LF's technical department in which had to investigate and do thorough tests on the quality of the new connector. Ultimately, these tests confirmed that the new connector was as good as the previous one, but, as the sourcing and procurement managers state, this weakened the trust in the relationship.

Component B

Component B is globally sourced from a supplier located in China, which will be referred to as Supplier B further in this thesis. The transport protector is produced by Supplier B in the same amount that the LF orders. After they receive the order from the LF, the supplier further orders the required raw materials from their suppliers, that they do not have in stock, to fulfill the LF's purchasing order. To get an indication of what the LF will order, Supplier B can ask the LF for their forecasts when they want through email. These forecasts

are reviewed approximately once a month. Further, the LF organizes the transport for the transport protectors in containers with 90 units by sea from China to Scandinavia, where the lead time for the transport protectors is 67 days. Sometimes to avoid going out-of-stock or if the delivery is urgent, the transport protectors are shipped by air which has high costs due to the large size of the component.

Supplier B has been the LF's supplier since 2008 (12 years), which was the year the LF started producing the FP. In the beginning, the design of the transport protector was developed in collaboration with Supplier B, where some product development was done to enable the transport protectors to fit the accessories of the FP. However, Supplier B is not considered a strategic partner by the LF due to the transport protectors' low criticality in regards to the production of the FP. Further, in the relationship, there exist no informal agreements with Supplier B and the routines have stayed about the same throughout its lifetime, according to the sourcing and procurement manager.

Today, the orders of the transport protector is made by one purchaser which is located at the headquarter in Scandinavia, where the communication and orders are made through email. Further, the LF also has another purchaser located at their facility in China which communicates with Supplier B if other issues with the transport protectors or other components occur. Still, it is rarely any social gatherings with Supplier B because Supplier B is located over a day's travel from the LF's location in China. However, the sourcing and procurement manager thought that Supplier B attended the same supplier-day, mentioned earlier, which Supplier A attended. Further, the LF's sourcing and procurement manager does not recall any conflicts with Supplier B, however, there were problems regarding quality and communication with the previous supplier. These conflicts became so large that the LF had to change suppliers, which is how Supplier B became their supplier.

4.2.2 Internally in the lead firm in Scandinavia

Every month, each of the LF's 12 distribution centers reviews the forecast for the production of the FP. This forecast is based on the previous three years of sales history, which the sourcing and procurement manager assessed to sometimes be good and other times poor. Further, the suppliers can request these forecasts, which they will receive through email. However, the sourcing and procurement manager emphasized that this is only meant for the suppliers as an indication of what the LF will produce, and is not a binding agreement in any way.

Based on this forecast, the production plan is developed each week, where the purchasing

orders of the cables are determined. Thus, the orders of the cables are aligned with the number of FPs. However, as there may occur changes to the production plan, the purchasing orders would also have to be aligned with the current safety stock (and incoming shipments), to bring the safety stock level back to the predetermined level. Moreover, the purchasing orders for Component B are triggered by the LF's ERP system. The production plan is put into this system, which the system uses to check if there are enough transport protectors in stock. If the stock level is too low, the system tells the LF that they need to order more transport protectors from Supplier B. The orders for the transport protectors are placed approximately once a month in bulk orders consisting of 90 transport protectors, which satisfy Supplier B's minimum order quantity of 45 transport protectors. The order is 90 transport protectors to make it optimized for one container for transport. In addition, the LF prefers to rather buy a bit more than they actually need of both components to produce the forecasted amount, to avoid stock-outs.

At the LF in Scandinavia, Component A has a safety stock level at 50 units, equal to less than 100 USD, and has a minimum order quantity of 300 units from Supplier A. Normally, the cables are stored two to three months in-stock before they are used in the production. For component B, the sourcing and procurement manager said that they are kept in inventory at the facility in Scandinavia for about one to two months on average before they are packed with the FP. The safety stock level for the transport protector is 90 components, equal to about 20 000 USD. Further, given the large size of the transport protectors, the LF said that the component consumes much inventory space at the facility. Moreover, both components are at low risk of becoming obsolete, as this will only happen when there are quality improvements. However, as the sourcing and procurement manager stated, even then the LF will likely be able to use up what they already have in stock.

Regarding the FPs, the LF is regularly experiencing stock-outs of required components for the production of the FP. This may be due to delayed deliveries, unregistered purchasing orders at suppliers, higher internal usage than what is registered in the ERP-system, etc. In addition, some components are deliberately determined to not be kept in-stock, thus a planned stock-out.

Moreover, the FPs are manufactured in Scandinavia by assembling all the components (including the cables) and molding the plastic parts with a one-piece flow production. This is a process that takes 10-16 hours to perform, and the LF in Scandinavia is the only manufacturing site that produces the FPs. The LF produces approx. 1200 FPs per year in which the production is stable at about 23 units per week. The customers cannot order a combination

of the 18 versions or customize their own finished product with the functionalities they want. However, the director of digitalization argued that to stay competitive in the future, this is something he believes that the LF will have to offer to their customers. When the FP has been produced, the transport protector will also be pulled from inventory which is used to pack the FP before being shipped to the DCs.

The LF does (almost) not have any limit for how long the FPs can be kept in-stock at the DCs, as there is no risk of obsolescence. However, sometimes the FPs would have to be remodeled or refurbished, which is conducted at LF's distribution centers by their engineers from their global technical centers, or be sold at a reduced price.

4.2.3 Downstream from the lead firm in Scandinavia

From the LF in Scandinavia, the FPs are distributed to their DCs, which are forecasting the demand of each version of the FP. The LF has 12 DCs which are spread globally to be located closer to the customers. The US is the region which has the most customers with about 50% of the total sales of the FPs, while Europe and Asia/Oceania has about 25% each. The DCs are operated by different third-parties and located in Europe, the US, Asia, and Oceania. From the DCs, the FPs are transported directly to the customers in the transport protector.

To the DCs from Scandinavia, the FP is mainly transported by sea in the transport protector. To the US, the transport takes about six weeks with a total delivery time of two months. The director of digitalization said that in a worst-case scenario, the time from a DC orders an FP until it is in-stock can take 5 months. In addition, he said that keeping a high number of FPs in stock is not sustainable for the LF in the long run, considering the high price of the FP, as they tie-up too much capital as inventory. To give us an indication of how much capital the FP tie-up, the sourcing and procurement manager thought that in Asia, there were about 70-80 FPs in safety stock. Still, she was unsure about this number. It was also stated that they had a large problem with overstocking last year (2019) in which the reason mentioned was due to poor forecasting parameters.

The demand for the FP globally is considered stable by the director of digitalization, but from region to region the demand is significantly more unstable. The LF is promising short delivery lead times to its customers. As a consequence, when a customer orders an FP that is out-of-stock at the regional DC, the FP is produced within a day in Scandinavia, and further shipped by air to the customer to deliver on the LF's promise of short delivery time.

This chapter has presented the findings from the case study, where a description of the FP, Component A and Component B has been given. The FP's SC has also been described. Further, the next chapter uses the conceptual framework from chapter 2 to analyze these findings.

5 Analysis

This chapter will analyze the information from chapter 4 to examine the research question of this thesis. To do this, the conceptual framework presented in section 2.4, will be used in relation to the SC of the finished product and the two components in this SC, respectively. Further, the chapter will also describe and analyze the customer – supplier relationships among the LF and the two suppliers, as the suppliers are also an important part of their current SC strategy.

5.1 The finished product

This section will analyze the SC of the FP in regards to the SC aspects, where this SC is illustrated in figure 4 in which is based on the information in section 4.2. The figure starts with the suppliers (S), where T_1 is the transportation of components from the suppliers to the LF in Scandinavia. Further, I_1 is the inventory located at the facility before the production (P) where the FP is assembled in Scandinavia. T_2 is the transportation of the FP from the facility in Scandinavia to the DCs, where the FP is stored (I_2). Finally, T_3 is the transport of the FP to the customer (C).

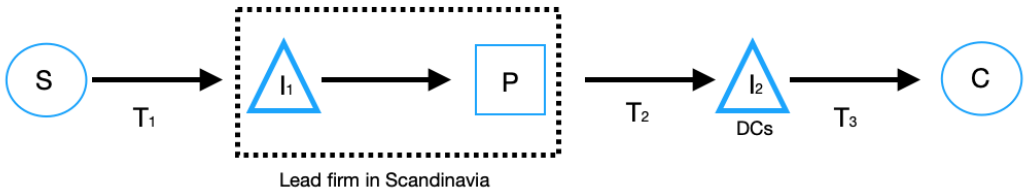

Figure 4. The finished product's supply chain

Further, the SC aspects of product and market characteristics, decoupling point, location of inventory, transportation, and bullwhip effect, will be used to analyze the FP in this SC from the LF's perspective. These aspects will look at how they impact the efficiency and effectiveness to assess the three sub-questions in relation to the FP:

1. *"How do the production methods impact efficiency and effectiveness of supply chain members?"*
2. *"How does the waste of inventory impact efficiency and effectiveness of supply chain members?"*
3. *"How does the waste of overproduction impact efficiency and effectiveness of supply chain members?"*

To clarify the terms efficiency and effectiveness in the three sub-questions, we will repeat the definitions from section 1.2. Here, *efficiency* is used as 'doing more with less', which is about the ability to produce more output with less input. *Effectiveness* is 'doing the right thing', which is about doing what one actually should do to fulfill what the customer demand. However, it is important to be aware that the SC aspects could impact the efficiency and effectiveness of SC members differently. Thus, changes by the LF to increase efficiency or effectiveness could decrease the efficiency or effectiveness of a supplier.

5.1.1 Product and market characteristics

The FPs are complex products that are produced with a high mix and at a low volume. In the 18 different versions of the FP, there are three high runners where the demand is predictable representing about 80% of total sales. Whereas the other 15 versions have an unpredictable demand, as these are distributed among the last 20% of the sales. To produce all these 18 versions, the LF is using an STS production method as they are shipped to the DCs before they have gained an actual order from any customer in which the LF will still be the owner of the FPs at the DCs. This production method should enhance the LF's efficiency in production, as they can optimize their batch production. However, as the method lack high effectiveness, the inventory efficiency will be low due to high inventory levels at the DCs. Moreover, these high inventory levels are needed to fulfill the LF's promise of delivering the FPs in only a few days after the customer places an order. The long time it takes from ordering the components until it is at the LF's facility in Scandinavia makes the supply lead times long. To cope with this, the LF keep these components in inventory, which lowers their efficiency as the components can be kept in inventory for a long time before they are used in the production.

5.1.2 Decoupling point

With the lead firm's STS production method, the decoupling point is located at the point where the products are shipped and stocked, which is at their DCs, as illustrated in figure 4 as I_2. Thus, it is from this location that the FPs are receiving an actual order from end-customers (downstream), while upstream from this point the LF is basing its operations on forecasting.

Locating the decoupling point this far downstream in the SC should enhance high efficiency in the LF's operations, which the LF is benefiting from with their STS production method. The reason for this is that the location of the decoupling point makes all production up-stream from the decoupling point dependent on forecasting. Such forecasting enhances a

predictable production which makes it easier to develop a production schedule to follow. This predictability can be utilized by the LF to optimize efficiency in their operations.

Nevertheless, poor forecasting parameters result in the LF ordering and producing more products than the actual demand, which decreases their effectiveness by overproduction and efficiency by higher inventory levels of components and the FP. Furthermore, if the LF continues to use an STS production method to produce as efficiently as possible with poor forecasting, they will continue to build up high inventory levels of the FP at their DCs, which paradoxically results in low efficiency and effectiveness. This inventory does tie-up much capital for the LF due to the high price of the FP. In 2019, this was the case for the LF where they had a large problem with overstocking of the FPs due to poor forecasting.

Another consequence of overproduction for the LF in the past has been that the FPs are kept in-stock for a long time, and then has to be refurbished or remodeled before it can be sold if a new design or model is developed. This can be done by field engineers from the LF's global technical centers at the DCs, which is costly and consumes time. This is a result of low effectiveness in the LF's operations, as they are producing FPs without any customer demand. Some components in the FP will also lose quality if the FP is kept in stock over a long time. The director of digitalization said that one of the components in the FP must be changed if the FP has been stocked for over six months. This is not an easy process, which also takes time and is costly.

Moreover, the LF is forecasting their production, as the decoupling point is located further downstream in the SC, through their STS production method. This means that the orders from their suppliers are forecast-based, and thus do not reflect the actual end-customers' demand. Furthermore, as stated by the sourcing and procurement manager, the LF's forecasts are sometimes good and other times poor. Hence, as the forecasts are sometimes poor, they lack reliability and can therefore not be trusted and followed accurately. Thus, this forces the LF to keep high inventory levels of the components before their production (I_1 in figure 4) which is lowering their efficiency and effectiveness in operations, as there may appear significant changes to the production plan.

5.1.3 Location of inventory

The location of inventory for the FP is located at the LF's 12 globally spread DCs, illustrated in figure 4 as I_2. With the LF's STS production method, their location of inventory is considered to be decentralized because they have located their DCs worldwide to be located closer to customers. The benefit of this is that it enables efficiency in operations and very

short delivery lead times to customers. On the other hand, this decentralization of inventory forces the LF to forecast for how much each of the DCs will require of each of the versions, and produce with an STS production method with low effectiveness. Thus, the decentralization of inventory forces the LF to keep safety stocks of all the 18 versions in all of the 12 DCs, which is to ensure that they can deliver the version that the customer orders in a very short time.

Furthermore, sometimes the LF's forecast is incorrect and the customer orders a version that is not in stock at the regional DCs. To cope with this, the LF produces this ordered version in Scandinavia and ship it by air in a few days to the DCs. This is done to ensure that the customer always receives the FP they order with very short delivery lead times. Hence, this demonstrates that the LF's location of inventory has low effectiveness. The director of digitalization said that this is quicker than utilizing any nearby DCs to check if they already have the FP in stock and ship it between the DCs. Thus, the LF is capable of being flexible in their production, and logistics from their production, to cope with variability in market demand. The reason that the LF can do this, is their one-piece flow production and short assembly time for each FP, which result in a high flexibility.

However, the transporting costs through shipping by air are high, which the LF has to utilize in these situations to keep the promise of very short delivery lead times. Thus, the LF produces with an STS production method, with low effectiveness, to fulfill their promise of very short delivery lead times to the customer by still having efficient transportation through sea shipments. Moreover, if the demand for one version is lower than expected at any of the DCs, the FP will be kept in-stock waiting for the demand to rebound, resulting in low effectiveness and efficiency.

5.1.4 Transportation

By having the FPs stocked without any actual demand at the DCs, the need for transportation and the amount of transit inventory for the LF will increase. The reason for this is that when the production of the FP is finished, it is shipped by sea or truck from the factory to the DCs where it is kept in stock. Further, it must be transported from the DCs to the customer when an order comes in. Hence, the transportation has low effectiveness as this way of SC setup adds a transporting distance from the factory to the DCs, as illustrated with T_2 in figure 4. In addition to the long distances that the components and the FPs are forced to travel due to the location of suppliers, the LF's manufacturing site, and the globally spread customers.

These long distances result in a high amount of transit inventory and long lead times in the SC. This is mainly because the LF uses ships for transport when possible in which greatly increase the transit inventory and tie-up more capital than shipping by air, as it takes significantly more time before the LF can sell the FP. Furthermore, sometimes the FPs are transported and stored at multiple DCs before reaching its designated DC, demonstrating low effectiveness in transportation in which greatly increases the transit inventory. E.g. FPs being sold in New Zealand are first sent to the main DC for Asia in China, where it is further shipped to the DC in Australia and finally shipped to New Zealand. This transport could, in the worst case, take up to five months, according to the director of digitalization, while air shipments may take less than a week. On the other hand, this SC setup enhances high efficiency in the transportation from the factory to the DCs (T_2) and from the DCs to customers (T_3), as each transportation can be optimized in regard to frequency, size (high utilization), and transport mode.

