MASTER'S THESIS 2020

Critical Supply Chain Factors for Scaling a Startup

– A Case Study in the Industry of Semiconductors

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Master's thesis work carried out at Acconeer AB.

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Abstract

Title
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Background
A well implemented supply chain strategy aligned with the company's overall strategy is a prerequisite in order to successfully scale a startup. About 90% of all startups fail to become successful, mainly because of premature scaling. Limited research, focusing on volatile high-tech startups and their supply chain, has previously been conducted. To bridge the gap this project will develop a framework of how to implement an aligned supply chain strategy to prepare for future growth.

Purpose
The purpose of this research project is to identify critical success factors and describe how to establish a supply chain strategy, in order to prepare the supply chain for future growth for a startup in the semiconductor industry. The following research questions were

formulated to fulfill this purpose:

- RQ1: How could a supply chain strategy be applied for a startup within the semiconductor industry?
- RQ2: Which factors in the supply chain are critical to succeed with in order to enable growth?
- RQ3: Which key performance indicators (KPIs) are relevant to track in order to measure the performance of a startup's supply chain during growth?

Methodology
The project had an inductive and qualitative approach with an exploratory purpose. The research strategy consisted of a literature review and case studies of three Swedish companies in the industry of Semiconductors.

Conclusion
A framework for determine how a supply chain strategy can be applied for a startup is presented. It is an iterative process where theoretical models along with success factors are used to form a supply chain strategy with associated critical success factors and key performance indicators.

Presented below in table 1 is the result with the 8 identified critical success factors. Based on their nature they, can be divided into three different categories, *product characteristics, industry characteristics* or *internal organization*.

Table 1: Identified critical success factors (author)

Product Characteristics	*Industry Characteristics*	*Internal Organization*
– User case & market fit	– Relationship to suppliers	– S&OP Process
– Minimize SKUs	– Ensure capability to scale	– Top management engagement
	– Postpone or avoid customization	– Ownership support

The essential key performance indicators to track in order to measure the performance of the supply chain are *flexibility, cost, delivery precision* and *quality*.

Keywords
Startup, Scale, Scaleup, Supply Chain Strategy, Critical Success Factors, Scaling Startup, Semiconductor Industry, Supply Chain Management

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Lund, May 2020
Pontus Landgren

List of Abbreviations

CODP	Customer order decoupling point
CSF	Critical success factor
EVK	Evaluation kit
IC	Integrated circuit
KPI	Key performance indicator
MCU	Microcontroller unit
R&D	Research and development
SC	Supply chain
SCM	Supply chain management
SCOR	Supply chain operations reference
S&OP	Sales and operations planning
SKU	Stock keeping unit
SME	Small and medium-sized enterprises

List of Figures

List of Tables

Contents

Chapter 1

Introduction

In this chapter, a background to the main problem is given together with a description of the company that will be investigated throughout the project. This is followed by a presentation of the purpose of the project along with the specific research questions that are to be answered. Finally, the outline of the entire project is laid out.

1.1 Background

When facing increasing customer demand a critical moment for a startup is the ability to scale. According to Marmer et al. (2011) 90% of the startups fail and for 74% of the high-tech startups the reason is due to premature business scaling. Proper business scaling compared to market growth could be the decisive factor between becoming a highly successful company or not. However, scaling might be challenging for todays startups since they often work in a reactive way instead of a proactive way. Late ad hoc decisions and corrective actions are costly and time consuming. A. Hill and T. Hill (2009) describes that every decision should be taken in accordance with the overall strategy to secure that the supply chain and the rest of the company functions aims toward the company strategy. To enable fast decisions the supply chain strategy has to be aligned with the overall strategy.

When scaling a company, strategies and policies are crucial to guide correct and fast decisions. Correctly implemented, this enables innovative actions to successfully navigate in the dynamic market. Understanding the process of effective scaling might increase the chance of becoming a successful startup.

OECD (2019) describes the semiconductor supply chain as one of the most R&D-intensive industries which spans over a significant number of specialized tasks performed by different companies around the world. At the same time, according to Ford (2018) a trend of increasing lead times in the semiconductors can be identified. As Hung, Chiu, and Wu (2017) describes the barrier for establishing a semiconductor plant (foundry) is extremely capital intensive which lead to the case that startups in the industry start as a fabless company and then partner up with a production plant company. Even though this reduces the barrier for startups, the industry of semiconductors has long lead times and is capital intensive due to the production process time that may require 700 process steps and up to 3 months to complete the silicon (Mönch, Fowler, and Mason 2012).

Besides the important process of purchasing, manufacturing, and finally delivery of products and services there are other crucial aspects of becoming a successful startup. Firstly, the right competence to support both the R&D team and the customers is needed. Secondly, the capability to acquire the right resources in terms of supply chain processes, raw material, and components must be secured. Thirdly, it is necessary to provide the right capacity throughout the whole supply chain. Fourthly, the products and services from the company must be in compliance with the requirements and agreements from customers, including the right quality and price level. (Ljungquist 2008)

The author has had the opportunity to become familiarized with the company Acconeer who is currently in a growth phase within the semiconductor industry. Acconeer has chosen to set up their supply chain in cooperation with some of the largest manufacturing partners in the industry. In the initial research the author has found out that very little research has been conducted in the area of which supply chain factors that will have the greatest impact on a growing company in the semiconductor industry.

1.2 Company Description

Acconeer is a company based in Lund, Sweden and was founded 2011. Based on technology from Lund University they develop and sell a radar sensor. The Acconeer radar sensor, which was launched March 2018, is based on pulsed coherent radar technology which offers high range resolution with a power consumption of less than one milliwatt. The product can be integrated in a various number of products and applications. In order to decrease the time to market for the customers Acconeer has developed and released evaluation kits with the sensor pre integrated with a microprocessor and software. All manufacturing of both sensors and evaluation kits is done through suppliers which makes Acconeer a fabless company, i.e. a company without own manufacturing. The production process is split between two companies located in east asia. Acconeer's current production volume is extremely small compared to the total production volume for both these suppliers.

This setup enables rapid ramp up in production volume when the customer demand increases, which supports the forecast of exponential sales growth during the coming years. Since the lead time in the industry is that long it is essential that the supply chain is optimized and aligned with the other company functions in the best possible way.

1.3 The Challenge

The semiconductor and electronics industry is costly due to both heavy R&D costs and long lead times. This lead to the requirement of highly invested capital in order to found a company in this industry. Founding a new wafer manufacturing company is almost impossible in todays business environment since it requires extensive funding and investment among with extremely high labor competence and secured demand from customers. The barrier has decreased with the fabless semiconductor business model but it still requires a

high amount of start capital. For an established company with a low uncertainty environment there are many theories, methods and processes to develop and follow up a company's supply chain strategy. Since most of the theories and methods rely on the condition of low uncertainty environment they are usually not applicable for startups. Although, the most critical phase for the survival of the company is prior to the growth phase. This time point play an important role in completing a successful transition from the startup stage. Therefore, this project will investigate which supply chain factors that are critical for the successful growth of a startup in the semiconductor industry.

1.4 Delimitations

In order for Acconeer to benefit as much as possible from the project, their requests and preferences have been taken into consideration when planning the subject of the project and its delimitations. Since Acconeer is a fabless semiconductor company aiming for rapid growth, the project has mainly been focusing on challenges and critical success factors regarding the supply chain of a fabless semiconductor hardware company.

1.5 Purpose of the Project and Research Questions

The purpose of this research project is to identify critical success factors and describe how to establish a supply chain strategy, in order to prepare the supply chain for future growth for a startup in the semiconductor industry. To fulfill this purpose, the following research questions are to be answered:

RQ1: How could a supply chain strategy be applied for a startup within the semiconductor industry?

RQ2: Which factors in the supply chain are critical to succeed with in order to enable growth?

RQ3: Which key performance indicators (KPIs) are relevant to track in order to measure the performance of a startup's supply chain during growth?

The first research question is constructed in a broader way to be able to allow insights in a wider spectrum regarding both successful recommendations as well as what to avoid. To support a strategy there is often critical success factors as well as key performance indicators included, thus the reason for choosing the second and third research questions.

1.6 Project Objective and Deliverables

The objective of this research project is to identify critical success factors for the supply chain of a startup company within the semiconductor industry. Based on the research, a strategic framework of how to setup a supply chain within this area will be presented, followed by identified critical success factors and relevant key performance indicators to trace. This project will be delivered though a scientific report, a popular scientific article and an oral presentation.

1.7 Report Outline

A visual representation of the structure of the report is found in Figure 1.1.

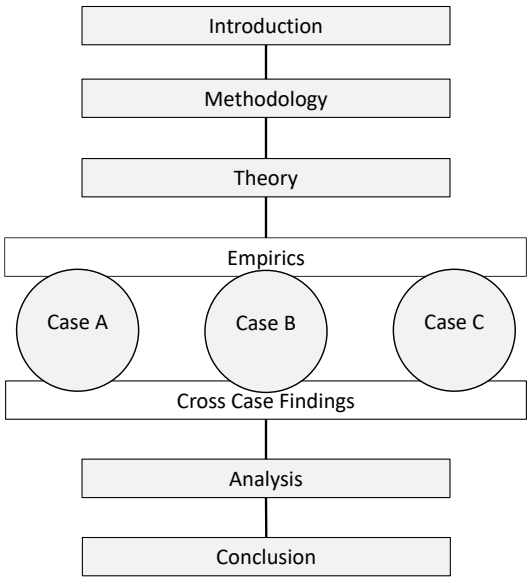

Figure 1.1: Visual representation of the report structure (author)

Chapter 1 – Introduction

Gives an introduction to the project and describes its purpose. The research questions are presented along with a presentation of structure of the report.

Chapter 2 – Methodology

The second chapter gives a description of different research strategies that are suitable for this type of project, which is followed by a discussion of advantages and disadvantages of a qualitative versus a quantitative research strategy. Secondly, the research design is presented together with a description of the research methods used to collect data for the project. Moreover, the analysis process for the collected data is also explained here. The chapter ends with a discussion of quality level on the research with consideration taken to the criteria of trustworthiness.