5.1.5 Bullwhip effect

The production of the FP is based on the LF's forecast system, which is based on sales of the FPs for the last three years. Thus, the system will have low effectiveness as it is basing future sales on historical data. Moreover, the forecasting system will become even less reliable whenever the LF introduces a new version of the FP in their portfolio, as it is incapable to cope with new changes in market demand. When a new version is introduced, they will have no data to estimate how much this version will sell, and the LF will not know how this new version impacts the sales of the other versions. To cope with this uncertainty, the LF overproduce the FP and keep them in inventory at the DCs. This was the case in 2019 where the LF had introduced changes in their portfolio making the forecast system produce a large backlog for older versions of the FP, leading to overproduction and overstocking. Furthermore, due to the LF's forecasting, they will often order more of both components than they actually need to be 'safe' instead of risking running out-of-stock. This play-safe tendency results in low effectiveness for the LF by ordering components in which there are no demand for, and low efficiency by unnecessary inventory. Moreover, this also shows that the LF could be creating a bullwhip effect in the SC with their forecasting system.

This section has analyzed the FP in regards to the SC aspects. Further, the next section will conduct the same analysis by looking at the two selected components of the FP.

5.2 Component A and Component B

This section will analyze the two components presented in chapter 4. The SC aspects will be used to analyze how the components move through the SC in figure 5. These aspects will look at how they impact the efficiency and effectiveness to assess the three sub-questions in relation to the two components:

1. *"How do the production methods impact efficiency and effectiveness of supply chain members?"*
2. *"How does the waste of inventory impact efficiency and effectiveness of supply chain members?"*
3. *"How does the waste of overproduction impact efficiency and effectiveness of supply chain members?"*

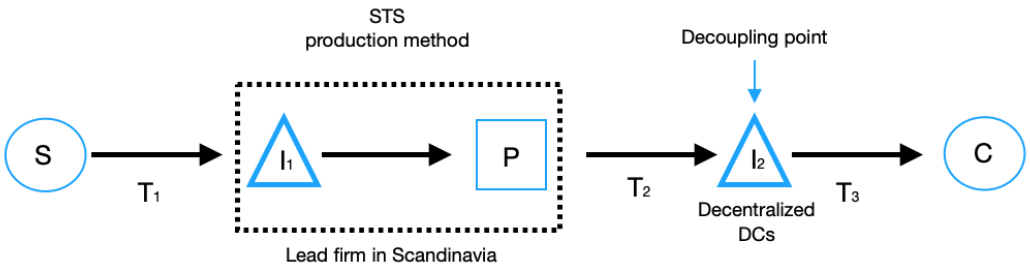

Figure 5. The finished product's supply chain with some supply chain aspects

Figure 5 shows the SC of the FP with some aspects, as these were identified in the analysis of the FP. This figure has added the information of the STS production method of the LF in Scandinavia, the decoupling point for the FP is identified to be located in the DCs at I_2, and that the DCs are decentralized.

5.2.1 Product and market characteristics

The demand for both components is related to the amount of the FP that is produced in which each produced FP requires one unit of the components. Both customer – supplier relationships have customized their component to the FP, but the component can be used in all of the 18 versions. This allows the LF to be efficient as they can combine all the versions' safety stock, purchasing, and have a demand that is equal to the total produced FPs compared to having unique components for each version. This means that both components, in relation to the FP, can be produced with a low mix and at a high volume.

Furthermore, as the total amount of produced FPs have been stable with about 23 units a week, and that the demand for the components are dependent and forecasted together with the FP, the demand for both components are considered predictable. The cables (Component A) are transported by air shipments due to its low weight and size, while the transport protectors (Component B) are shipped by sea due to its large size. The supply lead time for the components is long, which the LF copes with by carrying large safety stock of both components. These large safety stocks lowers the LF's efficiency in the SC, however, as these are inexpensive components, this impact is rather insignificant.

5.2.2 Decoupling point

Both components are produced with an MTO production method, as both suppliers are only producing according to purchasing orders from the LF. This means that the decoupling point for both components is located at the suppliers' facilities in China, which is marked S in figure 5. For the suppliers, this means that their production method enhances effectiveness, but it also causes longer supply lead times to the LF.

As the LF is not demanding any short supply lead times for the components, both suppliers can produce with an MTO production method. This enables the suppliers to keep a minimum inventory level and low risk of unsold products, as they can produce with high effectiveness. However, as the LF is producing with an STS production method, they have to plan for variability in the production schedules, since their forecasts' lack reliability. This forces the LF to keep high safety stocks of the components (I_1 in figure 5), and thus lowers the LF's efficiency in operations.

For both suppliers, this means that they have no uncertainty of keeping finished components as inventory, as the only uncertainty they have is the inventory of raw materials that can be applied in a range of their products. It could be argued that both suppliers are producing with an ATO production method, as they have raw materials in-stock. However, our and the sourcing and procurement manager's understanding is that the suppliers are producing MTO, since they do not have all, at least not deliberately, the necessary raw materials to produce with an ATO production method. In addition, whether they are producing with an ATO or MTO production method does not make any significant differences to the research. Thus, the thesis will further use that both suppliers produce with an MTO production method.

5.2.3 Location of inventory

Both components are stored at the LF's facilities in Scandinavia, where they are available to be used in the production of the FP. Thus, the location of inventory of the components is centralized at the LF's facilities, illustrated as I_1 in figure 5. Moreover, at the DCs, the cables are implicitly stored as they are assembled into the FP. This also applies to the transport protectors as they are also stored implicitly at the DCs, as the FP is packed with the transport protector at the DCs. Thus, at this location, the components are still unsold and therefore still owned by the LF. However, both components are no longer available to be used for any of the other FPs, as it has been "consumed" by one FP, compared to the inventory before the LF's production where they are available to be used in any version. Also, in theory, the LF can use the transport protectors on another FP at the DCs if necessary, for instance, to ship another FP from the DC. Still, this option is not used by the LF and we do therefore not consider this availability as a real option.

The LF's emphasis on high efficiency in operations with its STS production method makes it crucial to have the components available for assembling when a product is produced. However, due to the low price for both components, they will not tie-up much capital at the factory, causing the LF to rather overstock the components, to not risk running out-of-stock, than trying to reduce inventory to improve their efficiency. This high availability of the components facilitate to high effectiveness in the LF's production, as the LF has the necessary components available. Furthermore, the sourcing and procurement manager could not remember that they had ever run out-of-stock of the transport protectors, but that it might have happened with the cables.

Also, according to the sourcing and procurement manager, and the director of digitalization, the risk of the components becoming obsolete are considered low, as this will almost only happen when the components are upgraded, and that the components are independent of what version that is produced. Nevertheless, even when the components are upgraded, the LF will likely use what they have left in inventory first.

5.2.4 Transportation

Both components are globally sourced through two suppliers in China in which this distance significantly increases the supply lead time of the components to the LF in Scandinavia. With the cables, the LF has reduced the supply lead time by utilizing air shipments. These air shipments reduce the supply lead time with four to six weeks and are assessed by the sourcing and procurement manager to be an efficient transport mode for the cables due to their low

weight and size. Furthermore, as this choice of transport mode does reduce the supply lead time, the transit inventory is also reduced. On the other hand, the transport protectors are transported by sea shipments in which takes considerably more time than through air shipments. This transport mode is used because of the large size of the component.

To cope with the long supply lead time of both the components, the LF counterbalance by keeping higher inventory levels of the components, as longer lead times increase uncertainty. Moreover, as a consequence of long supply lead time for both components, it is unfeasible to apply any JIT practices to increase flexibility in the operations to produce MTO with higher effectiveness, without increasing inventory levels and keeping current suppliers and delivery terms.

However, the suppliers are located in a low-cost country, which makes the unit price low for the LF. Thus, the LF will rather optimize their transport efficiency and use global sourcing, as they do not require short supply lead time for the components with their STS production method. Nevertheless, as the suppliers are producing MTO and only has one customer of the component, the effectiveness of the transportation to the LF is high. Moreover, the suppliers are located in China and the only production of the FP is in Scandinavia. Hence, the components must first be shipped to the LF in Scandinavia and, when the components are assembled into the FP, some FPs will be sent back to the DCs in Asia to be further shipped to customers. This means that the components travel the same distances twice, which greatly increases the time the component is held as transit inventory for LF and has a great impact on the environment.

Further, the LF's choice to use global sourcing creates long supply lead times as the distance from both suppliers to the LF is long. This increases the risk of delayed deliveries and running out-of-stock. To cope with this uncertainty, the LF keeps high safety stock levels to ensure a steady flow in their operations in which lowers their efficiency, as the components can be stored for a long period before they are used. From the first interview, it was said that the components on average are stored for about one to two months in inventory. This inventory also enables the LF to continue production even if a delivery is delayed or, even worse, does not make it to the factory. However, keeping high inventory levels consumes much space, especially for the large size of the transport protector, and ties-up much capital for the LF.

The transit inventory will also increase as a consequence of the LF's global sourcing, especially for the transport protectors that are transported with sea shipments from Supplier B, resulting in lower efficiency of inventory. However, the transport efficiency of Component

B is high for the LF as they can optimize the transport utilization as they order 90 units, which are the equivalent of one container. Furthermore, if the demand for the transportation protectors is urgent, the LF will ship them by air which takes about two weeks compared to the six to eight weeks by sea shipments. Still, this is more expensive for the LF and indicates low effectiveness in their operations, as it could be caused by poor forecasting by the LF, where too few components are ordered. Hence, this results in air shipments to avoid running out-of-stock.

5.2.5 Bullwhip effect

Basing the production of the FPs on forecasts from the 12 different DCs makes the LF's orders of the components also based on forecasts. As a consequence, the LF's orders will have high uncertainty as the forecast is based on historical data, which increases the risk of a bullwhip effect through the SC.

Further, the sourcing and procurement manager said that the frequency and size of orders for the cables (Component A) vary depending on how much they produce and the current stock levels, which makes it difficult for Supplier A to plan their production as the orders from the LF have high variability. To cope with this high variability, Supplier A has set a minimum order quantity of 300 cables which the LF must follow. For Supplier B, as the transport protectors (Component B), are ordered at a fixed ordering size of 90 to fill a container, it should be easier for Supplier B to optimize their operations and achieve higher efficiency. However, as Supplier A and Supplier B produces with an MTO production method, achieving high efficiency is not what they emphasize in their production. This MTO production method should also mitigate the orders by the LF to be amplified further upstream to Supplier A's and Supplier B's suppliers.

In addition, the LF does not have any information about the minimum order quantity that Supplier A and Supplier B must fulfill towards their suppliers. This increases the risk of amplifying the LF's order for both components. If Supplier A and Supplier B must order raw materials with a minimum order quantity much higher than 300 cables or 90 transport protectors, both suppliers' inventory levels for raw materials will increase which creates low efficiency of their inventory. Thus, if the demand from the LF decreases, Supplier A and Supplier B could be forced to scrap the obsolete raw materials to avoid high inventory levels and overproduction. If this amplification continues upstream through the SC, a bullwhip effect will occur decreasing the effectiveness for all the upstream SC members.

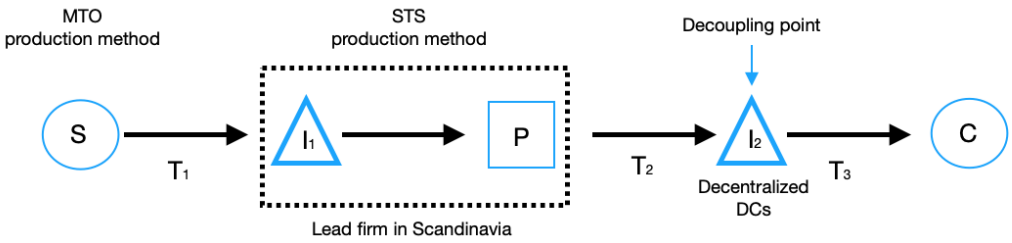

Figure 6. The finished product's supply chain with supply chain aspects

Figure 6 has added information from the analysis of the components to the SC of the FP. The information added in this figure is the MTO production method of the suppliers.

An analysis of the FP and the components through the SC from the LF's perspective has been conducted in regards to the SC aspects. Further, the next section will analyze the customer – supplier relationships among the LF and Supplier A and the LF and Supplier B.

5.3 Customer – supplier relationship

The choice of SC strategy is also dependent on the customer – supplier relationship, as the suppliers' SC strategy may determine what SC strategies that are feasible for other SC members in the SC. Thus, this part is included to examine this dependency through an analysis of the relationships, which will be further discussed in the next chapter. It will also provide a more holistic view on the choice of SC strategy. This section will use the information presented in chapter 4 to analyze the relationship that the LF has with the suppliers of the two components. The analysis will follow Håkansson and Snehota's (1995) structural and process characteristics, as presented in section 2.1.2.

5.3.1 Relationship among the lead firm and Supplier A

As of the structural characteristics of the LF's relationship with Supplier A, it has *continued* for about five to six years, and the relationship is now classified as a strategic partnership in the LF's supplier portfolio. The relationship has low *complexity* as there is only one from each of the LF's manufacturing sites that function as a liaison. This role is filled by a purchasing manager from each site which primarily uses email as the communication tool. Moreover, there are more people involved in the communication when they collaborate on projects together, which happen occasionally. Besides, when possible, the LF in Scandinavia utilizes employees at their manufacturing site in China as a resource to respond to issues that require the LF to be present. These issues can be related to Supplier A's manufacturing

site. Furthermore, there is some additional complexity in different cultures and languages. However, there have not been mentioned any issues regarding this. The sourcing and procurement manager could not tell for sure how the *symmetry* in the relationship is. She said that Supplier A is an important supplier for the LF, but she also said that the LF is likely an even more important customer for Supplier A. However, by considering that Supplier A is allowed to produce with an MTO production method, which results in long supply lead times and no other benefits for the LF, the power balance seems to be skewed in favor of Supplier A. As for the feature of *informality*, the sourcing and procurement manager said that she did not know or had heard of any informal agreements in the relationship with Supplier A.

Assessing the process characteristics in the relationship, there have been lots of episodes of *adaptations* since the beginning of the relationship. Initially, the relationship with Supplier A was a pilot in the LF's strategy of increasing its global sourcing. This pilot was started with only one component (another cable component). This pilot proved successful and has since then evolved into a larger product mix and Supplier A has increased its supply volume by delivering to all of the LF's factories. Regarding the feature of *cooperation and conflict*, there was one episode with Supplier A in 2019. In this episode, Supplier A switched the connector in one of the cables they supply to the LF, without telling the LF. This was done because the new material was cheaper than the current. However, this forced the LF to do thorough investigations and tests to assess the quality of the new connector. The result from this was that the new material had sufficient quality, however, as stated by the sourcing and procurement manager, this weakened the LF's trust in the relationship. Further, the sourcing and procurement manager did not know of any other episodes with conflicts. Nevertheless, the LF has cooperated on projects with the supplier from time to time to improve and expand the product portfolio supplied by the supplier.

Moreover, there is a great physical distance between the LF and Supplier A, and thus difficult to have many *social interactions*. However, the LF has had a gathering at their manufacturing site in China for its suppliers which involved price awards and events in the evening. This gathering was attended by Supplier A. Also, the LF in Scandinavia has visited Supplier A several times. As for the feature of *routinization*, the sourcing and procurement manager did not know of any operations that have evolved into routines through these years. However, this may still have occurred without her noticing.

These process and structural characteristics suggest that the relationship has low interdependency in the layer of actor bonds, as there are rarely social interactions, low informality, and low complexity in the relationship. The links of activities in the relationship are sequential,

and it appears that there are low interdependency by considering the low routinization that has been developed. Further, it suggests that the relationship has high interdependency in their resource ties as of the high adaptations and cooperation that have been done when developing Component A, and the subsequent chains of episodes of adaptations and cooperation. Also, there are interdependency in the activity links as of the episodes of adaptations and cooperation. Thus, the relationship is assessed to have high interdependency, especially because of the interdependency of resource ties.

5.3.2 Relationship among the lead firm and Supplier B

The relationship with Supplier B started when the LF began producing the FP and has *continued* until today, which is about 12 years. When looking at the communication between the LF and Supplier B, the relationship has low *complexity* as there is mainly one purchasing manager located at the LF's factory in China which communicates through email with Supplier B. However, as Supplier B is located in China they are used to a different language and culture which can increase the complexity. Still, in the interviews, this was not mentioned by the LF as an issue. Thus, it appears that their relationship has low complexity. Moreover, as with Supplier A, Supplier B is allowed to produce with an MTO production method by the LF. Considering this, this supplier is also assessed to have the *symmetry* in the relationship skewed in their favor. Further, it seems that the relationship with Supplier B has a low degree of *informal* agreements as said by the sourcing and procurement manager. However, it is clear that the LF trust Supplier B as they are willing to help them if they experience problems and they have previously collaborated on the product development of the component.