Chapter 3 – Theory

The third chapter provides the theoretical framework that will form the base for the literature review. Before elaborating on the ingoing components of the theoretical framework, an introduction to the supply chain and supply chain management is given. How to measure supply chain performance is also discussed here followed by a theoretical background to each ingoing element in the presented framework.

Chapter 4 – Empirics – Case Studies

In this chapter, findings from the three case companies are presented. An introduction to each case company is given, followed by a description of their supply chain and identified critical success factors. The chapter ends with a cross-case analysis to identify common denominators.

Chapter 5 – Analysis

In chapter 5, the analysis of the gathered empirical data and relevant theories from the literature review is presented. Product characteristics and industry characteristics are discussed and findings from the empirical data is compared with theoretical knowledge. Lastly, a strategic framework for how a startup can find their supply chain strategy is presented.

Chapter 6 – Conclusion

In chapter 6, answers to the research questions of the project are provided based on conclusions drawn from the analysis. Suggestions on future research of the subject are given, as well as a discussion on how this project has contributed to the theory of the subject.

Chapter 2

Methodology

This chapter describes the methodology of this project. It aims to explain and motivate which research strategy and research design were chosen as well as discussing the quality of the project in the form of trustworthiness and authenticity. Furthermore, it helps the reader understand how this project was executed to easier follow insights and conclusions made in later chapters.

2.1 Research Purpose

The purpose of any research can be categorized into four different areas: descriptive, exploratory, explanatory or problem solving (Höst, Regnell, and Runeson 2006). According to Robson (2002), an exploratory study is useful when addressing issues such as to understand what is happening, to seek new insights, to ask questions, to assess phenomena in new light, to generate ideas and hypotheses for future research. This is valuable when investigating problems that are less defined and with an unclear cause and effect. Descriptive research, on the other hand, addresses problems such as to portray an accurate profile of persons, events or situations. Thirdly, explanatory research is used to seek an explanation of a situation or problem, traditionally but not necessarily in form of causal relationships (ibid.). Lastly according to Höst, Regnell, and Runeson (2006), problem solving research approaches are most common in engineering studies. Additionally lies the matter that research studies also should have a certain degree of novelty. There is no point of redescribing what has already been described since research is not exclusively the gathering of information but the use of that information to describe, explore, explain something or solve a problem in a new way. The most feasible research methods are controlled by the purpose of the project, i.e. the research questions. The best research questions are simple ones that require a good analysis and which allows the researches to visualize both the goal as well as the path how to get there on beforehand (Badke 2014).

Evaluating the aforementioned purpose; *identify critical success factors and describe how to establish a supply chain strategy, in order to prepare the supply chain for future growth for a startup in the semiconductor industry,* the exploratory approach is the most appropriate since this assess a specific phenomenon and develop new theory rather than to test already existing theory and concepts.

2.2 Research Strategy

2.2.1 Deductive, Inductive and Abductive Research

A research strategy should start with determining what role theory will play since that role highly affects the design of the research project. On a high level, there are three ways of approaching the role of theory. Firstly, the deductive approach is appropriate when the objective is to test a theory and a hypothesis based on collected data. This involves the crafting

of a hypothesis with the use of the best available information and uses collected empirics to verify or reject this hypothesis. From this, the result is a logical conclusion drawn from the relationship between the hypothesis and empirics. The deductive approach works best for scientific principles with an abundance of quantitative data available for verification in a highly structured way. Secondly, if the objective is to *form a theory* based on the result of data analysis, the inductive approach is preferable. The target of the inductive approach is to explore and understand the meaning of individuals and groups ascribe to a social or human problem. Research using an inductive approach is likely to be particularly concerned with the context in which such events were taking place. Therefore the project of small sample of subjects might be more appropriate than a large number as with the deductive approach (Saunders, Lewis, and Thornhill 2007). Finally, the abductive approach, can be described as investigating the relationship between *everyday language and concepts*. According to Dubois and Gadde (2002) abductive approach is to be seen as different from a mixture of deductive and inductive approaches. The abductive approach is fruitful when the researcher's objective is to discover new things - other variables and other relationships - which have not been described before. At its core, abduction is related to the generation of new concepts and development of theoretical models, rather than confirmation of existing theory (ibid.).

Given the objective of identifying critical success factors in order to scale a startup, which can be described a forming a theory as a result of data analysis, the inductive approach is deemed superior to this project. Case studies in general provide a unique way of crafting theory by utilizing in-depth insights of empirical phenomena and their contexts. However, they tend to involve difficulties related to the interrelatedness of the various elements as well as their cause and effect. In order to overcome this challenge a flexible and iterative process is preferred. In this project, that approach involved the iteration of going back and forth from one type of research activity to another and between empirical data and theory in order to gain a more complete understanding of the underlying parameters.

2.2.2 Qualitative and Quantitative Approaches

Generally data exists in either quantitative or qualitative form. Quantitative data refer to data of numerical nature which need to be analysed and interpreted to be useful. Depending on the quality as well as the quantity of the data it can be processed, generate insight and, at the same time, be statistically reliable. In addition, quantitative data can only focus on a few variables at a time in order to be visually interpretable. A qualitative approach can compensate for this weakness by incorporating multiple variables in a holistic analysis

by words and images (Creswell 2014). It should be mentioned that studies benefit from the use of both approaches, where the combination provides a more complete understanding of the problem than either approach alone (Creswell 2014; Runeson and Höst 2009).

As the aim of this project is to understand a specific phenomenon and develop new theory, the main focus, supported by Runeson and Höst (2009), has been on collecting qualitative data. A qualitative research method will allow for adjustments to be done in the research strategy during the course of the investigation in order to narrow down the scope of the study, as the initial research focus can be considered rather general.

2.3 Research Design

2.3.1 Case Study

When the objective is to get a deep understanding of a topic or to investigate a certain phenomena in its natural context a case study is preferred (Skärvad and Lundahl 2016). This type of method, according to Bryman and Bell (2011), allow the researcher to gain a deeper understanding of a complex phenomena though an intensive examination of the selected case. Case studies are by definition conducted in real world settings, and thus have a high degree of realism (Runeson and Höst 2009). Since the characteristics of the studied phenomena are difficult to predict in advance, researchers must be flexible in their approach to be able to adjust their study as it progresses. Therefore case study researchers lose a certain level of control over the study and will never provide conclusions with statistical significance. However, in advantage case studies provides the researcher with conclusions based on a clear chain of evidence collected from multiple sources in a planned and consistent manner (ibid.). According to Yin (2003) there are two types of case studies, either single case or multiple case. Yin states a number of situations where a single case might be rationale, e.g. critical test of existing theory, the phenomena being studied occurs under rare circumstances, or the case is considered to be representable. However, the multiple case study is preferred due to the risk of misrepresentation and lack of evidence. Multiple case studies have a distinct advantage since the evidence from multiple cases is often considered more compelling and the overall study is therefore regarded as being more robust (ibid.). This project will be based on multiple cases as to distinguish between what is common and what is unique among the selected case companies, in order to identify critical success factors in the supply chain for scaling a startup.

Selection of Case Companies

Case selection is the primordial task of the case study researcher since it sets out an agenda for studying those cases. This means that case selection and case analysis are intertwined to a much grater extend in case study research than in large number cross-case analysis (Seawright and Gerring 2008). To choose good cases for extremely small samples is a challenge. This due to the fact that the chosen cases in the study of this sort is asked to perform a heroic role and represent a population of cases much larger than the case itself. Additionally, chosen cases must also achieve variation on relevant dimensions. A requirement Seawright and Gerring (ibid.) claims is often unrecognized. Furthermore, selection of case is a form of sampling and the process is highly relevant to address since one or a few cases cannot be based on theories of the statistical probability of selection (Curtis et al. 2000).

Purposive sampling, in contrast to probability sampling, is a widely used method of sampling cases where the objective is to sample in a strategic way so that the cases are relevant towards the research questions. What would be *bias* in statistical sampling, and therefore a weakness, becomes intended focus in qualitative sampling, and therefore a strength (Patton 2015). Furthermore, Patton (ibid.) argues that in order to sample purposefully, the researcher must first determine the selection criteria. Selection criteria are attributes that are crucial for the study and will directly reflect the purpose of the study. In purposive sampling cases are chosen because of their relevance to the research as well as for convenience, access, and geographical proximity (Yin 2003).

Pursuant to above, purposeful sampling was selected as the methodology for selecting case companies in this thesis, being the most appropriate given the overall research strategy. The criteria for the case companies to be eligible objects are:

- Case company started small and been though an exponentail growth
- Case company that develop and sell products based on semiconductors
- Case company that has a global presence and/or sources globally
- Accessible interview object that knows the company's growth phase

Based on these criterion, the companies presented in Table 2.1 were chosen for the case study. A more elaborate description of each company will follow in chapter 4.

Table 2.1: Case company overview (Fingerprint Cards 2019; Tobii 2019; H&D Wireless 2019)

Company	*Net Sales (TSEK)*	*Number of Employees*	*Active Since*
Fingerprint Cards	1 535 100	314	1997
Tobii	1 302 200	917	2001
H&D Wireless	4 949	30	2009

Interviews

An interview is a discussion with a purpose between two ore more people (Kahn and Cannell 1957). Saunders, Lewis, and Thornhill (2007) elaborates that there are three types of interviews: structured, semi-structured and in-depth/unstructured. The characteristics of these strategies are presented in Table 2.2. Structured interviews refer to questionnaires based on a standardized set of questions and can subsequently be used in quantitative analysis. Semi-structured interviews may differ in the exact form of the interview from case to case but the same themes and questions are raised. This gives the advantage of rearranging questions and add follow-up questions during the interview, enabling more in-depth knowledge to be extracted. Lastly, unstructured interviews are informal and award the interviewee the opportunity to freely elaborate on themes and aspects, there is no predetermined list of questions (ibid.).

Table 2.2: An overview of the different interview types (Höst, Regnell, and Runeson 2006)

	Unstructured	*Semi-structured*	*Structured*
Focus	How individuals qualitatively experience a phenomenon	How individuals qualitatively & quantitatively experience a phenomenon	Researcher aims to find relations between concepts
Interview questions	Interview guide with themes to cover	Mix of open and closed questions	Closed questions
Objective	Exploratory	Descriptive & explanatory	Descriptive & explanatory

Due to the exploratory focus of the study, semi-structured interviews are identified as the most suitable. When conducting interviews with the case companies a semi-structured approach was used since this part of collecting data to the study is characterized by a descriptive and explanatory situation. Furthermore, the semi-structured interviews were

used to identify similarities and differences between the involved companies as well as identifying key strategies.