Looking at the process characteristics, there is a low amount of *adaptations* in the relationship, according to the sourcing and procurement manager. Supplier B has almost no freedom in the production of the component as they must fulfill the specifications which the LF has set in terms of quality, material, etc. However, the LF must order the minimum order quantity which Supplier B demands to keep a steady production of the component. Further, as stated by the sourcing and procurement manager, there have been few *conflicts* with Supplier B since the beginning of the relationship. At the beginning of the relationship, the LF cooperated with Supplier B on the design of the component and some later product development of the component. However, today there is a low degree of *cooperation* with the supplier. Regarding the *social* feature of the relationship, there have been few social interactions outside of work with Supplier B. Some of this is due to the long distance from the LF's factory in China to Supplier B. The sourcing and procurement manager also said

that most of the interactions were work-related and rarely purely social. Lastly, even though the relationship has lasted for 12 years, it seems that the *routines* have stayed the same throughout the relationship, according to the sourcing and procurement manager.

These process and structural characteristics suggest that the interdependency in the activity links and resource ties in the relationship are considered low as of the low adaptations, cooperation, routinization, and complexity, even though there is some interdependency in the development of Component B. The interdependency in the actor bonds do also appear to be low as of the rare social interactions, low informality, and low complexity. Thus, the relationship between the LF and Supplier B is assessed to have low interdependency.

This analysis of the relationships has shown that the relationships with the suppliers are similar in the terms of the complexity, symmetry, informality, conflict, social interaction, and routinization. The differences are in the continuity, where the relationship with Supplier B has lasted about twice as long as with Supplier A. The adaptations and cooperation are assessed high for Supplier A, while they are low for Supplier B. Based on these, it was identified that Supplier A has high interdependency with the LF as of the resource ties and activity links, while Supplier B has low interdependency. Moreover, these relationships will be further compared in the next chapter.

In this chapter, the FP and the two components have been analyzed. This analysis has used the three sub-questions of the thesis, which include the SC concepts of production methods, the waste of inventory, and the waste of overproduction. These concepts have been analyzed in relation to the SC aspects impact on efficiency and effectiveness. Moreover, the customer – supplier relationship with the two suppliers have been analyzed, to identify what characterizes each relationship and their interdependencies. Further, the next chapter will present the LF's current SC strategy, based on the analysis. This chapter will also suggest four different SC strategies for the LF and how these will impact the LF and the suppliers if chosen by the LF.

6 Discussion

This chapter will first look at how the SC aspects impact the efficiency and effectiveness of the LF, Supplier A, and Supplier B with the current SC strategy. Then, the LF's current relationship with Supplier A and Supplier B will be compared, by looking at the structural and process characteristics. Further, different SC strategies from the literature will be presented in regards to how applicable they are for the LF and how they impact the LF and the suppliers. Lastly, how the different SC aspects can impact the LF's choice of SC strategy and which SC strategy is preferred for the LF will be discussed.

6.1 The current supply chain strategy of the lead firm

This section will relate the SC aspects to the LF's current SC strategy and how they impact the LF and the suppliers. The findings from the analysis are summarized in table 3, where *efficiency* and *effectiveness* are assessed with low, medium, or high impact on the SC aspects. Further, in this section, Supplier A and Supplier B will be examined together, as in the analysis there was not found any major differences between them in regards to the SC aspects.

Table 3. Overview of how the aspects are assessed concerning the suppliers and the lead firm's efficiency and effectiveness

Aspects	Lead firm*	Supplier A and Supplier B*
Product and market characteristics	Low/High	High/Medium
Decoupling point	High/Low	Low/High
Location of inventory	Low/Low	Low/Medium
Transportation	High/Low	High/High
Bullwhip effect	Medium/Low	Medium/Low

* Efficiency/Effectiveness.

Table 3 shows that most of the SC aspects for the LF is focused on high efficiency, expect for the product and market characteristics and location of inventory. Thus, this emphasis on high efficiency in the current SC strategy with an STS production method is aligned with a lean SC strategy. Based on this, the current SC strategy of the LF is a lean SC strategy with an STS production method. For the suppliers, it appears to be more emphasis on effectiveness than efficiency. Further, for the suppliers, the product and market characteristics are assessed as high for efficiency, while high effectiveness for the LF. This indicates that the LF should produce more agile and the suppliers more lean. Moreover, how this current lean SC strategy

impacts the LF and the suppliers will be assessed, beginning with the LF.

6.1.1 Impacts on the lead firm

The FPs are expensive and customized products with a high product mix and a low volume. The demand is considered predictable for the FP as a whole, but with unpredictable demand for the individual versions. Based on this, the LF should produce with more effectiveness, where an agile or hybrid SC strategy would be optimal. Moreover, the LF has located the decoupling point downstream in the SC from their production. This location of the decoupling point enhances a lean SC strategy with high efficiency and low effectiveness. This far downstream placement also makes the LF unable to offer the customers the opportunity to customize the FP, as they must forecast the operations until the DCs. Further, making the operations almost only based on forecasts creates a high risk for a bullwhip effect for the LF, which will decrease the LF's effectiveness as they can overproduce the FP.

Still, we were unable to identify clear evidence of a bullwhip effect through the finished product's SC. However, based on the data collected about their forecast system, if one was able to collect information several tiers upstream in the SC, we think one would find evidence of a bullwhip effect. Still, as we were only able to talk with the LF, which is the closest SC member to the customer, finding evidence of a bullwhip effect through the SC was difficult.

Moreover, in their current lean SC strategy, the LF produces based on forecasting with an STS production method by shipping the FP to the DCs. These decentralized locations of inventory are used to deliver on their promise of very short delivery lead times to customers without utilizing the expensive transportation mode of air shipments. Locating the inventory at the DCs results in low efficiency of inventory because the LF has to keep a large accumulated inventory to have safety stocks of all the 18 versions in all of the 12 DCs. This makes the forecasting process difficult for the LF, as they must forecast the sales of the 18 different versions to all of the 12 DCs, which results in a total of 216 forecasts. Further, this does also result in low effectiveness of the location of inventory, as there may be a DC that needs a version located in another DC. However, to cope with these situations, the LF produces a new FP to the DC that needs it, and ships it through air shipments, to comply with the LF's promise to deliver with short lead time to the customers. Thus, their current location of inventory in the lean SC strategy forces the LF to have much capital tied-up as safety stock in the DCs due to their high focus on efficiency in transportation.

Furthermore, the LF is strongly emphasizing high efficiency in transportation by optimizing the utilization and using inexpensive transportation modes. They are mainly using sea

shipments because of the large size and weight of the FPs. However, the transportation to the DCs adds a transporting distance, and the FPs do sometimes have to be transported to multiple DCs before it finally ends up at its designated DC. Thus, the transport of the FP to the DCs (location of inventory) has low effectiveness.

6.1.2 Impacts on Supplier A and Supplier B

The current SC strategy used by the LF impacts the suppliers differently when looking at the SC aspects. As both components are customized for the FP, but the same component is used in all of the different versions, the product mix is assessed low, and the volume high for both components. Hence, the product and market characteristics of the components show that the suppliers should produce the components with high efficiency and not high effectiveness as they currently do. Furthermore, as the components are customized to only fit the FP, the production of the components should also have some effectiveness.

However, the placement of the decoupling point in the SC forces the LF to forecast their orders towards the suppliers. On the other hand, the suppliers are producing with an MTO production method, which enables the suppliers to produce the components with high effectiveness. However, they do probably produce with low efficiency as they have to produce the orders from the LF when they arrive, which are not in a distinct frequency and ordering size for the cables (Component A), which makes Supplier A unable to optimize their operations to increase their efficiency. For the transport protectors (Component B), they are at a fixed ordering size to fill a container, which should make it easier for Supplier B to optimize their operations and achieve higher efficiency. Thus, the MTO production method does not appear as the optimal solution for either supplier.

Further, the decoupling point's location and the product and market characteristics are somewhat opposed to each other, as the decoupling point suggests that the suppliers should produce with high effectiveness, while the product and market characteristics suggest high efficiency. Thus, the location of the decoupling point by the LF in the current lean SC strategy makes it difficult for the suppliers to change their production method.

Moreover, none of the suppliers hold inventory of the components, as these are bought and located at the LF's facilities, in addition to being implicitly located in the DCs with an FP. As the production of the FP will be halted by missing a component and that the components are inexpensive, the LF emphasizes to keep large safety stocks of these components. Thus, the components are kept in inventory for a long time resulting in low efficiency in the location of inventory. Moreover, the transport protector is large and will consume some warehouse

space. On the other hand, the location of inventory will make the components available when needed for the production of the FP. Thus, as they have a low possibility of becoming obsolete, this increases the effectiveness of the LF. Further, the location of inventory in the SC increases the amount of transportation from the suppliers. As both components are globally sourced from China, all components must be transported the long distance from China to the factory in Scandinavia. However, this transport is optimized in terms of capacity utilization and costs, making the efficiency high. In addition, the suppliers' MTO production method ensures that they always deliver what the LF orders.

Another consequence of the decoupling point being placed far downstream is that the LF must forecast all orders to the suppliers, which can result in a bullwhip effect through the SC. A bullwhip effect will result in low effectiveness of each firm as components will be overproduced by upstream suppliers. These overproduced products will increase the inventory for the LF at both locations of inventory for the components. For the suppliers, a bullwhip effect could make them order excess raw materials for the components, decreasing their efficiency as these must be kept in inventory by the supplier. However, the current MTO production method by the suppliers will greatly reduce the risk of a bullwhip effect as they only produce what the LF orders.

As every SC aspect, see table 3, is considered to have low effectiveness in operations for the LF, except for the product and market characteristics, the LF should change their SC strategy to emphasize more on effectiveness than efficiency. The reason for this is that the product and market characteristics are difficult for the LF to change. Such a change would require the LF the reduce their versions of the FP to only a few, which will be in the opposite direction of what the director of digitalization said that would be necessary in the future. Thus, changing the product characteristics are assessed to be undesirable. Furthermore, changing the demand characteristics is out of the LF's control. Therefore, the LF should change their SC strategy to emphasize effectiveness. This should improve the identified issues in the LF's current SC, such as a complex forecasting process, high safety stock levels, much tied-up capital, and high risk of a bullwhip effect. Further, the next section will present the LF's current relationship with Supplier A and Supplier B. Here, the relationships will be compared based on the business relationship characteristics by Håkansson and Snehota (1995).

6.2 The current relationship among the lead firm and the suppliers

This section will discuss the current customer – supplier relationship the LF has with Supplier A and Supplier B, where an overview of the business relationship characteristics is presented

in table 4. This table is based on the analysis of both relationships in section 5.3. In the table, one can see that even though the relationship with Supplier B has lasted about twice as long as with Supplier A, the adaptation and cooperation with Supplier A is assessed higher. This coincides with that the LF considers Supplier A to be a strategic partner.

Table 4. Overview of business relationship characteristics among the lead firm and the suppliers

Relationship features	Lead firm - Supplier A	Lead firm - Supplier B
Continuity	5-6 years	12 years
Complexity	Low	Low
Symmetry (skewed towards)	Supplier A	Supplier B
Informality	Low	Low
Adaptations	High	Low
Cooperation/Conflict	High/Low	Low/Low
Social interaction	Low	Low
Routinization	Low	Low

The high adaptation and cooperation with Supplier A results in an interdependency in resource ties and activity links in the relationship. This is caused by both actors investing time and resources in developing the necessary technology and knowledge to produce Component A, and that the supplier is a strategic partner with cooperation on projects from time to time. In that way, the interdependency has kept growing larger for both actors, especially in the layers of resource ties and activity links. On the other hand, the interdependency of actor bonds is considered low because of the low social interactions, informality, and complexity.

On the other hand, Supplier B has been assessed to low on adaptations and cooperation, which keeps the interdependency low in activity links and resource ties. Indeed, there will be some interdependency in resource ties caused by the development of the customized component. Thus, there is a barrier to change the supplier. However, there have not been any more significant episodes of cooperation and development of Component B after the beginning of the relationship. Also, the relationship's interdependency of actor bonds is considered low in this relationship as of the low social interactions, informality, cooperation, and complexity.

Furthermore, the symmetry is assessed to be skewed in the suppliers' favor in both customer – supplier relationships, which is assessed due to their allowance to produce with an MTO production method by the LF. This production method combined with global sourcing forces

the LF to hold many components in inventory at their facility in Scandinavia, which results in low efficiency.

By assessing the characteristics of the relationships, it appears that relationship among Supplier A and the LF has higher interdependency than the relationship among Supplier B and the LF. This results in that the possibility for the LF to make Supplier A change their SC strategy is higher than making Supplier B change their SC strategy, as the relationship with Supplier B is more independent.

Furthermore, due to the high interdependency with Supplier A in their activity links and resource ties, it is difficult for the LF to change this supplier. However, changing Supplier B could be an option due to the lower degree of interdependency. By changing this supplier, the LF could change to a more local supplier in which the new supplier could transport more frequently. The result of this is that inventory levels can be reduced to improve efficiency, and the LF would increase their possibility to produce with a production method with higher effectiveness.

The relationships among the suppliers have been compared and discussed in this section. This discussion will be used later when assessing the choice of SC strategy for the LF. Moreover, the next section will present the four generic SC strategies by Christopher (2016), and briefly assess how applicable they are for the LF.

6.3 Supply chain strategy

This section will use the suggestions from the literature to briefly assess which SC strategy the LF could choose. Thus, from the literature Christopher (2016) applies the four generic SC strategies of *kanban, lean, agile*, and *hybrid*, which is also aligned with what Naylor et al. (1999) suggest. These SC strategies are dependent on the product and market characteristics, which will further be briefly assessed in relation to the LF in this section.

One option for the LF is to develop their current *lean SC strategy* to have higher effectiveness by postponing the logistics, as proposed by Pagh and Cooper (1998). This would mean a change from a decentralized to a centralized location of inventory. Also, as the LF has stable supply from the suppliers and there is a high product mix, following Schmitt et al.'s (2015) suggestion to combine decentralized inventory with an MTS or STS production method would not be feasible for the LF. Moreover, according to Christopher (2016) and Naylor et al. (1999), when looking at the *product characteristics* of the FP, the *agile SC strategy* is another SC strategy that can be utilized. According to the authors, this SC strategy is feasible with high

product variety and low product mix. Furthermore, this SC strategy is highly concerned with SC members' effectiveness by only producing products based on actual demand from customers by manufacturing with an MTO production method.

When the *market characteristics* for each product version have unpredictable demand and the supply chain lead times are long, Christopher (2016) suggest to use a *hybrid SC strategy*. This aligns with Naylor et al.'s (1999) leagility SC strategy, which is a combination (hybrid) between a lean and agile strategy. This is a strategy that is used to cope with the long supply lead times of an MTO production method (agile SC strategy) and the high inventory levels of an MTS/STS production method (lean SC strategy) by using an ATO production method.

Moreover, the *kanban SC strategy* described by Christopher (2016) is evaluated as unfeasible for the LF. This evaluation is based on that for the FP, the supply market characteristics are long, and the demand for the individual versions are unpredictable, which is the opposite of what is required for this SC strategy. Furthermore, a kanban SC strategy is used for inexpensive products whereas the FP is an expensive product.

In this section, the lean, agile, and hybrid strategy has been assessed as options in the choice of SC strategy by the LF. Further, these strategies will be discussed related to the LF, where a combination of the lean and hybrid strategy, a dual SC strategy will also be presented.

6.4 Alternative supply chain strategies for the lead firm

This section will discuss alternative SC strategies in terms of how applicable they are for the LF, and how they would impact the LF and the suppliers. As identified in section 6.1, the LF's current SC strategy is highly emphasizing efficiency instead of effectiveness, which does not align with what the literature suggests. Thus, in this section, four alternative SC strategies will be described, based on the literature in chapter 2 and the analysis in chapter 5, with the proposed SC strategies' applicability, and impacts on the LF and the suppliers. These four strategies are the lean, hybrid, agile, and dual SC strategy.

6.4.1 Lean supply chain strategy

This section will discuss the lean SC strategy with its applicability and impacts on the LF and the suppliers.

Applicability

Today, the LF uses a lean SC strategy which, according to Christopher (2016), suits predictable demand and long supply lead times. Thus, this SC strategy fits well with the global

demand of the FP and the global sourcing of suppliers. In this lean SC strategy, Naylor et al. (1999) state that the main production methods used are MTS and STS, where the latter is how the LF currently manufactures. These production methods will also enable the LF to keep their promise of delivering with short lead times to the customers. However, in this suggested lean SC strategy, the LF should change to an MTS production method, as this will give additional benefits, especially in the amount of tied-up capital due to the high safety stock levels of the FP. The difference between an MTS and an STS production method is that an MTS production method does not forecast for where the customers are located, and thus ships from a centralized inventory only when there is actual demand. On the other hand, an STS production method ships the products to locations before they have any actual demand there. Still, both production methods rely on forecasting in production.

Moreover, according to Naylor et al. (1999) and Bozarth and Chapman (1996), an MTS production method require standard products and a steady demand to enable accurate forecasts. However, the FPs are produced with high variability and low volume, resulting in unpredictable demand of the individual versions. Thus, this does not suggest a lean SC strategy with an MTS production method. Still, when looking at the global demand for the FPs, it is predictable. Based on this, and that the components can be used in all of the versions, the LF requires low flexibility in the deliveries of the components from the suppliers which does suit the lean SC strategy and the MTS production method. In addition, the components tie-up little capital in inventory at the factory due to their low price.

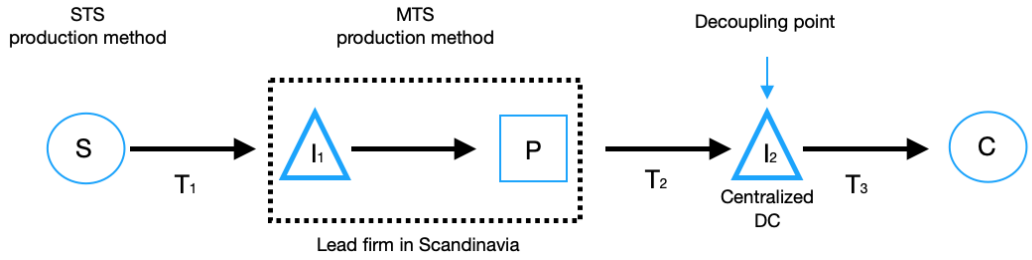

Figure 7. The supply chain of the finished product with a lean supply chain strategy

Figure 7 shows the proposed lean SC strategy for the LF, with the suppliers' STS production method and the LF's MTS production method. Further, the main difference with the proposed lean SC strategy compared to the LF's current lean SC strategy is that the location of inventory is centralized as shown by centralized DC at I_2. How this SC strategy impacts the LF and the suppliers will further be examined, respectively.

Impacts on the lead firm

An impact of the MTS production method with a lean SC strategy is that the decoupling point will be located downstream from the LF's production as it is currently in their SC setup. This is aligned with van Donk's (2001) possible decoupling point of the stock of finished products. However, the difference with an MTS production method is that instead of being placed at the 12 globally spread DCs, it will only be placed at one centralized location of inventory. This makes the LF's forecasting process less complex as they now only have to forecast for the 18 versions to one centralized location of inventory. Thus, this results in a reduction of forecasts to 18 compared to the 216 forecasts with the decentralized inventory. This increases the LF's operational effectiveness as it can reduce the amount of DCs by using a centralized location for inventory (Schmitt et al., 2015).

Another impact of the centralization for the location of inventory with an MTS production method is what can be achieved through Pagh and Cooper's (1998) logistics postponement strategy. With this strategy, the LF's transport effectiveness will increase as the distribution (logistics) to the final customer will be postponed until an order is placed. Thus, the product will not have to be transported unnecessary distances. Further, this postponement of logistics will reduce the LF's inventory levels as every decentralized location will not require safety stock for each version. Still, as Naylor et al. (1999) states, the impact of the LF's current STS production method and location of inventory, is that the delivery lead time will be short. Indeed, a disadvantage with the MTS production method is to keep the promise of delivering with short lead times as, according to Schmitt et al. (2015), a centralized inventory will increase delivery lead time due to the increased distances to customers.

One alternative to cope with this disadvantage is, as proposed by Christopher (2016), to use express deliveries from the centralized location of inventory. However, such express deliveries may increase the transport costs due to more frequent and smaller shipment sizes (Skjott-Larsen & Schary, 1996). Another alternative to cope with the longer delivery lead times and some of the high cost of express deliveries is by keeping a few centralized inventories strategically located close to customers. E.g. this could be using one DC located in the US, Europe, and Asia. This way, the LF can optimize its transport efficiency to the DCs through sea shipments, which will be at least as efficient as it is today. Further, express deliveries from these DCs to customers can be used. This will enable the LF to keep the delivery lead time short, and it will be less expensive than transporting all the FPs the long distance from one centralized location. Furthermore, this would allow the LF to reduce its forecasting to 3 DCs and 18 versions, which results in 54 forecasts (compared to the current 216). In addition, it will significantly reduce the necessary total safety stock levels by combining the

safety stock levels.

A further alternative is to use a 'virtual' or 'electronic' inventory, as suggested by Christopher (2016), which combines centralized and decentralized inventory. With this alternative, the FPs are still physically located decentralized at the DCs, but the inventory will be managed from a central location. This would mean that the LF still can provide short delivery lead times to its customers. However, the large benefit is that each DC does not have to keep its own safety stock, as the FPs will be distributed in-between the DCs to meet customers' demand. Thus, this will result in a major reduction in inventory levels.

Impacts on Supplier A and Supplier B

The MTS production method of the LF, with the decoupling point located at a centralized DC, makes it significantly easier to forecast the production of the FPs. More accurate forecasts will increase the LF's effectiveness which reduces the waste of inventory and overproduction. Thus, this impacts Supplier A and Supplier B, since the demand will now become more predictable and, as argued by Christopher (2016) and Naylor et al. (1999), this should be utilized to make upstream operations as efficient as possible.

Today, both suppliers produce MTO, which is emphasizing to produce with high effectiveness. Due to a predictable demand, a great focus on effectiveness in production is unnecessary as it results in lower efficiency in operations (Christopher, 2016; Naylor et al., 1999). Moreover, their current MTO production method with high effectiveness is something the LF does not appreciate, as it increases the supply lead times from the suppliers. Thus, due to the low price of the components, sacrificing some of the effectiveness by storing the components will reduce these supply lead times. However, as the symmetry is skewed towards the suppliers in the relationship, it appears more possible for the LF to influence Supplier A to make this sacrifice as they have higher interdependency in the relationship, than Supplier B and the LF have. Nevertheless, the suppliers might in return be able to operate with higher efficiency as they can plan and optimize their operations better.

If the suppliers would try to achieve this improvement in efficiency, the literature suggests that they should use a lean SC strategy, since they are located upstream from the decoupling point, with an MTS or STS production method (Christopher, 2016; Naylor et al., 1999). The literature argues that this is feasible due to high predictability in demand, which should preserve high effectiveness in production (Yang & Burns, 2003). Further, the differences with these production methods are that with an MTS production method, the location of inventory will be located at the suppliers' facilities in China, and the LF's facility in Scandinavia. Thus,

there will be two locations of inventory of the same component in which will require higher total safety stocks. Moreover, with an STS production method the suppliers can produce with high efficiency in their operations, have high availability, and supply the LF with a very short lead time of the components. When looking at the relationships, as the interdependency in the relationship with Supplier A is assessed as high, this change in production method appears to be more possible for the LF to influence on Supplier A than for Supplier B in which has low interdependency in the relationship with the LF.

For the suppliers, the benefit of an MTS production method is that they will not be forced to forecast the location of the customer. However, since the components are customized to the FPs, there is in fact only one possible customer. Hence, it is better to utilize an STS production method as this is regarded as a more efficient production method, and that it will not involve any more uncertainty of forecasting. Moreover, generally, the supplier will still be the owner of the components until the LF demands them, even though they are located at the LF's facilities. Furthermore, with an STS production method, both suppliers can optimize their operations' efficiency, as the components they supply will be stocked at the factory.

Indeed, to keep customized products in stock for the suppliers will decrease their effectiveness as this generally increases their risk of obsolete products, as these components cannot be sold to anyone else. However, the demand is stable and predictable, and the components are not at risk of becoming obsolete. Thus, this could provide the suppliers with a benefit as they can deliver with shorter supply lead times.

In literature such as Eltantawy et al. (2015), Kumar (2004), Machado Guimarães et al. (2013) and So and Sun (2010), information sharing with suppliers is a widely applied measure to mitigate the risk of overproduction to improve effectiveness, and lower inventory levels to improve efficiency. As these are inexpensive components, the LF can implement an approach in which there are predetermined stocking levels of the components. Thus, when the stock levels drop below a threshold, the LF will send out a new purchasing order to replenish the components. Also, by giving the suppliers access to real-time stock levels, they can easily predict when the next order will come. Moreover, the LF could outsource the whole purchasing process by giving the suppliers the responsibility to replenish the components when needed, such as with vendor managed inventory (VMI) (Machado Guimarães et al., 2013; Waller, Johnson, & Davis, 1999). This will enable the suppliers to optimize their operations and the LF to remove an unnecessary process of purchasing resulting in higher efficiency in operations.

Another impact on the suppliers with the LF's change to an MTS production method is the risk of a bullwhip effect through the SC. This has a larger impact on Supplier A and Supplier B than the LF, as the effect could be caused by the LF's current complex forecasting process, which leads to amplified orders upstream in the SC. These amplified orders can lead to high inventory levels and overproduction for both the suppliers. However, as mentioned, using the lean SC strategy with an MTS production method makes the LF's forecasting process less complex, and thus more accurate (Croson & Donohue, 2006; Eltantawy et al., 2015). According to Lee et al. (1997b), improving forecasts should increase the LF's effectiveness and reduce the risk of a bullwhip effect through the SC, reducing the impact on the suppliers. However, as the decoupling point is located after the LF's production, their operations will still be based on forecasts. Thus, the risk of a bullwhip effect through the SC is assessed to be medium.

The lean SC strategy has now been discussed for the LF in terms of applicability and impact on the LF and the suppliers. Further, a hybrid SC strategy for the LF will be discussed.

6.4.2 Hybrid supply chain strategy

This section will discuss the hybrid SC strategy with its applicability and impacts on the LF and the suppliers.

Applicability

The LF can use the hybrid SC strategy, proposed by Christopher (2016) and Naylor et al. (1999), by postponing the assembly of the FP with an ATO production method as illustrated in figure 8. This strategy is also suggested in Pagh and Cooper (1998) as a 'manufacturing postponement strategy'. The hybrid SC strategy is used to cope with the large inventories of an MTS or STS production method and the long delivery lead times of an MTO production method, by using an ATO production method (Feitzinger & Lee, 1997). As the LF has a production lead time of 10-16 hours for the FPs, a one-piece flow production, and steady demand from end-customers, the LF is highly capable of manufacturing with an ATO production method. This production method will give the LF the ability to postpone the customization of the FP.

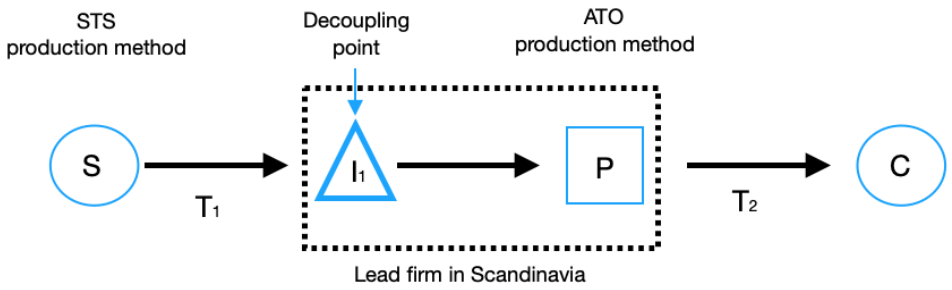

Figure 8. The supply chain of the finished product with a hybrid supply chain strategy

Figure 8 shows the proposed hybrid SC strategy in which has no DCs, an ATO production method by the LF, the decoupling point located before the LF's production, and the suppliers with an STS production method. How this change impacts the lead firm and the suppliers will further be examined, respectively.

Impacts on the lead firm

To achieve the hybrid SC strategy, the decoupling point must be moved upstream from the lead firm's DCs to their manufacturing site in Scandinavia, as is shown in figure 8. This is aligned with van Donk's (2001) possible decoupling point of the stock of semi-finished products.

Thus, the LF will not produce (assemble) any FPs without receiving an actual order from customers. According to Harris et al. (2011) and Nicholas (2011), moving the decoupling point upstream should increase the LF's flexibility, and eliminate the inventory of FPs. The reason for this is that the LF will produce the FPs with high effectiveness by assembling to order. However, to produce the FPs with high effectiveness, the LF needs to increase its inventory of the components before its production. The reason for this is to have all components available to produce and customize the FP according to customers' orders. Furthermore, the only risk for obsolete products is the components that are kept before the LF's production, as the LF will still have to forecast the number of components they will need from upstream suppliers.

By doing this, the customers would no longer be constrained to ordering the 18 versions that the LF offers, as the LF can now offer customers the opportunity to customize the exact functionalities and looks they want of the FP. The director of digitalization stated that he strongly believes that such customization is something that the LF would have to offer in the future to stay competitive. Hence, changing the SC strategy to a hybrid SC strategy with an ATO production method may give the LF a major competitive advantage, as it is capable

of offering the customers the opportunity to customize. Furthermore, it would be easy for the LF to keep adding new looks and functionalities, as their only risk is increased inventory levels of the new components in which may be of minor value. With this SC strategy, it will also be easier to remove functionalities and looks in which there is no or low demand for, to reduce the waste of inventory.

As the FP already will have a customer ready when the product is produced, the need for the DCs as the location of inventory will be eliminated. This is illustrated in figure 8. As a result of this, there will be no tied-up capital in these locations, and transportation can optimize its effectiveness by transporting directly to end-customers. High effectiveness in transportation will greatly reduce the LF's tied-up capital through transit inventory, as emphasized by Baumol and Vinod (1970) and Seth and Gupta (2005). On the other hand, shipping directly to end-customers may reduce transportation efficiency as it may be more difficult to have as high utilization as before. However, it is still possible to achieve high efficiency by using some DCs as hubs.

Nevertheless, the LF does promise their customers a short delivery lead time. This can be solved by more expensive air shipments. However, as the customers mainly are large institutions, they may accept longer delivery lead times. If not, the LF could shift the decision to the customer by making them choose an expensive, quick delivery, or an inexpensive, much slower delivery.

Moreover, another alternative with the hybrid SC strategy is to postpone the differentiation of the FPs to the DC(s). As mentioned, the LF offers the opportunity to differentiate the FPs into three different colors. Thus, by postponing this differentiation, the number of versions that the LF has to forecast for can be reduced from 18 to 6. This strategy can then be used with the same amount of decentralized DCs as they have now, or with less DCs to lower the need for forecasting even further. However, we have no information about how difficult and expensive this will be to implement in terms of production. Thus, this alternative will not be further assessed.

Impacts on Supplier A and Supplier B

The impact on Supplier A and Supplier B, if the LF changes to a hybrid SC strategy with an ATO production method, will be quite similar to the impacts from the lean SC strategy. In the hybrid SC strategy, the decoupling point is located at the factory in Scandinavia. Thus, the LF must be more agile to meet demand as they cannot rely on the safety stock levels of the FP in the DCs (Yang & Burns, 2003). Moreover, a prerequisite for the LF to use an

ATO production method is that the LF has a high availability of the components. For this to work, without keeping unnecessary high inventory levels, the supply lead times should be short, where currently the long transport distance from China to the LF in Scandinavia creates long supply lead times. This impacts the suppliers, as high efficiency is required in their operations and the location of inventory must be at the LF's factory to always ensure that the LF has the necessary cables and transport protectors available for the production. This could increase the waste of inventory. However, as for the lean SC strategy, the waste of overproduction should decrease.