2.3.2 Literature Review

The literature review is a method of thought organization, and a record of evidence gathered (Brewerton and Millward 2001). According to Saunders, Lewis, and Thornhill (2007) this is a fundamental step in the research process due to two reasons. Firstly, the preliminary search that helps to generate and refine the research idea. Secondly, as the *critical literature review* that enables the researcher to demonstrate awareness of the subject and find the appropriate place for the research in a wider academic context. The literature review should begin in a wide range and subsequently adapt a narrower scope as the research area becomes clearer (Höst, Regnell, and Runeson 2006). Saunders, Lewis, and Thornhill (2007) argue that the review shall start early and continue throughout the whole research. However, when a pattern starts to arise, and the subjects becomes clearer, the literature can be sorted and ordered. This will enable the researcher to be more selective (Brewerton and Millward 2001).

The available literature can be divided into three categories; primary, secondary, and tertiary (Table 2.3). Often as information flows from primary to secondary to tertiary sources it becomes less detailed and authoritative but more easily accessible (Saunders, Lewis, and Thornhill 2007).

Table 2.3: An overview of available literature sources (Saunders, Lewis, and Thornhill 2007)

Primary	*Secondary*	*Tertiary*
Reports	Books	Indexes
Theses	Journals	Abstracts
Emails	Newspapers	Catalogues
Conference proceedings	Government publications	Encyclopaedias
Company reports		Dictionaries
Unpublished manuscripts		Bibliographies
Government publications		Citation indexes

According to Rowley and F. Slack (2014), the literature search is a lengthy and complex task, in addition to selecting appropriate types of sources, a literature review strategy is advisable (Table 2.4).

Table 2.4: Literature review strategies (Rowley and F. Slack 2014)

Literature review strategies
1. Citation Pearl Growing
An easy approach appropriate for a newcomer to the topic. The review starts from a limited number of documents, ans successively expands.
2. Briefsearch
Retrieves a few documents crudely and quickly. A briefsearch is often a good starting point, for further work.
3. Building Blocks
A large number of documents is retrieved in a lengthy process by using variants of terms originating in the research area of interest.
4. Successive Fractions
Searching within an already retrieved set of documents can be used to eliminate less relevant or useful documents

The implemented literature process in this thesis is a combination of the *briefsearch* and *building blocks* strategy as the scope of the literature review was not entirely fixed on beforehand. Since the relevance of different theoretical models were not determined and no previous work (except for a limited number of theses touching the subject) was readily available. Furthermore, a number of sources were selected to be included in the final catalogue of sources. These were prioritized due to either their high number of citations, author's prominence, or general relevance to the topic.

2.3.3 Archival Research

Archival data refers to, for example, meeting minutes, organizational charts, and financial records (Runeson and Höst 2009). Taking part of archival data enables a better understanding for the researcher. However, according to Runeson and Höst (ibid.) it can be a challenge to properly assess the quality of this archival data. Therefore, there was always a quality verification process with the relevant case company when using archival data in this project.

2.4 Analysis of Research Strategy and Design

As discussed in 2.2.1, the research strategy can take the form of a deductive, inductive or abductive approach. This is the case for the analysis process as well, especially when analyzing qualitative data. Deductive approaches are however usually disfavored, due to the risk of closing the investigation prematurely, and the risk of introducing theories that are not aligned with the views of participants in a social setting (Saunders, Lewis, and Thornhill 2007). On the other hand, in the inductive approach data are collected and subsequently analysed in order to find themes and patterns to follow up and focus on. There is no theoretical framework in place, instead the theory emerges from the analytical process. Subsequently, relationships in the data are used to form and test hypotheses (ibid.). Finally, the abductive approach is, as previously explained, a combination of the inductive and deductive approach (Dubois and Gadde 2002).

To analyze the empirical data and identify cross-case findings a matrix containing the research questions on one axis and the interviewed companies on the other axis was created. Findings from each company where added to the matrix and thereafter analysis was preformed to identify topics that occurred several times.

2.5 Research Quality

Bryman and Bell (2011) argue that for evaluation of the quality of business research, the level of reliability, generalizability, and validity are commonly used as criteria. Regarding qualitative research, the trustworthiness is many times questioned by positivists, most likely because of the concepts of validity and reliability cannot be addressed in the same way in naturalistic, quantitative, research (Shenton 2004). Many writers within the field of research methods have attempted to incorporate measures that deal with these issues. Many naturalistic investigators have however, preferred to redefine trustworthiness for qualitative research using different terminology to distance themselves from the positivist paradigm. One of those investigators, Guba (1981) proposes for different criteria for qualitative researchers to ensure the trustworthiness (Table 2.5).

Table 2.5: The four dimensions of research quality (Guba 1981)

Aspect of research quality	*Description*
Credibility	Confidence in the truth of the findings
Transferability	Degree of applicability of the findings in other contexts
Dependability	Showing that the findings are consistent and could be repeated
Conformability	Degree of neutrality or the extent to which the findings of a study are shaped by the respondents and not researcher bias, motivation, or interest

Firstly, credibility is the equivalent of internal validity in quantitative research and is related with the aspect of truth-value (Korstjens and Moser 2018). It establishes whether the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views. Secondly, transferability is defined as the degree to which the results of qualitative research can be transferred to other contexts or situations. The researcher's responsibility is to provide information with respect to the research process in order to determine the level of transferability (ibid.). The idea is to enable the reader to assess whether the findings are transferable to their own setting, the so-called transferability judgement. Thirdly, dependability is the stability of findings over time and involves participants' evaluation of findings, interpretation, and recommendations of the study such that all are supported by the data received from participants of the study (ibid.). Finally, confirmability refers to the degree wo which findings of the study can be confirmed by other researchers. Confirmability is concerned with establishing that data and interpretations of the findings are not figments of the researcher's imagination, but clearly derived from the data (ibid.).

Throughout this thesis, the *credibility* of the research material has been confirmed by using sources published by well-recognized journals or publishers. Whenever necessary, original data have been used to validate secondary sources, such as articles and books. Regarding interviews with the case companies, which to a large extent is a mirroring of each interviewees' subjective experience and opinions, the credibility was more difficult to ensure. Because of the current situation with the Covid-19 pandemic most of the interviews were conducted without a physical meeting. Measures were still taken to validate and confirm answers in order to make sure that the author did not misinterpret certain facts. Secondly, the *transferability* of this project relies on the content of this specific chapter (2), which should provide sufficient information to replicate the research process. Thirdly, in terms of *dependability*, the evaluation should be clear as the findings in addition to interpretations, in all cases, have been made on the basis of the literature study and interviews. Lastly, the level of *confirmability* should correlate with the reliability of the empirics, whose quality assurance already have been clarified.

Chapter 3

Theory

The following chapter will outline the theoretical framework upon which the case study and analysis will be built. The chapter is divided into four major subjects, supply chain management, product characteristics, industry characteristics, and supply chain organization.

3.1 Supply Chain Management

3.1.1 Defining the Supply Chain

According to Mentzer et al. (2001), a supply chain is defined 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."* The modern supply chains are highly complex and dynamic due to constantly changing in relationships and configurations (Hausman 2004). Furthermore, the emergence of the internet as a technology enabler has increased the number of customer interactions and product configurations, thereby presenting pressure and demands on supply chain management (SCM) (ibid.).

3.1.2 Managing the Supply Chain

The main concern of supply chain management is to create seamless and agile supply chain processes that enable the chain members to meet customer needs, including satisfied quality and product variety, at the lowest possible cost (Simatupang and Sridharan 2005). Due to the globalization and the competitive landscape in the business environment SCM has become a key management focus which could yield competitive advantage (Anand and Grover 2015). Mentzer et al. (2001) defines SCM as *"the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."* It is complex to manage all the wide range of individual processes that together form the supply chain. One illustration of supply chain management is presented in Figure 3.1.

The following components are included in SCM according to Mentzer et al. (ibid.): information sharing, shared risks, cooperation among entities in the supply chain, aligning customer service goals and focus, integration of key processes, long-term relationships, and interfunctional coordination. Properly managed this will result in lower costs, improved customer value, improved customer satisfaction, and a strengthened competitive advantage. These are considered to be the key objectives of a supply chain. However, to make the right trade-offs between efficiency and effectiveness it is important to know what the value proposition of the company is. Being efficient means reducing costs in the supply chain, such as lowering inventory levels and leveraging on economics of scale, whereas,

being effective means providing availability by always having items in stock and ensuring high customer service. Nevertheless, what makes the supply chain profitable comes down to achieving the right balance between efficiency and effectiveness (ibid.).

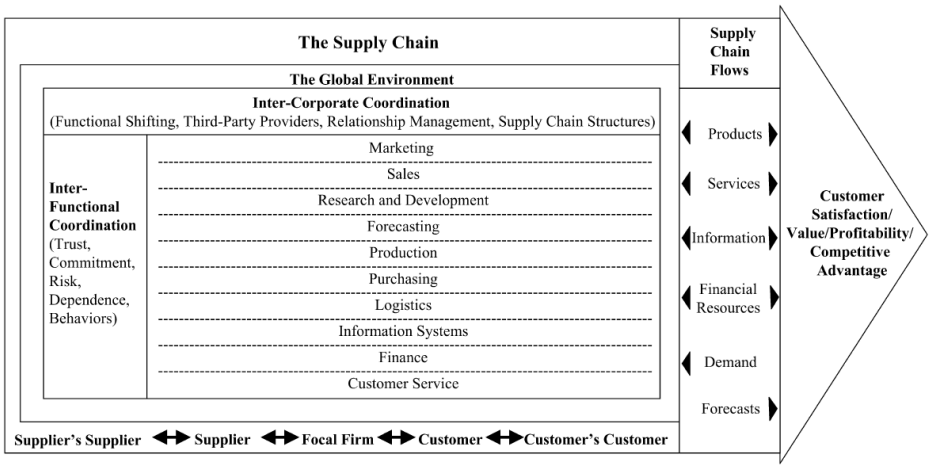

Figure 3.1: Conceptual supply chain management model (Mentzer et al. 2001)

Supply Chain Strategies

Lee (2002), has based on different conditions and the surrounding environment, identified four different supply chain strategies that a company could pursue (Table 3.1): *efficient*, *risk-hedging*, *responsive* and *agile*. *Efficient supply chains* should utilize strategies aimed at creating the highest cost efficiencies in the supply chain. That means eliminate non-value adding activities, optimization in capacity, pursue economics of scale, and accurate distribution of information across the supply chain. *Risk-hedging supply chains* should implement an efficient supply chain downstream and hedge for uncertainties upstream. As there might be supply issues with certain components, the risk of disruption should be secured by multiple manufacturing plants, multiple sources, or by pooling safety stock with other companies. *Responsive supply chains* are supply chains that pursue strategies aimed at being responsive and flexible to the changing and diverse needs from customers. Ways to become responsive are excess inventory and capacity together with build-to-order and mass customization processes. *Agile supply chains* should implement strategies towards becoming responsive to demand uncertainty while hedging for supply uncertainty upstream. The agility comes from mitigating the risks of supply shortages while still being responsive and flexible to customer needs.

Table 3.1: The four supply chain strategies (Lee 2002)

	Demand uncertainty low	*Demand uncertainty high*
Supply uncertainty low	Efficient supply chains	Responsive supply chains
Supply uncertainty high	Risk-hedging supply chains	Agile supply chains

Based on the company's current situation Lee (2002) argue that the combinations of uncertainties benefit from different supply chain strategies. These strategies are presented in his model (Table 3.1). When products have both low demand and supply uncertainties, the basis of completion is efficiency. This can be gained by productivity improvements and by having highly effective logistics system. For products with a stable demand, it is often possible to ship products directly from the manufacturing source to the customer without going through distribution centers (ibid.). Companies with innovative products together with a unstable supply processes face a major challenge according to Lee (ibid.). The appropriate strategy here is to establish agile supply chains. Because of shorter product life cycles, the pressure for dynamically adjusting and adapting a company's supply chain strategy is critical. Using the internet to develop agile supply chains with information sharing, coordination, and postponement has enabled companies to compete successfully in their market places. The challenges are great, but so are the opportunities (ibid.).

For achieving strategic fit between the company's supply chain and competitive strategies Chopra and Meindl (2006) present a three step model:

1. **Understanding the customer and supply chain uncertainty:** First, a company must understand the customer needs for each targeted segment and the uncertainty the supply chain faces in satisfying these needs. These needs help the company define the desired cost and service requirements. The supply chain uncertainty helps the company identify the extent of the unpredictability of demand, disruption, and delay that the supply chain must be prepared for.
2. **Understanding the supply chain capabilities:** There are many types of supply chains, each of which is designed to perform different tasks well. A company must understand what its supply chain is designed to do well.
3. **Achieving strategic fit:** If a mismatch exists between what the supply chain does particularly well and the desired customer needs, the company will either need to restructure the supply chain to support the competitive strategy or alter its competitive strategy.

3.1.3 Supply Chain Performance

The SCOR Model

Since it is a complex task to define the right performance measurements in the supply chain, Chae (2009) proposes that companies use the Supply Chain Operations Reference (SCOR) model to identify proper metrics for measuring the supply chain. The SCOR model provides a framework that links business process, metrics and technology features into a unified structure to support communication among supply chain partners and improvement of related supply chain activities (Council 2008). The SCOR model contains five core management process (Figure 3.2): (1) *plan,* (2) *source,* (3) *make* (4) *deliver,* and (5) *return.*

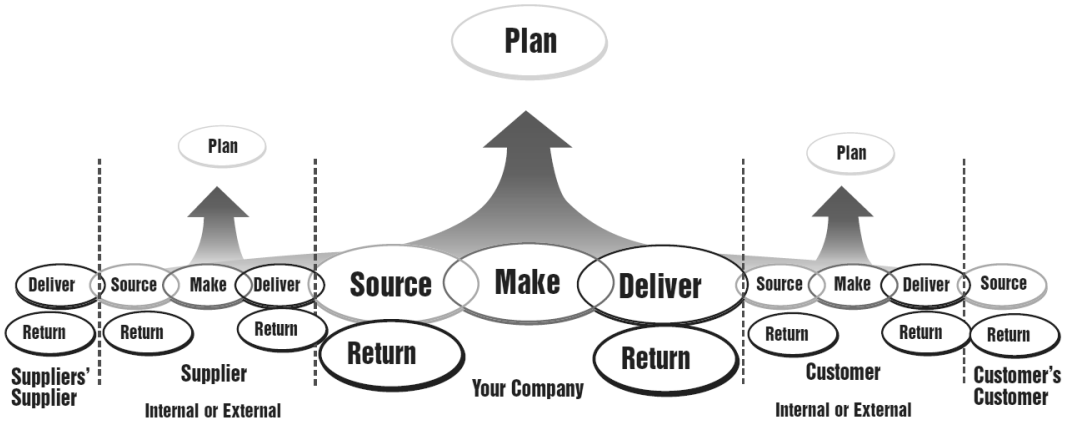

Figure 3.2: SCOR Core Management Processes (Council 2008)

Plan refers to the process of aligning and organizing the other categories in the SCOR model to best fullfil the supply chain requirements, including sourcing, production, and delivery. *Sourcing* is related to activities regarding procurement of goods as well as identify and select supply sources. This includes managing business rules, assess supplier performance, and maintain data. The *make* process encompasses activities that are part of the production process, where produced products or components are transformed to a final state that is to be delivered to the customer. When the production step is completed the next step will be to *deliver* the product. This means transporting the product either to its final destination or to a temporary location for storing. *Return* concerns the return flow of defective products including rules, policies and performance measurements. (ibid.). The SCOR model has recognized five performance attributes that should be used to set the strategic direction of the supply chain, each being provided with diagnostic metrics for three process levels in the supply chain. The levels are (ibid.):

- *Level 1 metrics,* also known as *key performance indicators,* measures the overall heath of the supply chain
- *Level 2 metrics* further break down level 1 metrics to identify the root cause of the performance
- *Level 3 metrics* are diagnostic metrics for the level 2 metrics, helping companies to identify the root cause for a problem

The SCOR performance attributes and their level 1 metrics are presented in Table 3.2.

Table 3.2: SCOR Performance Attributes (Council 2008)

	Attribute	*Strategy*	*Key Performance Indicators*
Customer	Relability	Consistently getting the orders right and fulfill product quality requirements	– Perfect order fulfillment
	Responsiveness	The consistent speed of providing products/services to customers	– Order fulfillment cycle time
	Agility	The ability to respond to changes in the market (external influencers)	– Upside supply chain adaptability – Downside supply chain adaptability – Overall value at risk
Internal	Cost	The cost associated with managing and operating the supply chain	– Total SCM costs – Cost of goods sold
	Assets	The effectiveness in managing the supply chain's assets in support to fulfillment	– Cash-to-cash cycle time – Return on SC fixed assets – Return on working capital

Since SCOR has a broad applicability and cover the entire chain, it has become a preferred tool to use when evaluating the performance of a supply chain (Council 2008). However, there are several hundred metrics to choose from in the SCOR model and to be successful the chosen metrics needs to be aligned with the company's overall business strategy, product strategy, and value proposition (Hausman 2004).

Choosing the Right Metrics

As every company is different from another it is important that the supply chain is aligned with the overall business strategy (Chopra and Meindl 2006). According to Hausman

(2004) the metrics of the supply chain need to be tailored to the company's value proposition. Furthermore, Rompho (2018) emphasizes that metrics must be tailored in context with the company's specific organizational and external factors. This is especially the case regarding large corporations and a startup company. The current research done in the field of performance metrics are mainly focused on already big and established companies which makes the results not applicable (ibid.). Even though there is not much research conducted regarding performance metrics for startups, measuring performance is still highly relevant in order for the startup to know where and how to improve to become successful (Davila and Foster 2005). According to Rompho (2018) the most significant difference between the metrics used for large companies and the metrics startups should use is their time perspective view. Large companies tend to focus more on long-term planning, whereas startups have a more short-time focus. For a startup, one objective is to generate enough revenue to continue operations and enable further search for a sustainable business model. Another objective is to provide confidence for potential future growth of the company that could result in additional investment from investors who see the potential for future revenue (Lester, Parnell, and Carraher 2003).

3.1.4 Global Supply Chain

Almost every supply chain is international to some degree and the companies will face some major challenges due to the globalized world (Skjott-Larsen et al. 2007). According to Skjott-Larsen et al. (ibid.) some of these challenges are:

- Supplying a unique value proposition to customers around the world.
- Meeting intensifying competition from around the world.
- Adapting to multiple national environments with differing cultures, political and economics systems, business practices, wax and legal systems.
- The global politics of economics and trade relationships.
- The availability and level of infrastructure in transport and telecommunications.
- The complexity of managing an extended network of supplier, production plants, intermediaries, and customers in the supply chain.
- The impact of geography: time and distance and the location of markets.
- Responding to changes in monetary exchange rates by shifting production to lower cost sites, with the consequent changes in network configurations and routings.

Although the globalization is strong, according to Christopher (2016), there is still a requirement for local variation in many product categories. Unless there is a high level coordination the complex logistics of managing global supply chains may result in higher costs and extended lead times. However, it is clear that the global brands and companies now dominate most markets. A steady trend towards the worldwide marketing of products under a common brand umbrella can be identified during the past two decades (ibid.). SMEs also play an important role in this modern economics because of their flexibility and ability to innovate. With the advancement in technology and the erosion of trading boundaries, even the smallest companies now has the potential to trade in this global economy (Tan, Smith, and Saad 2006). Tanev (2012) presents several reasons for a SME to early choose a global market strategy. For example, one reason is that market in the home country is not large enough to support the scale the company needs to operate. Another reason is that the company operates in a knowledge-intensive or high-technology sector. To survive and grow in this new global economy, SMEs have to re-examine and modify their competitive strategies. Forming strategic alliances can be an effective way to diffuse new technologies rapidly, to enter new markets, ant to learn quickly from the leading companies in a given field (Tan, Smith, and Saad 2006).