To achieve this, as with the lean SC strategy, Supplier A and Supplier B should produce with an STS production method. This production method will enable the suppliers to provide high availability of components with low inventory waste as their operations' will have high efficiency. This combined with the location of inventory being located in Scandinavia leads to very short supply lead times, as the suppliers will keep the inventory of the components close to the LF. Thus, the suppliers will be responsible for that the components are available for the LF. Furthermore, due to the low price of the components, and that they can be used in all versions, the risk for obsolescence is low and the inventory at the factory will tie-up little capital for the suppliers. Thus, applying an STS production method for Supplier A and Supplier B should enhance their efficiency without major consequences on their effectiveness, and strengthen their relationship with the LF as they can deliver with short supply lead time.

Furthermore, as with the lean SC strategy, the hybrid SC strategy enhances even more to implement information sharing through visibility of actual demand and real-time production schedules. Thus, the demand for the FPs could be visible for Supplier A and Supplier B, enabling them to avoid the waste of inventory and overproduction. The reason for this is that the suppliers can produce and store components based on the demand for the FPs.

The risk for a bullwhip effect through the SC will be low in the hybrid SC strategy, as the LF assembles the FPs towards actual demand. Thus, as the components can be used for all of the versions, the risk for overproduction and obsolete components will be low. Further, if the LF shares the information about actual demand with the suppliers, they can replenish their inventory at the factory with the amount that the LF needs to produce the orders of the FPs. This would further decrease the risk of the bullwhip effect. However, if the market demand changes very unexpectedly, the information about the change could become delayed to the suppliers leading them to overproduce components. Still, if the LF implement information sharing to give the suppliers visibility of actual demand, this risk for delayed information

would reduce. Thus, this would further decrease the risk of a bullwhip effect.

6.4.3 Agile supply chain strategy

This section will discuss the agile SC strategy with its applicability and impacts on the LF and the suppliers.

Applicability

The agile SC strategy illustrated in figure 9 is, according to Christopher (2016) and Naylor et al. (1999), feasible with the product characteristics of the FP's high product variety and low product mix. Also, an agile SC strategy is a well-suited SC strategy for the FP when considering the unpredictable demand for the individual versions. Naylor et al. (1999) state that in an agile SC strategy, all products will be produced based on actual demand, which is achieved with an MTO production method. Thus, the LF does not have to rely on forecasts in its production of the FPs. As with the hybrid SC strategy, this SC strategy is suitable for the LF's one-piece flow production and production lead time of 10-16 hours.

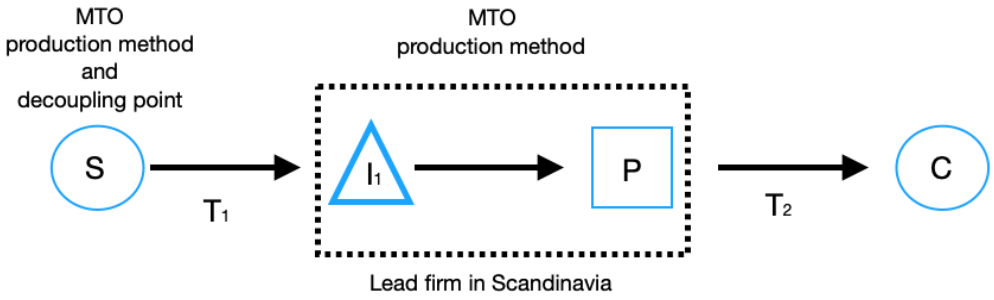

Figure 9. The supply chain of the finished product with an agile supply chain strategy

As figure 9 shows, this SC strategy eliminates all DCs, and the LF and the suppliers use an MTO production method. The decoupling point in this strategy is located at the suppliers' facilities. How this change in SC strategy impacts the lead firm and the suppliers will further be examined, respectively.

Impacts on the lead firm

By manufacturing with an MTO production method, the LF will not keep any FPs or components in inventory, as the LF will order exactly what components they need to produce the version ordered by the customer. A major benefit of this is that the LF can offer the customer the exact customization of functionalities and looks that they desire in the FP without any risk of keeping inventory.

In an agile SC strategy with an MTO production method, the decoupling point will be located at the suppliers' production upstream in the SC, as shown in figure 9, and thus the operations will mainly be driven based on actual demand (Christopher, 2016). This is aligned with van Donk's (2001) possible decoupling point of the stock of raw materials. Both the LF and the suppliers' production will then be entirely based on actual customer's orders, and thus have very high effectiveness. Further, as the LF will not hold any inventory of the FP, the need for DCs will be eliminated. Thus, it will have the same benefits as with the hybrid SC strategy.

Another impact of the LF producing and ordering toward actual demand is that the risk for a bullwhip effect occurring through the SC should be eliminated for the LF and the tier 1 suppliers. This will greatly reduce overproduction, which will further increase the effectiveness (Lee et al., 1997b). However, further upstream of the tier 1 suppliers in the SC, a bullwhip effect could still occur. Still, as this is not part of the thesis, this will not be assessed.

Moreover, the consequence of this strategy is that it will result in longer delivery lead times for the customer, especially if the components are still sourced globally. This is because the production of the FPs must wait for the required components to be produced and shipped by the suppliers before the LF can produce and ship the FP to the customer. In addition, the market characteristics of an agile SC strategy require short supply lead times (Christopher, 2016; Naylor et al., 1999). To cope with this, and reduce the delivery lead time, the LF might have to change from global to local sourcing. This will reduce the transport distance and, according to Moradlou and Tate (2018), it will generally lead to higher flexibility, thus enhance an MTO production method with high effectiveness, and shorter supply lead time. Another option to reduce the delivery lead time to the customer and the supply lead time is, according to Holweg et al. (2011), to have more frequent transportation in the SC with JIT deliveries with high effectiveness. According to Holweg et al. (2011), this would reduce inventory levels both for the LF and the suppliers further increasing their effectiveness.

Impacts on Supplier A and Supplier B

In the LF's agile SC strategy with an MTO production method, the suppliers are impacted as their focus should be on producing with high effectiveness. A result of this is that the decoupling is located at the suppliers' production. Thus, Supplier A and Supplier B should produce with an ATO or MTO production method, wherein the ATO production they would only hold the necessary raw materials needed to produce the components. Indeed, the suppliers are currently producing MTO, where they hold no inventory in the same manner as

the LF will do in this agile SC strategy. However, there is a major difference when the LF (downstream supplier) is producing MTO, because now the LF will not have the necessary inventory to keep their production going without a frequent supply of components. Thus, Supplier A and Supplier B would have to deliver with short supply lead times. The suppliers can also change to producing with an ATO production method, as this will reduce the production lead time of the components. Thus, Supplier A and Supplier B will keep raw materials for the components in inventory, rather than ordering them from their suppliers, according to the demand from the LF. Further, this could help reduce the supply lead time, however, the long transport distance will still have a great impact on the supply lead time.

Furthermore, as the tier 2 suppliers of the LF is not a part of the scope of the research, information on the supply lead time for the raw materials that the suppliers' order to the components is unknown. Based on this, the suppliers could use both MTO or ATO as their production methods.

To enable the LF to produce with an MTO production method with short delivery lead times, the literature suggests implementing JIT practices (Holweg et al., 2011). However, as the LF is using global sourcing such practices is difficult due to the long transportation distances. Thus, the suppliers would have to do major improvements in their supply lead times, where they must shorten the time of production and transportation. Such a change appears more possible for the LF to influence on Supplier A, based on the interdependency with the LF in resource ties and activity links. On the other hand, this may appear difficult for Supplier B, as the relationship between Supplier B and the LF has less interdependency, especially in the resource ties and activity links. Nevertheless, if the suppliers do not carry out this change, the LF might be forced to change suppliers, preferably to someone more locally which can deliver with higher frequency. As of the high interdependency with Supplier A such a change appears to be difficult and expensive, while it appears more realizable with Supplier B. However, there is a barrier to change supplier, as the components are customized, and thus the LF would have to do development projects with a new supplier if they change supplier.

Furthermore, in the agile SC strategy, as the decoupling point is located at the suppliers, the waste of overproduction could be eliminated as all production by the LF, Supplier A, and Supplier B is based on actual demand. Thus, all components produced by the suppliers will be directly used in the production of the FPs. This makes the risk for the bullwhip effect to be considered as very low.

6.4.4 Dual supply chain strategy

This section will discuss the dual SC strategy with its applicability and impacts on the LF and the suppliers.

Applicability

The dual SC strategy can be used to suit the different product and market characteristics for the individual versions. Based on these, there can be constructed two groups of the versions; high and low-runners. 3 of the 18 versions are considered high-runners with predictable demand and relatively high volume (80% of the total demand). While the remaining 15 versions are considered low-runners, which have unpredictable demand and low volume.

Based on these groups, the three high-runners could continue to be produced using a lean SC strategy with an STS production method through forecasting (as the LF currently produces these versions), or an MTS production method as described with the lean SC strategy in section 6.4.1 and illustrated in figure 10.

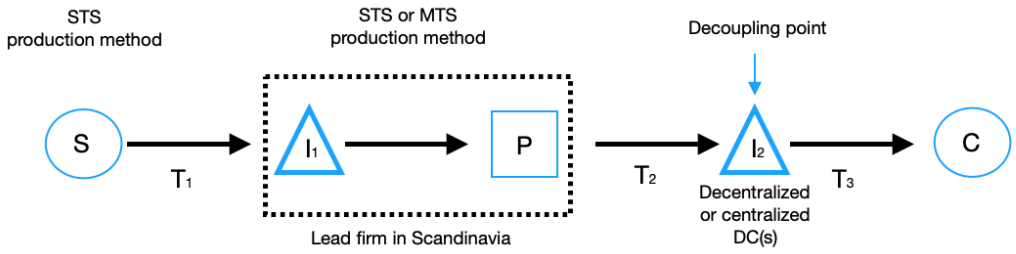

Figure 10. The supply chain for the high-runners with a lean supply chain strategy

While, on the other hand, the 15 low-runners could be produced using a hybrid SC strategy with an ATO production method, as illustrated in figure 11, which does not require any forecasting of what versions they expect to sell. Furthermore, the ATO production method will allow the LF to deliver customized versions of the FP to customers. This SC strategy is aligned with what was described in section 6.4.2 with the hybrid SC strategy. Further, how this dual SC strategy impacts the LF and the suppliers will be examined, respectively.

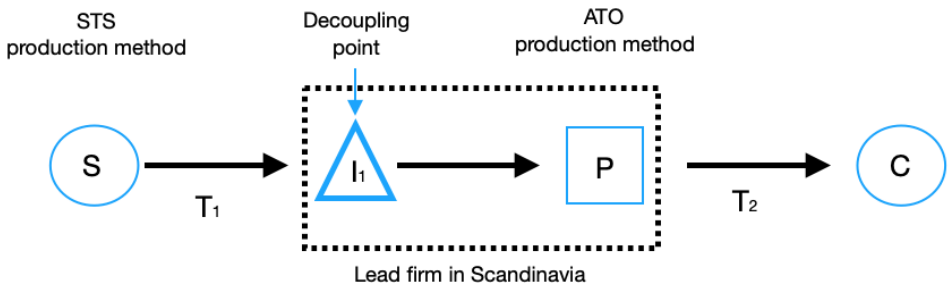

Figure 11. The supply chain for the low-runners with a hybrid supply chain strategy

Impacts on the lead firm

For the high-runners, this would leave the decoupling point at a decentralized (STS production method) or centralized (MTS production method) location of inventory. Thus, with the STS production method, the LF can keep the downstream operations as it is today for the high-runners. This will still result in very short delivery lead times to customers, but it will have a higher waste of inventory than with an MTS production method. The MTS production method uses a centralized location of inventory in which lowers the waste of inventory. However, the delivery lead times to customers will be longer compared to the STS production method.

Moreover, changing to the hybrid SC strategy for the low-runners will impact the placement of the decoupling point as it will be moved to the LF's production from the DCs.

By using this combination of SC strategies, the LF can drastically reduce its uncertainty of forecasts, as there will only be necessary to forecast for the three high-runners since the low-runners are produced towards actual demand with the ATO production method. Thus, the number of forecasts will be reduced from 216 to 3 forecasts, as the location of inventory is centralized. Also, since the high-runners have a stable and predictable demand are these the easiest of the 18 versions to forecast. Improved forecasts will have major impacts on their effectiveness in production by preventing overproduction and keep high efficiency through significantly less FPs located in decentralized inventories in all of the DCs.

As for the effectiveness of transportation, it will be as it is now for the high-runners if the STS production method is applied, while it will be considerably improved with an MTS production method. For the low-runners, on the other hand, the transportation effectiveness will significantly improve, as they can be transported directly from the factory to the end-customers, as illustrated in figure 11. However, the efficiency may be reduced, because it may be more difficult to optimize transportation utilization, and more air shipments might

be necessary.

Regarding the risk for a bullwhip effect, for the low-runners, this will be low as previously mentioned in the hybrid SC strategy. Also, as the high-runners have a predictable demand and the amount of forecasts is reduced, the forecasting for the high-runners should have higher accuracy compared to the forecasts in the lean SC strategy. Thus, the risk for bullwhip effect is also assessed to low for the high-runners.

Impacts on Supplier A and Supplier B

As suggested for the lean and hybrid SC strategy in section 6.4.1 and 6.4.2, the suppliers in this SC strategy should use a lean SC strategy with an STS production method to operate as efficiently as possible. This production method will give a high availability of components at the LF's facility, which is especially important with the low-runners that are produced with an ATO production method. As the high-runners will be produced with a lean SC strategy, they will also need components in stock at the LF's facility to produce the forecasted demand. Thus, the suppliers can use the same SC strategy for the components, as the components can be used in both the high- and low-runners. Thus, the suppliers will not have to use a dual SC strategy for the high- and low-runners as the LF does. As mentioned earlier, based on the relationships with the suppliers, it appears more possible for the LF to make Supplier A change to a lean SC strategy with an STS production method than Supplier B, as of higher interdependency with Supplier A than with Supplier B.

This section has presented the four suggested SC strategies that the LF can choose and how they impact the LF and the suppliers. Further, the next section will give an overview of the impacts from the SC aspects on the four strategies and the current SC strategy by the LF. This section will also look at the SC aspects separately in regard to how they impact the choice of SC strategy.

6.5 Supply chain aspects impact on the choice of supply chain strategy of the lead firm

This section will assess the impacts of the SC aspects in the choice of SC strategy. These impacts will be assessed in regards to the current SC strategy and the four suggested strategies, where table 5, which is based on the discussion in section 6.4 of the four presented SC strategies, shows the major similarities and differences between them. Further, this table will be used to discuss how the different SC aspects, which are *product and market characteristics*, *decoupling point*, *location of inventory*, *transportation*, and *bullwhip effect*, can impact the

choice of SC strategy of the LF, which follows the research question:

"How can aspects of supply chains impact the choice of supply chain strategy of a lead firm?"

Table 5. Overview of impacts on the supply chain strategies

	Current	**Lean**	**Hybrid**	**Agile**	**Dual***
Production method	STS	MTS	ATO	MTO	MTS or STS/ ATO
Suppliers' production method	MTO	STS	STS	MTO or ATO	STS/STS
Supply lead time	Long	Very short	Very short	Short**	Very short
Delivery lead time	Very short	Short	Medium	Long	Short/Medium
Decoupling point	Decentralized DCs	Centralized DC	Before the LF's production	Suppliers' production	Centralized DC/Before the LF's production
Location of inventory (FP)	Decentralized DCs	Centralized DC	None	None	Centralized DC/ None
Location of inventory (components)	LF Scandinavia	LF Scandinavia	LF Scandinavia	Suppliers	LF Scandinavia
Transport efficiency to customers	High	High	Medium	Medium	High/Medium
Transport effectiveness to customers	Low	Medium	High	High	Medium/High
Risk for bullwhip effect	High	Medium	Low	Very low	Low/Low
Customization of FP	No	No	Yes	Yes	Yes

* High-runners/Low-runners.
** This strategy will require short lead times.

6.5.1 Product and market characteristics

If one solely looks at the product characteristics for the FP, an agile SC strategy is the best fit. Still, this strategy will have longer delivery lead times to customers, whereas the LF is currently promising short delivery lead times. Moreover, the product characteristics make a lean SC strategy appear less feasible than the other strategies due to the SC strategy's necessity of forecasting, in addition to that the FPs are expensive products.