3.1.5 Strategic Purchasing

Chen, Paulraj, and Lado (2004) argue that strategic purchasing will drive competitive advantage and their research result provide robust support for the links between strategic purchasing, supply management, customer responsiveness, and financial performance of the buying company. Fundamentally, the term strategic purchasing suggests that purchasing is managed in a strategic way within a company (Giunipero et al. 2014). More specifically, it implies that purchasing contributes to, and is aligned with, the overall corporate objectives and strategies. Where purchasing in many companies historically used to have limited visibility and influence in organizations it has climbed to the top of the table within many organizations that understand the need for a high-performance purchasing function (ibid.). Furthermore, Giunipero et al. (ibid.) argue that strategic purchasing plays a key role in the sustainable economic development.

Moreover, the choice of the number of suppliers can be a important strategic decision in purchasing risk management (Costantino and Pellegrino 2010). When possible it could be beneficial to have more than one supplier to reduce the risk of production interruptions. Costantino and Pellegrino (ibid.) in Table 3.3 presents advantages and disadvantages of single respectively multiple sourcing strategy.

As discussed in Van Weele (2014), a company could choose to implement either a decentralized or a centralized purchasing structure. A *decentralized* structure can be found in companies with a business-unit structure with the major characteristics that the business-unit manager is responsible for the unit's finances results. Hence, the management of the business-unit is responsible for all its purchasing activities. This structure is particularly attractive to conglomerates that have a business-unit structure, and where each unit purchases products that are unique and different from those of the other units. In a *centralized* purchasing structure, the corporate level decisions on product specifications are made centrally. The main advantage is that, through co-ordination of purchasing better conditions from suppliers can be achieved. Furthermore, this structure will facilitate efforts towards product and supplier standardization. (ibid.)

Table 3.3: Advantages and disadvantages of single respectively multiple sourcing strategy (Costantino and Pellegrino 2010)

	Single sourcing	***Multiple sourcing***
Advantages	– Partnership between buyers and suppliers allows cooperation, shared benefits and long-term relationship based on high levels of trust – Reduction of risk of opportunistic behaviour – Large commitment of the supplier that is willing to invest in new facilities or new technology – Lower purchase price resulting from reduced production costs, due to better knowledge of the manufacturing process by supplier and achieved economies of scale	– Alternative sources of materials in case of delivery stoppage by a supplier – Reduced probability of bottlenecks due to insufficient production capacity to meet peak demand – Increased competition among suppliers leads to better quality, price, delivery, product innovation and buyer's negotiation power – More flexibility to react to unexpected events that could endanger supplier's capacity
Disadvantages	– Great dependency between the buyer and the supplier – Increased vulnerability of supply – Increased risk of supply interruption, especially for asset specific products	– Reduced efforts by supplier to match buyer's requirements – Higher costs for the purchasing organization

3.2 Product Characteristics

3.2.1 Process Choice

Generically there are five types of manufacturing processes: project, jobbing, batch, line, and continuous production (A. Hill and T. Hill 2009). A company may find that in reality it has little option but to choose the one appropriate process. However, a company must be aware of the business implications involved in the choice it is forced to go along with and that the trade-offs associated with these dimensions are themselves fixed (ibid.).

- **Project** – this is used for one-off products that have to be built on site because it is difficult or impossible to move once they have been made. Consequently, the resources involved need to be brought to the site and released for reuse elsewhere when they are no longer needed.
- **Jobbing** – for one-off products that can be moved once completed, jobbing is normally preferred process. The responsibility for making the product is typically given to a skilled person (or group of skilled people), who decides how to best make it and then completes all or most of the operations involved, including checking quality conformance at each stage.
- **Batch** – with an increase in volumes and the repeat nature of products, companies select batch as the effective way to meet the requirements involved. Because the products are repeated, with a corresponding increase in volumes, companies can now evaluate at each of the operations steps. This includes engineering time to decide how best to make a product, jigs and fixtures to facilitate the completion of certain operations and equipment purchased with an eye to making these and other products with similar characteristics. However, the volumes involved do not warrant the purchase of dedicated equipment. The operations necessary to complete a product are therefore not linked and are said to be *decoupled*.
- **Line** – when demand is sufficient to justify dedicating equipment solely to making a specified range of products, a line process is normally chosen. The operations necessary to complete a specified range of products are linked together so that each product goes from one operation directly to the next and so on. The operations necessary to complete a product in this instance are said to be *coupled*. The operations involved will physically take part in assembling the products.

- **Continuous processing –** when the demand for a product is such that the volume required necessitates a process being used all day and every day, further investment is justified. Restricted to the products whose characteristics enable them to be moved between processes, the equipment in this instance is designed to automatically transfer the product from one stage to the next, check the quality conformance within the process and make adjustments where necessary. The investment associated with this is warranted by the volumes involved.

3.2.2 Type of Product

Similar to the earlier mention framework by Lee (2002), Fisher (1997) has set up a framework for choosing the right supply chain strategy based on the nature of the demand for the products offered by the company. According to Fisher (ibid.) a supply chain can be categorized as either *efficient* or *responsive* and a product can be either *functional* or *innovative*. As visualized in Table 3.4 a functional product benefits from an efficient supply chain and an innovative product benefits from a responsive supply chain.

Table 3.4: The framework developed by Fisher (1997)

	Functional Product	*Innovative Product*
Efficient	Match	Mismatch
Responsive	Mismatch	Match

Furthermore, Fisher (ibid.) argue that functional products typically have longer life cycles compare to innovative products that typically are more sensitive for fashion and new technology. Presented in Table 3.5 is the difference between the two product types.

Based on the type of product or service a company is selling, the main purpose will be either to supply a *predictable demand* efficiently at the lowest cost or to respond quickly to *unpredictable demand* in order to minimize stock outs, forced markdowns and obsolete inventory. The responsive strategy will generate a higher cost while the efficient strategy instead is operated with lower flexibility. Chopra and Meindl (2006) provide a framework that also connects what type of supply chain that is appropriate based on the characteristics of the demand (Figure 3.3).

Both frameworks conclude that an efficient supply chain is the best fit for a product with a predictable demand and that a responsive supply chain is the best supply chain for a product with an unpredictable demand.

Table 3.5: Aspects of demand presented by Fisher (1997)

Aspects of Demand	*Functional Product*	*Innovative Product*
Product life cycle	More than 2 years	3 months to 1 year
Contribution margin	5% to 20%	20% to 60%
Product variety	Low (10-20 variants per category)	High (often millions of variants per category)
Average margin error in the forecast at the time production is committed	10%	40% to 100 %
Average stockout rate	1% to 2%	10% to 40%
Average forced end-of-season markdown as percentage of full price	0%	10% to 25%
Lead time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

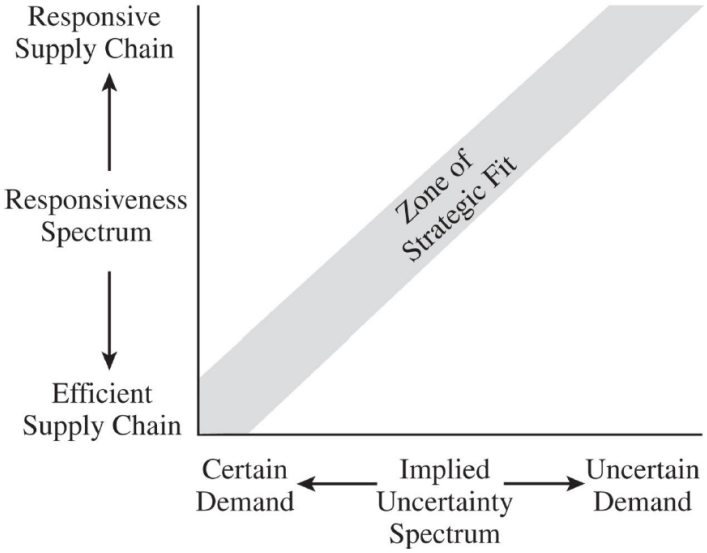

Figure 3.3: Zone of Strategic fit (Chopra and Meindl 2006)

3.3 Industry Characteristics

3.3.1 Customer Order Decoupling Point

The Customer Order Decoupling Point (CODP) is traditionally defined as the point in the value chain for a product, where the product is linked to a specific customer order (Olhager 2010). Different manufacturing situations such as make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO), and engineer-to-order (ETO) all relate to different positions of the CODP (Figure 3.4). The different situations are related to the ability of manufacturing operations to accommodate product customization or a wide product range. Thereby the CODP divides the material flow that is forecast-driven (upstream the CODP) from the flow that is customer order-driven (downstream the CODP). (ibid.)

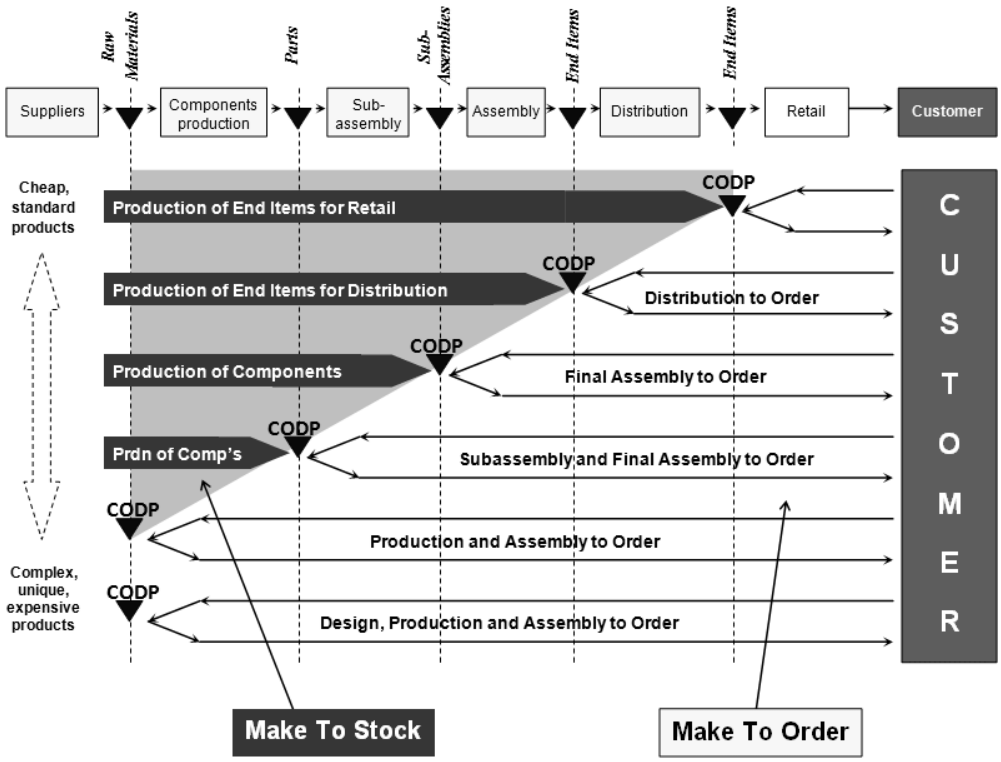

Figure 3.4: Variety of possibilities to position Customer Order Decoupling Point (Andreev 2009)

Another way of characterizing the graduation between MTO and MTS is by contrasting the total length of time customers have to wait between asking for a product or service and receiving it, demand time and the total throughput time (N. Slack et al. 1995). Demand

time is the total time a customer will have to wait from placing an order to receiving the goods. Throughput time is the total processing time for an order, i.e. the sum of demand time, purchasing time and production time. This means that if the customer is not willing to wait during the throughput time, which often is the case, the company will have to act on speculation of eventually receiving an order (N. Slack et al. 1995).