On the other hand, the market characteristics for the FP suggest that the LF should use a hybrid SC strategy, as this strategy can cope with long supply lead times and unpredictable demand, and eliminates all inventory and overproduction of the FP. While an agile SC strategy also will eliminate inventory and overproduction of the FP, this strategy will have

difficulties to cope with the current long supply lead times caused by global sourcing and customized components. Furthermore, the dual SC strategy can be tailored to market and product characteristics with its grouping of high- and low-runners, which makes it a highly feasible SC strategy for the LF considering the product and market characteristics.

6.5.2 Decoupling point

To cope with overproduction and high inventory levels, the position of the decoupling point is a valuable aspect to assess. By positioning it upstream at the suppliers (as with the agile SC strategy) instead of downstream in a centralized DCs (as with the lean SC strategy), the risk of overproduction will be lowered significantly as no products will be produced without any demand. Also, by locating it that far upstream in the SC, there will be no FPs or components in stock for the LF. Thus, locating it at the supplier with the agile SC strategy will eliminate the need for forecasting for the FPs and any components that they will need. Moreover, the hybrid and dual SC strategy will be something in-between these two. Furthermore, locating the decoupling point far upstream would increase the delivery lead time to the customers as there are no FPs in inventory ready to be shipped. Thus, the trade-off is between short delivery lead time, high inventory levels, and high risk for overproduction or longer delivery lead time, low inventory levels, and low risk for overproduction.

6.5.3 Location of inventory

To cope with the waste of inventory and overproduction, the SC aspect of the location of inventory can be examined as it can impact the choice of SC strategies. The reason is that this aspect determines where the FPs and components are kept in inventory. Thus, the trade-off in the SC strategies related to this aspect is high inventory levels and shorter delivery lead time (decentralized inventory), or low inventory levels and longer delivery lead time (centralized inventory).

Further, the only SC strategy which uses centralized inventory for the FPs is the lean SC strategy. This makes the production of the FP based on forecasting which can lead to increased waste of inventory and overproduction. Keeping an inventory of the FPs enables the LF to deliver with short lead time to the customers, however, customers will be unable to customize their own FP, which is considered to be a great competitive advantage by the LF's director of digitalization.

On the other hand, having no inventory of the FPs, as with the hybrid and agile SC strategy, will greatly decrease inventory levels and the risk for overproduction as the FP will be pro-

duced based on actual demand. Furthermore, this will enable the LF to offer customers the opportunity to customize the FPs to fit their specific needs and preferences. However, with these strategies, the LF must keep more components in inventory before their production, as they will need a high availability of the components. Still, these are inexpensive components and will therefore tie-up little capital compared to the stored FPs with the lean SC strategy. Furthermore, as the agile and hybrid SC strategy does not keep an inventory of the FPs, the delivery lead time will become higher than with the lean SC strategy.

Moreover, with the agile SC strategy, the LF should aim to have no inventory and order everything based on actual demand. This makes the location of inventory of the components located at the LF's suppliers, which eliminate the risk for overproduction for the LF and the LF's suppliers (if they also produce MTO or ATO). However, keeping no inventory would require the customers to accept longer delivery lead times for the FP. The hybrid SC strategy is similar to the agile SC strategy, but here the LF will keep the components in their own inventory. As the components tie-up little capital, this strategy enables the LF to reduce their delivery lead time (compared to the agile SC strategy) while keeping the waste of inventory low. Furthermore, the dual SC strategy enables the LF to deliver the high-runners of the FP with short lead time, and still offer customers the opportunity to customize their own FPs.

6.5.4 Transportation

All the suggested strategies do increase the LF's effectiveness in transportation by reducing or eliminating all the locations of inventory of the DCs. In the agile SC strategy, the effectiveness of transportation is very high, both for the components and the FPs, but only with a medium efficiency. This is because the products can be transported directly to customers from the manufacturing site (high effectiveness), but it might be difficult to maximize transport utilization since the products have to be transported to widely different locations (medium efficiency). On the other hand, the lean SC strategy will have medium effectiveness and high efficiency. Furthermore, reducing the delivery lead time will also reduce the amount of transit inventory, which would further reduce tied-up capital. Transit inventory is a waste of inventory for the LF with their current SC strategy, as the FPs are traveling all around the world, mainly with the slow transporting mode of sea shipments.

6.5.5 Bullwhip effect

With the different SC strategies, the risk for the bullwhip effect will mainly be impacted by how much of the operations in the SC in which are based on forecasting. Thus, the risk for a bullwhip effect will decrease the further upstream the decoupling point is located in the SC,

which is also illustrated in table 5.

The forecasting will have uncertainty and can lead to several of the causes for the bullwhip effect described by Lee et al. (1997b). Thus, the lean SC strategy will have a medium risk for a bullwhip effect as both the production of the FPs and the components are based on forecasts. This forecasting could lead to overproduction of the components from suppliers and the FPs by the LF, which will further increase inventory levels. In the dual strategy, as the LF will only have to forecast for the three high-runners which has a steady demand, the risk for bullwhip effect is assessed as low. For the low-runners, as they will be produced using the hybrid SC strategy, they will also have a low risk of a bullwhip effect. Further, with the hybrid SC strategy, as the FPs are produced based on actual demand, the bullwhip effect could only impact the production of the components by the suppliers. This risk is considered to be low as both of the components can be used in all versions.

Moreover, the agile SC strategy should have a very low risk for a bullwhip effect as no forecasting will be done by the LF or the suppliers. Thus, a bullwhip effect could only happen for the LF's tier 2 suppliers. However, these are not part of the scope in this thesis, but there is possible that a bullwhip effect will occur there. A discussion on the impact of every SC aspect in the choice of SC strategy has been made in this section. Based on this discussion, the next section will present which of the suggested SC strategies is preferred for the LF.

6.6 The choice of a supply chain strategy

This section will discuss which of the suggested SC strategies that are preferred for the LF. As has been evident in this thesis, the SC aspects that have been examined can impact the choice of SC strategy. Solely using the *decoupling point* would suggest the agile SC strategy, but, by including the *product and market characteristics*, this choice appears less feasible due to the long supply lead times from the suppliers in which suggest the lean, hybrid, and dual SC strategy. Moreover, high efficiency in *transportation* is gained with a decentralized *location of inventory*, as with their current SC strategy, but higher effectiveness in transportation is achieved through a centralized location of inventory, which is gained with all of the proposed SC strategies. Moreover, the SC aspect of the *bullwhip effect* will suggest an agile SC strategy to reduce the risk for it to occur.

Looking at the customer – supplier relationships with both suppliers, the *continuity* of the relationship with the suppliers has lasted 5-6 and 12 years for Supplier A and Supplier B, respectively. The *symmetry* in the relationships are skewed towards the suppliers. This was

made evident since the LF allows the suppliers to produce MTO, while the LF must keep high inventory levels. Both relationships have low *complexity, informality, social interactions*, and *routinization*. However, there are some significant differences in the relationships, as the LF has high *adaptations* and *cooperations* with Supplier A, while those are low with Supplier B. Thus, the LF appears to have higher interdependency in the relationship with Supplier A than Supplier B.

As previously discussed, all of the proposed SC strategies should provide major benefits for the LF. Looking at the lean SC strategy, it is very efficient but it is unsuited with the product characteristics of the FP. This strategy forces the LF to keep forecasting the demand, which leads to tied-up capital of FPs, and customers will be incapable of customizing their FPs. From the LF's perspective, this strategy will enhance the suppliers to change to an STS production method. It could be difficult for the LF to make the suppliers change their production method, as the symmetry is skewed towards the suppliers and this would not necessarily provide any large benefits for the suppliers. Nevertheless, as the LF and Supplier A has high interdependency in their resource ties and activity links, might the LF be able to influence this supplier to change their SC strategy. However, it is not a requirement to enable the proposed lean SC strategy that the suppliers change their SC strategy. Moreover, considering the short assembling time of the FPs, keeping a centralized inventory with an MTS production method (lean SC strategy) does not seem to give any major benefits that can compete with the hybrid SC strategy. In addition, the hybrid SC strategy will only require to forecast for components and will allow customers to customize FPs.

The agile SC strategy, on the other hand, will reduce all the necessity of forecasting and tied-up capital for the LF, which should eliminate all inventory waste and the risk for over-production. However, the current long supply lead times do appear to be a major problem with the agile SC strategy, where it might require more local sourcing to enable more frequent and shorter supply time deliveries. Looking at the relationships with the suppliers, such a change of suppliers would be difficult considering the high interdependency with Supplier A and long continuity with Supplier B. However, it appears that the LF has less interdependency with Supplier B than Supplier A. Thus, there might be an option to change Supplier B, but there will still be a barrier to change this supplier as the component is customized to the FP. Thus, a new supplier would have to develop a new component in which will require investment in new interdependencies in resource ties and activity links. Still, only looking at the LF, their one-piece flow production, and low production lead time for the FPs makes this strategy feasible to implement.

Nevertheless, by assessing the impacts of the aspects of SCs, the hybrid and dual SC strategy are both assessed to be very good choices as SC strategy for the LF. These SC strategies can strongly cope with the high inventory levels of the FP, and the necessity of forecasting and the risk of overproduction is greatly reduced. Furthermore, both SC strategies are enabling the capability of customizing the FPs, while still keeping the delivery lead times to medium. Also, the dual SC strategy can deliver the high-runners with a short delivery time.

Moreover, by considering the relationships with the suppliers, the hybrid and dual SC strategy could be implemented while still keeping the relationships as they are. However, all actors will have benefits by the suppliers changing to an STS production method, as the suppliers can produce with high efficiency in their operations and have high availability and very short delivery time of the components. Still, if the suppliers change to an STS production method, they will hold the inventory of the components at the LF's facility which increases their tied-up capital. Moreover, looking at the high interdependency the LF has with Supplier A, it might be possible for the LF to determine such terms. On the other hand, it appears more difficult for the LF to make Supplier B change their production method, due to the low interdependency in activity links and resource ties.

The preferred SC strategy of the LF has now been presented. Further, a summary of the discussion will be given as this chapter contains much information and has answered the research question.

6.7 Summary of the discussion

First, this chapter discussed the impacts on efficiency and effectiveness of each SC aspect concerning the current SC strategies of the LF and the suppliers. Then, the current customer – supplier relationship among the LF and the suppliers were discussed by considering the features of structural and process characteristics.

Further, the discussion suggested four alternative SC strategies for the LF with a preferred SC strategy for the suppliers. These four alternatives are the *lean, hybrid, agile,* and *dual SC strategy*, where their applicability and impact on the LF and the suppliers were discussed. After presenting these strategies, how the different SC aspects can impact the choice of SC strategy was discussed with how each SC aspect differs within each strategy, including the current SC strategy of the LF, which was summarized in table 5.

Lastly, it was assessed that the preferred SC strategy of the LF would be a hybrid or dual SC strategy as these can cope with the current high inventory levels of the FP and reduce the

risk of overproduction due to significantly reducing the necessity of forecasting. Also, these will enable the capability of offering customization of the FP. Moreover, both of these SC strategies can be implemented with the suppliers' current SC strategies. However, there will be benefits for both the LF and the suppliers if the suppliers change to a lean SC strategy with an STS production method. Considering the discussion of the relationships, it seems more likely that the LF can influence Supplier A to achieve this change compared to Supplier B. A summary of the discussion has been described in this section with the LF's preferred SC strategy. Further, the conclusion of the thesis will be presented.

7 Conclusion

To conclude this thesis, we will first present the research question and the sub-questions of the thesis. Further, an overview of what the thesis has done will be briefly described. Then, we will conclude how the findings answer each of the sub-questions before we perform a final discussion about the main research question. Moreover, the thesis's implications to theory and practice will be presented, before the limitations of the thesis and suggestions for future research will be described.

In this thesis, we have attempted to answer the research question: *"How can aspects of supply chains impact the choice of supply chain strategy of a lead firm?"*. To answer this, the three concepts of production methods and the waste of inventory and the waste of overproduction were used. These concepts were further related to several SC aspects, where we developed three sub-questions: (1) *"How do the production methods impact efficiency and effectiveness of supply chain members?"*; (2) *"How does the waste of inventory impact efficiency and effectiveness of supply chain members?"*; and (3) *"How does the waste of overproduction impact efficiency and effectiveness of supply chain members?"*.

Further, a literature review was conducted with a narrative methodology, to present relevant literature related to the three sub-questions and the SC aspects of *product and market characteristics, decoupling point, location of inventory, transportation*, and *bullwhip effect*.

The methodology used in the thesis is an explanatory case study, which was conducted to examine if what the theory suggested in the literature review, also was the case in practice. In this case, the unit of analysis was the SC of an FP where we used the perspective of an LF. Two components of the FP were used to examine upstream operations in the SC of the FP. To collect data about the case, we had two virtual meetings and two interviews with people from the LF. Also, we received some documents from the LF and searched the Internet for complementary data. Based on this data, the findings from the case study was presented, where the LF's current SC setup was described. This was described by examining the FP's SC upstream through Component A and Component B, internally in the LF in Scandinavia, and downstream from the LF in Scandinavia.

In the analysis, the FP, and Component A and Component B were analyzed related to the SC aspects. This analysis identified how the SC aspects impact the suppliers' and the LF's efficiency and effectiveness when looking at the LF's current SC strategy. It also found that the current SC strategy of the LF emphasizes high efficiency. Furthermore, as an SC strategy should not be changed without considering one's suppliers because of the interdependency

with these suppliers, the two suppliers and their relationship with the LF (customer – supplier relationship) were also analyzed. Further, a discussion on that the LF should put more emphasis on effectiveness and how to achieve this effectiveness was given. To achieve this, four different SC strategies for the LF including a preferred SC strategy by the suppliers was presented. Further, how the three sub-questions have been answered will be presented, before we continue by describing how the main research question has been answered by assessing the impact of the SC aspects.

7.1 The three sub-questions

The first sub-question examined the production methods in the SC of the FP. It was found in the analysis that the product characteristics of the FP are that they are produced with a high variability and at a low volume, and that the market characteristics are that the demand is predictable for all the versions as a whole but unpredictable for each individual version. This implies that the LF should produce the FP with high effectiveness. However, their current STS production method emphasizes high efficiency in their operations, especially in transportation. This enables the LF to deliver with very short delivery lead times to customers by mostly utilizing low-cost sea shipments with high efficiency to transport the FPs around the globe. On the other hand, both suppliers are emphasizing effectiveness by using an MTO production method, which may lower their efficiency and increase the supply lead time to the LF.

In the LF's current SC strategy, the LF forecasts each of the 18 versions to each of the 12 DCs, which multiplies to 216 forecasts. Thus, changing to an MTS production method with a centralized location of inventory of the FP can reduce the amount of DCs to one, which reduces the amount of forecasting from 216 to 18. This will greatly improve the LF's effectiveness. Further, by changing to an ATO or MTO production method, the production of the FP can put even greater emphasis on effectiveness by producing according to customer's demand. This change will move the decoupling point further upstream (from where it currently is) and, as a result, there will be no need to forecast how many FPs to produce. However, these two production methods will require high availability of components and reduce the delivery lead time to customers.

The second sub-question examined the waste of inventory in the SC of the FP. One reason for a high waste of inventory in the current SC strategy is that the decoupling point is located at the decentralized DCs, which makes the forecasting process for the LF complex resulting in high inventory levels of the FP. Moreover, by moving the decoupling point to the suppliers,

the LF will only produce towards actual demand with high effectiveness. Thus, the inventory levels for LF will be greatly reduced. However, both suppliers could be forced to keep more components in inventory, to enable the LF to operate with high effectiveness.

The location of inventory of the FP is decentralized, which results in high waste of inventory as the LF keeps safety stock for every version of the FP at all of the 12 decentralized locations of inventory. Thus, the LF operates with low effectiveness as many FPs are produced and stored without any actual demand, and low efficiency as the inventory levels are high. For the suppliers, they only need to keep an inventory of the raw materials to the components as the components are directly shipped to the LF after they have been produced. This enables the suppliers to operate with high effectiveness while keeping the waste of inventory low. On the other hand, centralizing the location of inventory of the FP will improve the LF's efficiency, as the safety stock levels can be reduced. Furthermore, by producing according to orders, the location of inventory for the FP can be eliminated, and thus the waste of inventory of the FP. This enables the LF to operate with high effectiveness. However, this might require the LF to keep somewhat higher inventory levels of components to enable this effectiveness. Higher availability of components causes lower efficiency for the LF, but this is offset by the elimination of the inventory of the FPs, which might in total result in higher efficiency.