3.3.2 The Semiconductor Industry

Depending on the manufacturing strategy, semiconductor product companies can be segmented into either an *Integrated Device Manufacture (IDM)* or a *Fabless* company (Hurtarte, Wolsheimer, and Tafoya 2011). Furthermore, to complete the two competitive business models, Hung, Chiu, and Wu (2017) argue that a third *foundry* segment shall be included.

- **Integrated Device Manufacture (IDM)** – have their own semiconductor manufacturing plants and resources and thus have direct control over their capacity, processes and resources.
- **Fabless** – outsource all semiconductor manufacturing to a foundry that has semiconductor manufacturing as core business.
- **Foundry** – focus on manufacturing of semiconductor products and are not involved in IC design.

Additionally, a *hybrid* version has been established. These are typically IDMs who outsource some of their manufacturing requirements to foundries when they need some additional capacity or some other processes not available in-house. This hybrid strategy allows the IDMs to bypass or delay additional capital expenditures (Hurtarte, Wolsheimer, and Tafoya 2011).

According to Hung, Chiu, and Wu (2017) the combination fabless – foundry model has two major advantages. Firstly, risk sharing where fabless companies are risk-free in terms of the capital expenditure for building semiconductor fabrication plants. By pooling the demand from various fabless companies, foundry companies reduce the risk of rapid decrease in demand caused by sales failure of individual fabless companies. Moreover, foundry companies can provide extra capacity to IDMs that face a surge in demand or inefficient capacity. This cooperation not only allows IDMs to reduce their investment in equipment and capacity but also provides flexibility to their production. Secondly, the fabless – foundry model can shorten the cycle time from IC design to IC mass production by using a modular design and manufacturing concept. Fabless companies can design ICs based on various

component modules, most of which have been validated by foundry companies as being reliably manufactured. If this opportunity is applicable for the fabless company, the outcome is cost savings because of the shared production development as well as reduced time to market since the validation process is already ongoing or completed.

3.4 Supply Chain Organization

3.4.1 Orchestrated Networks

Prahalad and Hamel (2006) first introduced the concept of core competences in their article in 1990. Before then, most companies valued vertical integration highly but through the Internet the possibility to cooperate grew. The advantage of specializing in core competencies and outsourcing other functions to gain increased competitiveness was discovered. Based on that, the term "orchestrated networks" was developed highlighting the importance of organizing the value-creating process, rather than owning and controlling all resources. The idea with orchestrated networks is that a company should focus on their core capabilities and outsource other functions to companies that can benefit from scale of economics or are better at managing the resources. The company doing that, becomes the core company orchestrating the network (Figure 3.5). It is common that the core company has the responsibility to align all entities and to be the interface outward from the network against customers. Managing all entities in the network can be a challenging task and the main concern in supply chain management. However, there are some risks connected to outsourcing. Firstly, it can be hard to specify deliverables and quantify a price. Secondly, it might be challenging to know if a contractor actually can deliver. Finally, it can be hard to get the knowledge back if it is once outsourced. (Edgren and Skärvad 2014)

A high-tech, born global, startup company is dependent on its network for several reasons, such as being able to raise funding, scale production, and deliver units across the world. Both Cavusgil and Knight (2015) and Hite and Hesterly (2001) argue that a vital part to born global companies competitive advantage should include networks of customers, suppliers, partners, and external stakeholders. To secure financing, as well as other resources, a startup's network of investors, mentors, and partners is critical for survival and growth. Furthermore, a startup generally has a lower degree of legitimacy than companies in later growth stages. Founders usually have a good understanding of the product, however, they might face uncertainty regarding markets, customers, and scaling the business as the company is trying to achieve something it has never done before. Thus, startups benefit from

external resources with the knowledge that cannot be produced internally. (Hite and Hesterly 2001)

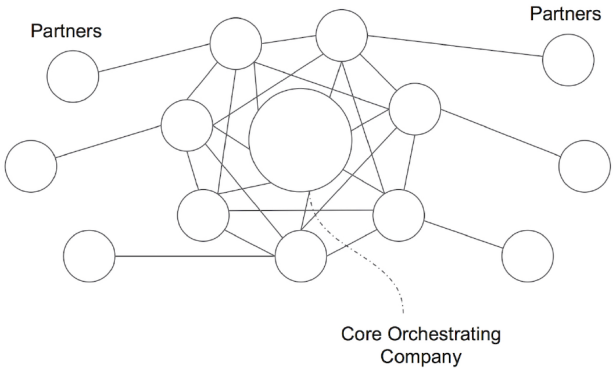

Figure 3.5: Representation of Core Orchestrating Company (Edgren and Skärvad 2014)

3.4.2 Clusters

The definition of a cluster is when multiple companies within the same sector or industry are geographically located near each other. Companies located in these clusters have been found to exhibit higher innovation performance, rates of growth, and survival than companies not located in clusters (Gilbert, McDougall, and Audretsch 2008). The short geographical distances makes it easy for companies to communicate, although the Internet has made this force weaker, as well as finding skilled labor. Companies in a cluster tend to perform better and have a higher competitive advantage due to the superior access to knowledge (Edgren and Skärvad 2014). According to Gilbert, McDougall, and Audretsch (2008) this is also true for new ventures, especially with technology knowledge spillover that contributes to product innovation. The downside of a cluster might be higher costs due to competitiveness regarding office space and labor.

Chapter 4

Empirics – Case Studies

In this chapter, findings from the conducted semi-structured interviews will be presented. Firstly, a summary of the case companies is given. This is then followed by an introduction along with the results from each interviewed company. Lastly, a summary presenting cross-case findings from the empirics is presented.

4.1 Case Company Data

Three companies, as seen in Table 4.1 were interviewed in this project. They are all active in the industry of semiconductors and located in Sweden.

Table 4.1: Case company overview (Fingerprint Cards 2019; Tobii 2019; H&D Wireless 2019)

Company	*Net Sales (TSEK)*	*Number of Employees*	*Active Since*
Fingerprint Cards	1 535 100	314	1997
Tobii	1 302 200	917	2001
H&D Wireless	4 949	30	2009

4.2 Case Company A – Fingerprint Cards

4.2.1 Introduction to Fingerprint Cards

Fingerprint Cards, hereafter Fingerprints, founded 1997, is a leading global biometric company with Swedish roots. Fingerprints develops biometric systems consisting of sensors, algorithms, software and packaging technologies. Most of their current product offering consists of fingerprint sensors where the main customers are companies that manufacture smartphones. As the usage of biometric solutions expands Fingerprints also develop and offer solutions in the market segments of smart cards, vehicles and internet of things (IoT). (Fingerprint Cards 2019) During the 2010s the biometric fingerprint sensor for the smartphone market was introduced and later lead to a rapid increase in sales and scale up of the company. Since this period of time was the most interesting for this project Thomas Rex and Jonas Spannel were interviewed as they were Senior VP Sales respectively Senior VP Operations & Quality at Fingerprints during this time.

Fingerprints is a fabless company that uses suppliers to produce their semiconductor products. This is described as a necessity for a company of Fingerprints' size, as wafer foundries are highly specialized companies, making huge investments in silicon wafer manufacturing. The products are produced by several foundries located in east Asia and then shipped to a third-party logistics company located in Hong Kong. The production was managed

from the Operations department in Sweden (it was later moved to Asia). The smartphone industry where Fingerprints operate is characterized as a fashion industry meaning that visual aspects of the products are highly important in order to satisfy the customers. (Rex 2020; Spannel 2020)

4.2.2 Critical Success Factors

Since Fingerprints is a company without their own manufacturing they are depending on the relationship and allocation from the manufacturing supplier, i.e. the foundry. This relationship and trust from the foundry is crucial for enabling a scale up. Furthermore, it is important to get the opportunity to buy directly from the supplier and avoid a distributor in between. The way to accomplish this, according to Fingerprints, is firstly to present and convince the foundry about the potential of the company and secondly through engagement by the top management. In the electronics industry top management engagement regarding supply chain affairs are necessary.

Another important factor is the forecast and the associated sales and operations planning (S&OP) process. The business idea of a foundry is to manufacture semiconductor products to its customers. To become a profitable company and pay off the investment they need a certain utilization level in the factory. Since they only produce to their customers and have no own products they have to rely on the forecasts provided by Fingerprints and other customers. If a customer then places an order with another volume this will affect the utilization and profit for the foundry. Submitting several forecasts that later are changed to a lower volume order will probably lead to a lower allocation from the foundry than actually needed when the demand increases. This phenomena, named *second-guessing the forecast*, is important to avoid in order to not lose influence regarding the allocation. However, doing the opposite and submitting too low forecasts comes with the risk of not receiving the allocation necessary to satisfy the customers and avoid missing business opportunities. To balance this situation Spannel (2020) describes a well implemented S&OP process as a crucial step. A recommended approach is a monthly process where the demand firstly is determined and then secondly the supply is determined before the complete S&OP plan is authorized.