The third sub-question examined the waste of overproduction in the SC of the FP. Here, it was identified that the decoupling point of the FP was located far downstream in the SC. This causes uncertainty through forecasting for the LF in which increases the risk of overproduction, and thus lowering the effectiveness of the production. To cope with this uncertainty, the LF orders more components from the suppliers than they actually need to ensure a high availability of both components. As a consequence, the orders might be further amplified upstream in the SC (bullwhip effect), which also increases the risk for overproduction. Furthermore, this is highly interconnected with the risk for a bullwhip effect, because this risk increases the farther downstream in the SC the decoupling point is located. Moreover, by locating the decoupling point at the suppliers' production, the risk for a bullwhip effect will be much lower, compared to the current location of the decoupling point at the decentralized DCs with its high risk for a bullwhip effect.

7.2 The main research question

To answer the main research question, the LF's current SC strategy was examined, where it was identified that their current SC strategy does not fit what the literature suggests. Thus, to identify an SC strategy for the LF, which fits what the literature suggests based on the SC

aspects, the thesis discussed four SC strategies. These are the *lean, hybrid, agile*, and *dual* SC strategy in which has a greater emphasis on effectiveness than their current SC strategy.

In the lean SC strategy, the location of the decoupling point combined with the LF's MTS production method makes the operations mainly based on forecasts. Furthermore, this forecasting creates a medium risk for a bullwhip effect, which can lead the LF and both suppliers to overproduce. Regarding the location of inventory, as this is centralized, the LF can operate with low safety stock levels, as the FP will be shipped globally to the customers from this location. However, the delivery lead time to the customers can be kept short which is a promise from the LF. Moreover, this SC strategy proposes a lean SC strategy with an STS production method for the suppliers. With this SC strategy, the suppliers will hold the inventory of the components at the LF's facility in Scandinavia as they will produce STS. However, this lean SC strategy may still be used by the LF with the suppliers' current SC strategy.

The hybrid SC strategy with an ATO production method is feasible with the FP's product and market characteristics, as it can cope with the low volume of each variant, and that the supply lead times are long and demand is unpredictable of each individual version. The decoupling point is then located before the LF's production which significantly reduces the risk of overproduction and eliminates the location of inventory of the FP in the DCs. As there will be no DCs, the FPs can be transported directly to customers in which enhances high effectiveness in the transportation. However, compared to the current SC strategy, this will cause longer delivery lead times to customers, and the transportation efficiency may be reduced.

The agile SC strategy with an MTO production method is emphasizing high effectiveness and is feasible with the unpredictable demand of the individual versions. The decoupling point is then located at the suppliers in which should eliminate the LF's waste of inventory and overproduction. However, this SC strategy requires short supply lead times by the suppliers, which may be difficult as the components are globally sourced. Furthermore, it might be difficult for the LF to determine the delivery terms of the suppliers since the power balance is skewed in the suppliers' favor. Especially Supplier B could be difficult because they appear to have less interdependency in resource ties and activity links with the LF than Supplier A and the LF has, however, it might be possible with Supplier A.

As the dual SC strategy applies both the hybrid and lean SC strategy to fit the different demand for the versions of the FP, the SC aspects will mainly impact this strategy in the

same manner as in both of the previous strategies. However, in this dual SC strategy, as the lean SC strategy is used for the high-runners with a predictable demand, the forecasting should improve significantly, which makes the risk for a bullwhip effect low. This will decrease the waste of inventory and overproduction for the LF and both suppliers. Thus, the lean SC strategy is here better aligned with the market characteristics of the FP. Moreover, the suppliers will not need to implement a dual SC strategy, as the preferred SC strategy for them is the lean SC strategy. As mentioned, looking at the customer – supplier relationships, as the relationship between Supplier A and the LF has high interdependency, the possibility of the LF making Supplier A change their SC strategy appears to be higher than making Supplier B change their SC strategy. The reason is that the relationship between Supplier B and the LF is more independent.

Looking at the four proposed strategies, the agile SC strategy appears infeasible due to the necessity of short supply lead time. Further, the lean SC strategy does not appear to have any major benefits compared to the hybrid and dual SC strategy, as its advantage is the savings of 10-16 hours in production time. The hybrid and the dual SC strategy, on the other hand, both appear to be very good options for the LF, based on the SC aspects. These can cope with the current high inventory levels of the FP and greatly reduces the risk of overproduction. Also, they enable the capability of customization of the FP. Thus, by using these aspects of SCs the hybrid and the dual SC strategy are assessed to be the SC strategy that the LF should choose preferably.

7.3 Implications to theory

The conceptual model in this thesis has novelty in the unique combination of SC aspects in which were examined in relation to an SC of a product with the perspective of an LF, which also included two suppliers in the SC and their relationship to the LF. Moreover, this model can use the SC aspects to assess if SC strategies emphasize efficiency or effectiveness when looking at the production methods, and the waste of inventory and overproduction. Further, this model can be used to assess which SC strategy that firms should choose.

From the research, novelty to the theory on SCs can be found in that changing the location of the decoupling point can drastically impact the location of inventory, the market characteristics of the supply lead time, and the transportation efficiency and effectiveness. Further, the SC strategy, production method, product and market characteristics, and the location of the decoupling point are valuable to assess in relation to the waste of overproduction and inventory. Thus, these should be aligned together to optimize efficiency and effectiveness in

operations.

Further, the research contributes to the theory on SCs that efficiency in transportation is preferred over reducing inventory levels in practice. This is preferred even though the product and market characteristics suggest that the inventory levels of products should be kept low by producing with high effectiveness. The research has also contributed to the theory on business relationships in that some SC strategies require changes from upstream suppliers. Thus, the relationship with these suppliers can be an important determinant to enable these SC strategies.

Furthermore, the research has also contributed to the theory on SC networks. It was found that the suppliers might be difficult to move because they also have a vast amount of other buying firms in their SC network. Thus, when choosing SC strategy in which requires suppliers to also change their SC strategy, the SC network of the suppliers must be considered.

Moreover, as SCs have high complexity, the research has shown that only considering one or a few of these SC aspects might be insufficient to choose an SC strategy. Thus, the choice of SC strategy should be made by combining a multiple of the SC aspects. This has implications to the theory on SCs, as it shows how these SC aspects can be used in this unique combination to choose an SC strategy.

7.4 Implications to practice

This section will describe this thesis' implications to practice, where we will describe the implications for buying firms and suppliers, respectively.

7.4.1 Implications for buying firms

Initially, buying firms should reflect on why they use their current SC strategy, and how this strategy impacts their operations. They should think about if their current SC strategy is used for any strategic reasons, or if it has evolved unconsciously over time. Furthermore, buying firms should also think about if they have the required ability and motivation to change their SC strategy.

Moreover, the research has shown that it can be very beneficial for buying firms to consider the SC aspects when choosing an SC strategy, where they should begin by assessing the SC aspects in regard to their current SC strategy. This will help the buying firm to identify if their SC strategy should emphasize efficiency or effectiveness, where the SC aspects can be

assessed in relation to the key concepts of production methods and the waste of inventory and the waste of overproduction.

Further, if the buying firm identifies that they do not have the optimal SC strategy, they can use the SC aspects to ease the choice of choosing an SC strategy. The thesis presented four generic SC strategies from the literature that the buying firm can choose, which are the kanban, lean, agile, and hybrid SC strategy. These strategies are suitable in different environments in which the SC aspects can be used to choose which specific SC strategy, or combination of SC strategies, that is most feasible for the buying firm's SC.

Buying firms should also think about their own position in the SC in regards to their suppliers, as the suppliers' choice of SC strategy can impact the feasibility of the buying firm's SC strategy. Thus, to achieve benefits for both the buying firm and its suppliers, the chosen SC strategy by both parties should be aligned. However, the power balance in the relationship might be skewed in one direction, which could make it difficult for one of the parties to actually have any influence on the other's SC strategy. Moreover, if the buying firm tries to make the supplier to change their SC strategy, the supplier might respond by removing them as a customer, as the supplier might not be dependent on the buying firm. Thus, the buying firm might not be considered an important enough customer to implement such adaptations. Thus, the research has shown that even though a change in the SC strategy might have benefits for both parties, it could be difficult to implement, because it is not valued important enough to the other party. Thus, even though an SC strategy appears to have huge benefits for the buying firm, it might be inhibited by the supplier.

7.4.2 Implications for suppliers

For suppliers with high interdependency in the relationship with the buying firm, it was found in our research that if they change or align their SC strategy to the buying firm's strategy, it can provide 'win-win' situations for these suppliers in an SC context. These 'win-win' situations can be achieved by aligning the SC strategies, where their operations can be optimized and their knowledge and technology combined. This can further be utilized to achieve benefits in efficiencies and effectiveness. Thus, suppliers should consider aligning their SC strategy with buying firms, if such benefits can be achieved, where it appears more likely to be beneficial for suppliers in which have high interdependency in the relationship. However, the suppliers should be aware that this may increase the interdependency with the buying firm even further.

The research has been conducted in an SC context, however, it must be acknowledged that

the suppliers also have other buying firms of their components in their SC network. Thus, for suppliers with low interdependency, there might be considerable disadvantages by aligning their SC strategy with the buying firm as such a change can increase their interdependency on the buying firm and impact other relationships. As a consequence, these suppliers should consider this network as it can cause a lack in their ability and willingness to adapt their SC strategy to a buying firm's SC strategy as they also supply other firms. Therefore, adaptations that suppliers do towards buying firms must also fit well for their other customers in the network, especially for their important customers. Thus, adapting to one buying firm might not be worth the supplier's time and effort, as this can impact the relationship and SC strategy towards other firms. Based on this, the suppliers should assess their SC network before changing or adapting their SC strategy to a buying firm's SC strategy.

7.5 Limitations

A limitation in our case study was that, due to the COVID-19 pandemic, we were unable to travel to the LF. This caused a lack of valuable information in the form of direct observations and informal conversations with people from the LF. However, we were still able to collect sufficient data through email, virtual meetings, and interviews.

Furthermore, another limitation was due to limited time and resources we were unable to conduct interviews with people in the downstream part of the SC, such as someone from the DCs and sales offices of the LF. This could have added more in-depth information about the LF's forecasting process, the inventory at the DCs, and the transportation of the FP.

Moreover, interviews with the upstream suppliers could have given valuable information about the relationships. However, as these were located in China, we did not have the opportunity to conduct interviews with them. Furthermore, including suppliers further upstream in the SC of the FP, such as the tier 2 suppliers, would have given even more information about the bullwhip effect. These were not included due to limited time and resources. Also, the lack of this information made us assume some of this information, however, when assumptions have been made, this has been stated clearly in the thesis.

7.6 Suggestions for future research

A suggestion for future research is to include other aspects of SCs, such as time and customer satisfaction, to examine how these impact the choice of SC strategy. The SC aspects could also be used to investigate if they impact other decisions in the SC, such as in the choice of supplier, location of production, etc. Future research could also add digitalization as a key

concept, to examine how this can impact the efficiency and effectiveness of the aspects of SCs. Furthermore, using a quantitative analysis where one determines which SC aspect that has the highest impact on the choice of SC strategy, could provide valuable information about which SC aspects that should be given the greatest emphasis in the choice of SC strategy.

Future research could also include components that are only used in some of the versions of the FP and research how these impact the choice of SC strategy. The perspective could also be changed from a buying firm to a supplier, where it can be researched more in-depth how the supplier's choice of SC strategy impacts the buying firm or how the buying firm's SC strategy impacts their suppliers.

If a supplier aligns their SC strategy with a buying firm, this will impact more than just this relationship. Thus, it could be interesting to research how such triads impact other customers of the supplier. Also, as some suppliers are difficult to move, it would be interesting to research how buying firms do maneuver when their influence is not strong enough to change the suppliers' SC strategy when this is necessary.

Another suggestion for future research is to conduct a single embedded case study to enable the researcher to compare the SC strategies of two or more products. This might generate more insight into why the current SC strategy is as it is now, such as if the firm applies the same strategy to all of their products, and if the SC aspects differ significantly between the products within the same firm.

Furthermore, an opportunity for future research could be to analyze SCs in the extreme situation as the COVID-19 pandemic gives. The reason for this is that this pandemic greatly impacts the operations in the SC, thus making it a unique case. This makes the COVID-19 pandemic interesting to research because it makes the risk of global sourcing in SCs more visible. These risks are connected to the long transportation distances among the SC members which creates long supply lead times, and the trade barriers as the suppliers are located in different countries. Findings in this extreme case might reveal that firms have underestimated this uncertainty of global sourcing in their SC. Based on this, it would be interesting to research how this pandemic impacts the SC aspects and concepts in the choice of SC strategy.

Another field of study, which future research can include, is sustainability. Today, the focus on sustainability increases, as firms realize that they can no longer maximize their own profits without considering their impact on the triple bottom line of the economy, society, and environment. Thus, when choosing SC strategy, these impacts must be considered in the

long-run to become sustainable and survive in the market. For example, the growing trend of globalization has increased the transport distances in SCs, which has a negative impact on the environment as the carbon footprint increases.

References

Aitken, J. (1998). Supply chain integration within the context of a supplier association: Case studies of four supplier associations.

Baumol, W. J., & Vinod, H. D. (1970). An inventory theoretic model of freight transport demand. *Management science*, *16*(7), 413–421.

Beamon, B. M. (1998). Supply chain design and analysis: Models and methods. *International journal of production economics*, *55*(3), 281–294.

Blumenfeld, D. E., Burns, L. D., Diltz, J. D., & Daganzo, C. F. (1985). Analyzing trade-offs between transportation, inventory and production costs on freight networks. *Transportation Research Part B: Methodological*, *19*(5), 361–380.

Bozarth, C., & Chapman, S. (1996). A contingency view of time-based competition for manufacturers. *International Journal of Operations & Production Management*.

Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press.

Chen, F., Drezner, Z., Ryan, J. K., & Simchi-Levi, D. (2000). Quantifying the bullwhip effect in a simple supply chain: The impact of forecasting, lead times, and information. *Management science*, *46*(3), 436–443.

Christopher, M. (2000). The agile supply chain: Competing in volatile markets. *Industrial marketing management*, *29*(1), 37–44.

Christopher, M. (2016). *Logistics and supply chain management* (5th ed.). Financial Times.

Christopher, M., Mena, C., Khan, O., & Yurt, O. (2011). Approaches to managing global sourcing risk. *Supply Chain Management: An International Journal*.

Christopher, M., & Towill, D. R. (2000). Supply chain migration from lean and functional to agile and customised. *Supply Chain Management: An International Journal*, *5*(4), 206–213.

Corsten, D., & Gruen, T. W. (2004). Stock-outs cause walkouts. *Harvard Business Review*, *82*(5), 26–28.

Croson, R., & Donohue, K. (2006). Behavioral causes of the bullwhip effect and the observed value of inventory information. *Management science*, *52*(3), 323–336.

De Steur, H., Wesana, J., Dora, M. K., Pearce, D., & Gellynck, X. (2016). Applying value stream mapping to reduce food losses and wastes in supply chains: A systematic review. *Waste management*, *58*, 359–368.

Dyer, J., Furr, N., & Lefrandt, C. (2014). The industries plagued by the most uncertainty. *Harvard Business Review*, *11*, 563–584.

Eisler, M., Horbal, R., & Koch, T. (2007). Cooperation of lean enterprises - techniques used for lean supply chain. *Advances in production management systems*, Springer, *246*, 363–370.

Ellram, L. M., Tate, W. L., & Petersen, K. J. (2013). Offshoring and reshoring: An update on the manufacturing location decision. *Journal of Supply Chain Management*, *49*(2), 14–22.

Eltantawy, R., Paulraj, A., Giunipero, L., Naslund, D., & Thute, A. A. (2015). Towards supply chain coordination and productivity in a three echelon supply chain: Action research study. *International Journal of Operations & Production Management*, *35*(6), 895–924.

Feitzinger, E., & Lee, H. L. (1997). Mass customization at hewlett-packard: The power of postponement. *Harvard business review*, *75*, 116–123.

Fuller, J. B., O'Conor, J., & Rawlinson, R. (1993). Tailored logistics: The next advantage. *Harvard Business Review*, *71*(3), 87–98.

Gattorna, J., & Jones, T. (1998). *Strategic supply chain alignment: Best practice in supply chain management*. Gower Publishing, Ltd.

Håkansson, H., & Snehota, I. (1995). *Developing Relationships in Business Networks*. 1. Routledge.

Hallén, L., Seyed Mohamed, N., & Johanson, J. (1989). Relationships and exchange in international business. *Hallén, L. & Johanson, J.(eds.), Networks of Relationships in International Industrial Marketing: Advances in International Marketing*, *3*, 7–23.

Han, C., Dresner, M., & Windle, R. J. (2008). Impact of global sourcing and exports on us manufacturing inventories. *International Journal of Physical Distribution & Logistics Management*.

Handfield, R. B. (1994). Us global sourcing: Patterns of development. *International Journal of Operations & Production Management*, *14*(6), 40–51.

Harris, C., Harris, R., & Streeter, C. (2011). *Lean supplier development: Establishing partnerships and true costs throughout the supply chain*. Productivity Press.

Heskett, J. L. (1977). Logistics-essential to strategy. *Harvard Business Review*, *55*(6), 85–96.

Hines, P., & Rich, N. (1997). The seven value stream mapping tools. *International Journal of Operations & Production Management*, *17*(1), 46–64.

Holweg, M., Reichhart, A., & Hong, E. (2011). On risk and cost in global sourcing. *International Journal of Production Economics*, *131*(1), 333–341.

Hopp, W. J., & Spearman, M. L. (2004). To pull or not to pull: What is the question? *Manufacturing & service operations management*, *6*(2), 133–148.

Hopp, W. J., & Spearman, M. L. (2011). *Factory physics*. Waveland Press.

Karlsson, C., & Norr, C. (1994). Total effectiveness in a just-in-time system. *International Journal of Operations & Production Management*.

Koren, Y., Heisel, U., Jovane, F., Moriwaki, T., Pritschow, G., Ulsoy, G., & Van Brussel, H. (1999). Reconfigurable manufacturing systems. *Annals of the CIRP*, *48*, 2.

Kumar, D. (2004). Beyond the low-hanging fruit: Designing an enduring lean supply chain in the consumer packaged goods industry. *Industrial Engineer*, *36*(5), 44–49.

Lafley, A., Martin, R., & Riel, J. (2013). A playbook for strategy. *Rotman magazine*, *9*.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997a). Information distortion in a supply chain: The bullwhip effect. *Management science*, *43*(4), 546–558.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997b). The bullwhip effect in supply chains. *Sloan management review*, *38*, 93–102.

Liker, J. (2004). *The toyota way*. McGraw-Hill, New York, NY,

Lin, C.-C., & Wang, T.-H. (2011). Build-to-order supply chain network design under supply and demand uncertainties. *Transportation Research Part B: Methodological*, *45*(8), 1162–1176.

Machado Guimarães, C., de Carvalho, C. J., & Maia, A. (2013). Vendor managed inventory: Evidences from lean deployment in healthcare. *Strategic Outsourcing: An International Journal*, *6*(1), 8–24.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, *22*(2), 1–25.

Metters, R. (1997). Quantifying the bullwhip effect in supply chains. *Journal of operations management*, *15*(2), 89–100.

Monden, Y. (1998). *Toyota production system: An integrated approach to just-in-time* (3rd ed.). Engineering & Management Press.

Moradlou, H., & Tate, W. (2018). Reshoring and additive manufacturing. *World Review of Intermodal Transportation Research*, *7*(3), 241–263.

Naylor, J. B., Naim, M. M., & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International Journal of production economics*, *62*(1-2), 107–118.

Nicholas, J. (2011). *Lean production for competitive advantage: A comprehensive guide to lean methodologies and management practices* (1st ed.). Taylor and Francis Group.

Ogawa, R. T., & Malen, B. (1991). Towards rigor in reviews of multivocal literatures: Applying the exploratory case study method. *Review of educational research*, *61*(3), 265–286.

Pagh, J. D., & Cooper, M. C. (1998). Supply chain postponement and speculation strategies: How to choose the right strategy. *Journal of business logistics*, *19*(2), 13.

Pan, A. C., & Liao, C.-J. (1989). An inventory model under just-in-time purchasing agreement. *Production and Inventory Management Journal*, *30*(1), 49.

Sabri, E. H., & Beamon, B. M. (2000). A multi-objective approach to simultaneous strategic and operational planning in supply chain design. *Omega*, *28*(5), 581–598.

Savino, M. M., Mazza, A., & Marchetti, B. (2014). Lean manufacturing within critical healthcare supply chain: An exploratory study through value chain simulation. *International Journal of Procurement Management*, *8*(1-2), 3–24.

Schmitt, A. J., Sun, S. A., Snyder, L. V., & Shen, Z.-J. M. (2015). Centralization versus decentralization: Risk pooling, risk diversification, and supply chain disruptions. *Omega*, *52*, 201–212.

Seth, D., & Gupta, V. (2005). Application of value stream mapping for lean operations and cycle time reduction: An indian case study. *Production Planning & Control*, *16*(1), 44–59.

Sha, D., & Che, Z. (2006). Supply chain network design: Partner selection and production/distribution planning using a systematic model. *Journal of the operational research society*, *57*(1), 52–62.

Shamah, R. A. (2013). Measuring and building lean thinking for value creation in supply chains. *International Journal of Lean Six Sigma*, *4*(1), 17–35.

Skjott-Larsen, T., & Schary, P. B. (1996). *Managing the global supply chain*. Copenhagen Business School Press DK.

So, S., & Sun, H. (2010). Supplier integration strategy for lean manufacturing adoption in electronic-enabled supply chains. *Supply Chain Management: An International Journal*, *15*(6), 474–487.

Sterman, J. D. (1989). Modeling managerial behavior: Misperceptions of feedback in a dynamic decision making experiment. *Management science*, *35*(3), 321–339.

van Donk, D. P. (2001). Make to stock or make to order: The decoupling point in the food processing industries. *International Journal of Production Economics*, *69*(3), 297–306.

van Weele, A. J. (2018). *Purchasing and supply chain management* (7th ed.). Andover, Hampshire: Cengage Learning.

Viken, K. E. H., & Haraldstad, E. (2019). Coping with waste through supply chains: A literature review.

Waller, M., Johnson, M. E., & Davis, T. (1999). Vendor-managed inventory in the retail supply chain. *Journal of business logistics*, *20*, 183–204.

Wee, H., & Wu, S. (2009). Lean supply chain and its effect on product cost and quality: A case study on ford motor company. *Supply Chain Management: An International Journal*, *14*(5), 335–341.

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corperation* (1st ed.). Simon and Schuster.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world*. Simon and Schuster.

Yang, B., & Burns, N. (2003). Implications of postponement for the supply chain. *International journal of production research*, *41*(9), 2075–2090.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage publications.

Zainal, Z. (2007). Case study as a research method. *Jurnal Kemanusiaan*, *5*(1).

Appendix

A Overview of the literature included in the literature review

Reference	Year	Methodology	Geographical area	Aspect(s)
Baumol and Vinod (1970)	1970	Mathematical model	None	Transportation
Blumenfeld et al. (1985)	1985	Conceptual model	None	Transportation
Bozarth and Chapman (1996)	1996	Literature review	Global	Product and market characteristics and decoupling point
Chen et al. (2000)	2000	Mathematical model	None	Bullwhip effect
Christopher (2016)	2016	Book	None	Product and market characteristics, decoupling point, location of inventory, and transportation
Christopher et al. (2011)	2011	Multiple case study	Global	Transportation
Christopher and Towill (2000)	2000	Conceptual model	None	Decoupling point
Eisler et al. (2007)	2007	Case study	Poland	Transportation
Ellram et al. (2013)	2013	Survey	Global	Transportation
Eltantawy et al. (2015)	2015	Case study	US	Bullwhip effect
Feitzinger and Lee (1997)	1997	Case study	US	Decoupling point
Fuller et al. (1993)	1993	Conceptual model	None	Bullwhip effect
Han et al. (2008)	2008	Mathematical model	US	Transportation
Handfield (1994)	1994	Survey	US	Transportation
Heskett (1977)	1977	Conceptual model	None	Decoupling point
Holweg et al. (2011)	2011	Literature review	None	Transportation
Hopp and Spearman (2004)	2004	Literature review	None	Decoupling point
Hopp and Spearman (2011)	2011	Book	None	Decoupling point
Karlsson and Norr (1994)	1994	Case study	Sweden	Transportation

Continues on next page

Reference	Year	Methodology	Geographical area	Aspect(s)
Lee et al. (1997a)	1997	Mathematical model	None	Bullwhip
Lee et al. (1997b)	1997	Conceptual model	None	Bullwhip
Lin and Wang (2011)	2011	Mathematical model	None	Location of inventory
Metters (1997)	1997	Mathematical model	None	Bullwhip effect
Moradlou and Tate (2018)	2018	Case study	UK	Transportation
Naylor et al. (1999)	1999	Case study	Global	Product and market characteristics, decoupling point, and transportation
Pagh and Cooper (1998)	1998	Conceptual model	None	Product and market characteristics, decoupling point, and location of inventory
Pan and Liao (1989)	1989	Mathematical model	None	Transportation
Schmitt et al. (2015)	2015	Mathematical model	None	Location of inventory
Seth and Gupta (2005)	2005	Case study	India	Transportation
Sterman (1989)	1989	Mathematical model	None	Bullwhip effect
So and Sun (2010)	2010	Survey	Global	Transportation
van Donk (2001)	2001	Case study	Unknown	Decoupling point
van Weele (2018)	2018	Book	None	Transportation
Yang and Burns (2003)	2003	Conceptual model	None	Product and market characteristics, decoupling point

B Interview guide 1

Before we start, we just want to establish some information about you.

1. What is your position in the LF?
2. For how long have you worked there?
3. Have you had any other positions in the LF?
4. What have you worked with before?
5. What kind of education do you have?

Component A:

General:

1. Can you give a description of the component?
   (a) What does Component A do in the FP?
   (b) Why does this component have to be customized for the FP?
2. Is Component A sometimes upgraded to a new improved model?

   Supplier/purchasing/transport:
3. What triggers your purchasing orders for the Component A?
   (a) How is the frequency and size of the order of the component determined?
   (b) What is included in the lead time of X days?
      – Is it the time from where you place an order to when the component arrives at the factory?
4. Do you know if Component A are produced make-to-order (MTO) by Supplier A?
5. Would you say/think that for Supplier A, Component A they are supplying you are a low volume for them?
6. Why ship this component by air?
7. Why do Component A and Component B have the exact same lead time?
8. Will you rather order too many Component A to be "safe" than risk running out of stock?
   (a) Have you ever ran out of stock?
   (b) Do you inform your supplier that your order is larger than what you actually expect to use?
9. If the supplier is unable to deliver, how do you cope with this?

Inventory:

10. On average, how many and for how long are the components stored at the factory before they are used in an FP?
11. Do you sometimes have to scrap some of the transport protectors in terms of them becoming obsolete?

Relationship with Supplier A:

12. How long has Supplier A been your supplier?
13. Does the LF have any collaborations and communication with Supplier A?
    (a) How was the component developed?
14. What kind of informal agreements do you have?
15. How would you say the power is balanced in the relationship?
    (a) How difficult would it be for you to find a new supplier?
    (b) Do you have to make any adaptations to meet Supplier A's requirements?
    (c) Or is it Supplier A which must make the adaptations?
16. Has there been any conflicts with Supplier A?
17. Have you had any social interactions with Supplier A (outside of work)?
18. How have your routines with Supplier A developed over time?

Component B:

Supplier/Purchasing:

1. What triggers your purchasing orders for Component B?
    (a) Is it included in the forecasting of the FP?
    (b) What is normally the frequency for the order of Component B?
2. Do you know if Component B is produced make-to-stock (MTS) by Supplier B?
3. Will you rather order too many of Component B to be "safe" than risk running out of stock?
    (a) Do you inform your supplier that your order is larger than what you actually expect to use?
    (b) Have you ever ran out of stock?
4. If the supplier is unable to deliver, how do you cope with this?

Inventory:

5. On average, how long are you storing Component B before they are packed with an FP?

Relationship with Supplier B:

6. How long has Supplier B been your supplier?
7. Does the LF have any collaborations and communication with Supplier B?
   (a) How was the component developed?
8. What kind of informal agreements do you have?
9. How would you say the power is balanced in the relationship?
   (a) How difficult would it be for you to find a new supplier?
   (b) Do you have to make any adaptations to meet Supplier B's requirements?
   (c) Or is it Supplier B which must make the adaptations?
10. Has there been any conflicts with Supplier B?
11. Have you had any social interactions with Supplier B (outside of work)?
12. How have your routines with Supplier B developed over time?

Finished product (FP)

General:

1. What makes the FP so expensive?
   (a) What are the main differences between the 18 versions of the FP?
   (b) Are all of these also delivered with differentiations such as color?
      – What other type of similar differentiation do you do (that has nothing to do with its functionality)?
      – How and when in the process do you determine the differentiation of the FPs?
      – Do you think that the customers have to accept what the available differentiations in the DCs are?
   (c) Why do you keep the 15 low runners in the product family?
2. How stable are end-customers' orders (demand)?
3. How long does it take to make/assemble one FP (in Scandinavia)?

C Interview guide 2

Before we start, we just want to establish some information about you.

1. What is your position in the LF?
2. For how long have you worked there?
3. Have you had any other positions in the LF?
4. What have you worked with before?
5. What kind of education do you have?

Finished product (FP)

General:

1. What makes the FP so expensive?
   (a) What are the main differences between the 18 versions of the FP?
   (b) Are all of these also delivered with differentiations such as color?
      – What other type of similar differentiation do you do (that has nothing to do with its functionality)?
      – How and when in the process do you determine the differentiation of the FPs?
      – Do you think that the customers have to accept what the available differentiations in the DCs are?
   (c) Why do you keep the 15 low runners in the product family?
2. How stable are end-customers' orders (demand)?
3. How long does it take to make/assemble one FP (in Scandinavia)?

Distribution centers/inventory:

4. Why have the DCs?
5. Why are the DCs placed where they are? (Any strategic reason?)
6. How many and how are the FPs transported to the DCs?
7. On average, how many and how long are the FPs stored at the DCs?
   (a) Is there any safety stock for the FP at the DCs?
8. You said you sell the FP to the DCs from the factory, do you think that this will lead your production to try to push as many FPs as possible to the DCs?
9. If the close by DC is out-of-stock on the required FP from a customer, do you have the option to utilize other DCs inventory?
10. How accurately are you forecasting?
11. If you do not have the specific FP that the customer wants, will that normally result

in a loss of sale (or does the customer buy the one in stock)?

12. You mention that you had a large problem with overproduction and overstocking due to poor forecasting. Has poor forecasting been a common problem leading to overproduction and overstocking of the FP?
    (a) What is the cause for the poor forecasts?
    (b) Do poor forecasting lead you to overestimate your orders to the suppliers?
    (c) How does poor forecasting impact the stock of Component A and Component B?

Customers:

13. How are the FPs distributed from the DCs to the customers?
14. Our understanding is that you promise your customers short delivery time.
    (a) What do you determine as short lead times?
    (b) Can you elaborate on why this is an important promise to your customers?
15. Do you offer customers the opportunity to order a combination of the FP versions, if the customer wants?
    (a) If not, do you think customers would appreciate this opportunity, or do you think that the 18 versions cover enough functions and looks that a combination is unnecessary?
16. Is there a limit for how long an FP can be kept in inventory before you must do/change something?
17. You mentioned FPs having to be remodelled or refurbished when a new design arrives. Can this only be done in Scandinavia?
    (a) How can the FPs be changed to fit a demand?
    (b) Does it happen often?

Production:

18. Do you sometimes have to make significant changes to your production schedules?
    (a) Why does that occur?
    (b) How regularly does that occur?
    (c) How do you cope with this situation?
19. Do you sometimes get urgent orders which must be delivered ASAP?
20. You said you are buying from your other factories. Is this a regular thing, or only in special cases?
    (a) Do you have any other synergies?
21. Have you considered the possibility of producing the FPs at other factories in addition to or instead of the factory in Scandinavia?

Even Haraldstad, Kjell Erik Hjorth Viken

How aspects of supply chains impact the supply chain strategies of manufacturing firms

NTNU
Kunnskap for en bedre verden