To streamline the supply chain and minimize the inventory and capital tied up Spannel (ibid.) emphasizes the importance to reduce the number of stock keeping units (SKUs) and avoid customer specific products as far as possible. Regarding inventory management Fingerprints successfully partnered up with a third-party logistics company who managed

storage and distribution of the products. Furthermore, it is crucial to be prepared and done with the implementation of the processes before the scale up starts. To accomplish this level of preparedness the company need a clear strategy and support together with the right conditions from the owners, board of directors, and corporate governance. The owners of Fingerprints made sure that there was a clear focus on the smartphone market and that the company had the right financial capability to implement processes and secure resources on beforehand.

4.2.3 KPIs during Growth Phase

From the presented KPIs Fingerprints highlighted the supply chain performance metrics of *supplier availability* and *procurement cost reduction* as the most important to trace. The motivation for supplier availability was that it is everything for a growing startup company where it is necessary to understand both the total capacity and awarded allocation. Regarding procurement cost reduction this is important to track and improve since this affects the business case.

An essential part is to understand the cost, both the manufacturing cost for the supplier and the market price. Spannel (2020) emphasizes that even if the manufacturing cost is known it does not mean that the buyer price is set. This depends on the number of potential buyers and which price they are willing to pay. Because of that the cost could be hard to negotiate and improve, even if the situation changes to the better if the company becomes a big and important customer. In a similar way, the lead time is hard to affect since the foundry uses a standardized process with low possibilities to improve. Instead, the way forward, is to continue to develop the S&OP process with confidence in the forecasts.

It is also essential to continuously review the quality system and make sure that the quality processes are updated so that the customers receive fast and clear feedback in case of nonconforming products. Once again Spannel (ibid.) argue that this process should be in place before the ramp up starts.

4.3 Case Company B – Tobii

4.3.1 Introduction to Tobii

Tobii, founded 2001, is a company who develops and sell products based on their eye tracking technology. Eye tracking is a sensor technology that makes it possible for a computer or other device to know where a person is looking. An eye tracker can detect the presence, attention and focus of the user. It enables unique insights into human behavior and facilitates natural user interfaces in a broad range of devices. The ability to control a computer using the eyes is also vital for people who are unable to speak or use their hands. (Tobii 2019)

Within the Tobii Group there are three business units that address the potential of eye tracking in various applications. Tobii Dynavox focuses on assistive technology for communication, Tobii Pro focuses on eye tracking solutions to study behavior and Tobii Tech on integration of eye tracking in consumer electronics and other volume applications. (ibid.) Since this project has a focus on scaling a startup the business unit Tobii Tech was scoped as the most interesting part of the Tobii Group. Interviews were held with Jonas Jakstad, Senior VP Global Operations, Catharina Hökfelt, Head of Strategic Sourcing and Sofie Jordeby, Head of Supply at Tobii Group.

The eye tracking technology industry is relatively young and Tobii is a world leading company within this industry. The interest for the technology is high but according to Jakstad (2020) the perfect high volume user case with eye tracking is still unknown. Furthermore, the price level for eye tracking technology is high because of the low volume sales, the short product cycle and the requirement for further development (Jakstad 2020; Hökfelt 2020).

4.3.2 Critical Success Factors

To be able to grow a company like Tobii the relationship with suppliers and partners is mentioned as the most critical success factor regarding the supply chain because of several reasons. It is important that the partner has a long term perspective and endurance to continue business even with an absent of volume increase. Furthermore, the technical competence regarding development of semiconductor products is crucial since this competence

is impossible to have in-house in a small company. Open communication and an information sharing environment with partners is also necessary to create a good foundation for future scale up. Finally, the selection of strategic partner could enable and introduce new business opportunities based on the partners existing business and network. (Jakstad 2020; Hökfelt 2020; Jordeby 2020)

The lead time for the products Tobii sells are too long to be able to produce after a customer order which means that Tobii produce their products based on forecast and sell from an inventory. The forecast process in a critical step to secure business continuity while avoiding having too much products in inventory. To succeed with the forecast process, Jordeby (2020) argue that the right people need to be involved internally and that the right level of product detail as well as the right frequency need to be achieved. This could be supported by implementing a S&OP or integrated business planning process with clear responsibilities within the company. Furthermore, since Tobii manufacture products based on forecast they need to minimize the number of SKUs and strive against standardized products as far as possible throughout the supply chain. To facilitate a minimized product range, Jordeby (ibid.) mean that support from the ERP-system as well as good communication with the logistics department is needed.

Since the product cycle is short and comes with rapid changes it is important that the supply chain organization cooperate closely with both the sales organization and the product management organization to facilitate good communication and an understanding towards the potential future business scenarios. In line with that, it is also crucial to have engagement from the top management regarding big strategic supply chain affairs, especially with partners in the US or Asia where the culture is more hierarchic compared to Europe. (Jakstad 2020; Jordeby 2020)

4.3.3 KPIs during Growth Phase

From the presented KPIs Tobii highlighted the supply chain performance metrics of *cost* and *procurement cost reduction* as the most important, with the motivation that for a low volume startup it is essential to keep track of the costs to enable scaling and ensure that it is possible to offer the products with an attractive price level.

Furthermore, flexibility as well as quality and delivery precision are highlighted as the most relevant KPIs to keep track of for a startup. Firstly, flexibility is essential for a small company with high demand uncertainty during the growth period. Although, a missed sales opportunity could be devastating for a company of that size. Secondly, quality is as always

an important factor both to satisfy the customer and to assure that the supplier fulfill the requirements. Thirdly, delivery precision is one way of measuring the performance and continuity of the supply chain and promised delivery dates. (Jakstad 2020; Hökfelt 2020; Jordeby 2020)

4.4 Case Company C - H&D Wireless

4.4.1 Introduction to H&D Wireless

H&D Wireless, founded 2009, is an IoT company located in Kista, Stockholm that develops hardware radio-modules and software for real-time locating systems (RTLS). The main market for these products are manufacturing companies that perform a transition towards smart factory and Industry 4.0. The technology enables one to track and trace products, tools and components to improve the logistics and bridge the information gap between physical assets and the company business system. The interviewed founder and CEO, Pär Bergsten has been active in this wireless semiconductor industry for more than 30 years and describes the industry as highly cyclical where mergers and acquisitions are common. Furthermore, the industry requires a high amount of invested capital as well as good risk management and timing with the market opportunity. (Bergsten 2020; H&D Wireless 2019)

Bergsten (2020) describes H&D Wireless as a company divided between the semiconductor industry and the cloud industry where they develop applications that are easily scalable and where the software is protected by the hardware due to application constraints. With that strategy the target is to secure business continuity and find applications where it is beneficial to develop and produce customized hardware. H&D Wireless has an outsourced manufacturing setup where most of the production is performed in Asia and then, based on the situation, the product is shipped to a customer, to a distributor or third-party logistics, or to H&D Wireless' facility in Sweden.

4.4.2 Critical Success Factors

Firstly, it is crucial to find the right market opportunity for a potential startup company. H&D Wireless found this opportunity when there was a market need to collect big data

and meanwhile both control and program a microcontroller unit (MCU). Especially the differentiation with customized software connected to the standardized hardware chips is mentioned as a success factor. Because of that H&D Wireless can offer customized software applications based on the standardized hardware which generate a potential bigger customer base that can contribute to the scale up of hardware demand. Secondly, it is beneficial to introduce new products to the market through a few selected strategic partners or customers. Both to receive immediate feedback and to gain advantage of their network to create awareness and interest for the new product. (Bergsten 2020)

Furthermore, the relationship and the selection of supplier is crucial. Bergsten (ibid.) elaborates that in the initial startup phase the best supplier for the moment might not be the best high volume supplier that is needed in a later phase with higher volume. As a small company it can be time consuming and costly to set up a highly scalable supply chain as well as it comes with the risk that a small company has a low prioritization regarding allocation and flexibility. To find and win new projects it is necessary that the distribution is well functioning and that there is a small sample stock and evaluation kits available immediately. (ibid.)

4.4.3 KPIs during Growth Phase

H&D Wireless emphasizes that the most important KPI to keep track of is cash risk and progress of the financial status of the company. Furthermore, the balance between *cost* and *lead time* is crucial and Bergsten (ibid.) argue that this balance has to be evaluated on a case by case basis due to customer requests and requirements.

Two other KPIs are highlighted as important to trace. Firstly, delivery precision is mentioned as important both to set and communicate reasonable targets and then meet the targets to build confidence and trustworthiness towards the customers. Secondly, procurement cost reduction can play an important role when working with especially larger companies who has a dedicated procurement organization that can spend much time on trying to lower the cost for products and components. To avoid lower margins on the sold products this negotiation must continue downstream in the supply chain. (ibid.)

4.5 Cross Case Findings

To summarize the empirics, some cross-case findings will be presented. Notably, all companies have research and development as well as software production in-house. However, none of the interviewed companies perform any hardware production in-house. The core competencies are thus research and development, sales and marketing, support as well as some functions that differ from company to company. The cross-case findings are below divided between supply chain findings, critical success factors and KPIs during the growth phase.

4.5.1 Supply chain Findings

All the interviewees addressed the relationship with their suppliers and discussed the trade-offs with outsourced production. Most of the companies production contractors are located in Asia where the manufacturing cost is lower for high volume products, compared to having it in Europe. However, having the production in Asia might increase the mentioned risk for misunderstandings due to communication issues. The long time perspective regarding the relationship with the supplier is discussed in different ways with all interviewees. The representatives from Fingerprints and Tobii addresses the strategic choice of a partner that enables rapid scale in volume as well as the endurance to still be a competitive partner when the volume increase is postponed or absent at the moment. Moreover, Hökfelt (2020) emphasizes that it could be of importance which network and potentially new customer the selection of a partner could enable. On the other hand, Bergsten (2020) from H&D Wireless mention that it can be costly to establish and set up the production with the high volume partner from start and that it can be preferred to use a small volume company in the initial phase.

Throughout the interviews the product range and the number of stock keeping units (SKUs) were discussed with the conclusion to strive for as few SKUs as possible and postpone the customization of products as far as possible in the supply chain, preferably even customize at the customer if possible. Jordeby (2020) emphasizes that since the product cycles are so short the internal communication with the sales and product management organizations is a key factor to avoid obsolete products and unnecessary capital tied up in inventory.

4.5.2 Critical Success Factors

All companies highlighted the importance of planning for higher turnover and the complexity of scaling since premature scaling might turn out wrong due to the difficulty of forecasting true growth in the future. However, not preparing enough might lead to missed sales opportunities and generate unsatisfied customers. Bergsten (2020) emphasizes the importance of tracking the cash flow to avoid bankruptcy and that it is crucial to always have products in stock for new projects and sample production since that is needed to win new projects. Each interviewee discussed their individual business problems, however, they all mentioned that it is hard to forecast and that the forecast always has to be reviewed and modified continuously. Spannel (2020) describes the risk with outsourced production and the advantage to avoid the investment cost when increasing the production volume, but also the risk of building up too much inventory. Furthermore, Spannel (ibid.) argue that it was a critical success factor for Fingerprints that they had the resources in place before the ramp up of the company.

A strategy for both forecasting and sales and operations planning (S&OP) is addressed by all companies as something that is needed and can make a great difference if implemented correctly. Both Jordeby (2020) and Spannel (2020) describes the need of communication between the functions in the company and that it can be hard for the different functions to understand respectively perspective.

One crucial factor that is mentioned by all the companies in different ways is the product fit in the market. There must exist a market demand and a clear user case for the product in order to be able to scale. Tobii emphasizes that they are still looking for the perfect user case when it comes to high volume sales in their business unit Tobii Tech. Moreover, Fingerprints describes the early decision and clear strategy to target the mobile segment as a key factor. Worth to mention is also the need of support and confidence from the owners and the board of directors when deciding on these types of strategies. Finally, H&D Wireless highlights the combination of scalable hardware together with customized software for their real-time logistics system product offer. (Jakstad 2020; Spannel 2020; Bergsten 2020)

To conclude, the companies present and describe similar solutions about the difficulties going from a startup company to a significant global competitor. Many factors seem to play a role and the landscape of scaling is hard to assess. Where should the production be situated and how should the set up of the supply chain be arranged? Which market strategy should be applied? The interviewed companies seemed to identify the complex

landscape and have their idea of what solutions are the best.

4.5.3 KPIs during Growth Phase

Two KPIs, *cost* and *procurement cost reduction*, from the presented supply chain performance metrics were highlighted as highly important to trace by all interviewed companies. Since these KPIs touch each other and is about how much money that can be saved when purchasing components or products this confirms, as stated by Bergsten (2020), that capital management is very important for a startup.

Furthermore, *supplier flexibility* and *delivery precision* is mentioned in different ways by all interviewed companies. For example, Spannel (2020) emphasizes that flexibility and the possibility to receive extra production allocation on short notice can be everything for a small growing startup that must be able to accept customer orders to survive.

Chapter 5

Analysis

This chapter includes the analysis of reviewed theory together with the gathered empirical data. Initially different supply chain strategies are discussed, followed by identified CSFs and KPIs. Lastly, there is a summary of the analysis including a presented framework to support the process of setting up a supply chain for a startup.

5.1 Supply Chain Management

5.1.1 Theoretical Strategy

According to Lee (2002), the supply chain strategy depends on the combination of demand and supply uncertainty on the market. To determine the right supply chain strategy based on the industry characteristics for a company this model can be applied (Table 5.1).

Table 5.1: Supply Chain Strategies Framework (Lee 2002)

	Demand uncertainty low	*Demand uncertainty high*
Supply uncertainty low	Efficient supply chains	Responsive supply chains
Supply uncertainty high	Risk-hedging supply chains	Agile supply chains

Meaning, all of the suggested supply chain strategies can be relevant for a startup to apply if only the industry characteristics are taken into account. For a new product on the market the conditions are uncertain and without access to any historical data regarding both supply and demand. Because of that, the efficient supply chain strategy may be unlikely to be implemented successfully since it is preferable in a low variety environment. As the lead time is long in the semiconductor industry the conditions are hard to affect even though it might be possible, in some cases, to shorten the lead time if allowing a cost increase. The long lead time to produce products causes problems since the startup need to purchase material based on forecast and not on actual customer orders. For a startup, fluctuations in demand is what characterizes such a company. For a new product on the market and a company in the initial phases, the demand uncertainty will be high. As mentioned by Spannel (2020), the allocation is crucial when the volume increment kicks in, with a need of rapid scale up in the production capacity. One can argue that as long as the volume does not increases the uncertainty is low. However, the timing regarding the objective of a rapid scale up might be highly uncertain which results in a high supply uncertainty. Thus, this issue with timing uncertainty might be the determining factor between a recommended implementation of either a *responsive* or *agile* supply chain strategy.

As the semiconductor industry is highly international where most of the market players are competing on a global basis, another dimension of challenges becomes relevant. Skjott-Larsen et al. (2007) mentions challenges such as adapting to multiple national environments with different cultures, political and economics systems, business practices, wax and legal systems, and the global politics of economics and trade relationships. This increases

the level of uncertainty and adds additional cost for exporting and importing components and products. Moreover, it is affecting the supply chain with a risk of increasing the number of SKUs because of local variation requirements resulting in a higher risk for obsolete products. According to Giunipero et al. (2014) strategic purchasing plays a key role in the sustainable economic development. Procurement in many companies historically used to have limited visibility and influence in the organization it has now climbed up to the top table within many organizations that understand the need for a high-performance procurement function. The global landscape and the many legal aspects of global purchasing is most likely affecting this transformation.

5.1.2 Identified Critical Success Factors

As Lee (2002) describes with his uncertainty model, it is essential for a company to identify the level of uncertainty on both the demand side as well as the supply side in order to determine the right supply chain strategy. Since there is no historical data available and unidentified customers, the level of uncertainty can be hard to predict for both demand and supply. Thus, solid analysis of the market, customers and suppliers is essential. To create a holistic understanding of the environment and its conditions, an initial step could be to perform a SWOT analysis.

Since forecast is identified as a critical success factor by all interviewed companies, a sales and operations planning process is highlighted as a strategic tool to address this uncertainty. Both Spannel (2020) and Jordeby (2020) describes the importance in having a solid process and routine as well as, besides sales and operations, include the functions product management and finance in order to access all relevant information. Moreover, Bergsten (2020) emphasizes that it is always crucial to have a small number of products and evaluation kits (EVKs) in stock so that potential customers always can buy EVKs and build prototypes. This is needed in order to win and secure new customer projects who may choose another alternative if the product is not available at the moment.

A common ground for the case companies, and for other small semiconductor companies, is that they are all fabless. Because of that they have outsourced production which means that the role of their suppliers' are crucial for the business. All the potential foundry partners comes with a huge network. As Hökfelt (2020) mentioned, this could be a factor and an advantage taken into consideration when selecting business partner. Their network could also open up new unknown business potentials for a small startup. Furthermore, the empirical data points out the importance of internal top management engagement. Sup-

ply chain management and supply chain affairs requirers a strategic plan and continuous development. In some cases top management engagement might also improve the trustworthiness, in a positive way, towards the suppliers in discussions regarding allocation and forecasts, especially in regions where the hierarchical culture becomes more present.

5.2 Product Characteristics

5.2.1 Theoretical Strategy

As stated in the Theory chapter (3) a company, and especially a startup, may find that they have no option to choose the production process. For a growing startup the batch process described by A. Hill and T. Hill (2009) seems to be appropriate since it is a repeatable process with the capability to increase the product volumes. This enables the possibility for the manufacturing foundry to produce other products and easily switch between production of different batches. To determine whether it is a functional or innovative product the supply chain is to be designed for, the product could be matched based on the nature of the demand for the product (Fisher 1997). However, for a startup all aspects may not be appropriate. The product variety is probably low and average margin error in the forecast probably high, due to the new market but also the characteristics of the semiconductor industry where the forecast error usually is higher. Since there are many processes that need to be established in order to design and manufacture the products based on silicon it can cause an initially longer lead time for both functional and innovative products. According to Fisher (ibid.), a functional product benefits from an efficient supply chain strategy and an innovative product benefits from a responsive supply chain. This recommendation is based on the level of uncertainty regarding downstream demand. Thus, this model does not take the special conditions into consideration meaning that other factors needs to be included in order to apply the best supply chain strategy based on the product characteristics.

5.2.2 Identified Critical Success Factors

From the gathered empirical data a critical success factor is that there are high volume user cases with a perfect product fit available. Furthermore, it is crucial to minimize the product range and reduce the number of SKUs in order to optimize the inventory and reduce

the risk of obsolete products. Moreover, Bergsten (2020) describes an approach where the silicon based hardware is standardized and designed for high volume production at the same time as the associated application software can be customized based on the requirements from the customer. Because of that, the same hardware can be used for different user applications which opens up a bigger market with potentially higher total volume. Another benefit is that the product offer is based on the hardware together with the software which makes it easier to keep an existing customer since they cannot change only one part of the solution. Additionally, Spannel (2020) describes that a way of reducing the number of SKUs can be to introduce another step in the supply chain responsible for customization and modification in compliance with the requirements from usual customer. Hence, use the competences and the capabilities in the best possible way performing the unique value adding activities. However, a risk with implementing such a strategy is to create a weaker position in the value chain since the company loses control and influence in the supply chain.

5.3 Industry Characteristics

5.3.1 Theoretical Strategy

As stated by Olhager (2010), the Customer Order Decoupling Point (CODP) divides the material flow between forecast-driven and customer order-driven. As a startup it would be preferable to have the opportunity to only produce products based on actual customer orders and thereby avoid the risk of producing obsolete inventory. Unfortunately, there are long lead times in the semiconductor industry which can be hard for the customers to accept when they place an order and expect the delivery shortly afterwards. Because of the long lead time for semiconductor manufacturing in the foundry, which in best case is two to three months, it is necessary to start the production to a certain degree based on the forecast in order to satisfy the customers and shorten the time frame from a customer order until delivery. One potential way to reduce the risks with forecast-driven production is to standardize the production and divide it into steps. This may lead to a possibility to store, for example, assembled products. Then, after receiving an actual customer order, finish and customize the last production steps based on that customer orders instead of based on the forecast.

Since a semiconductor manufacturing plant requires a high amount of invested capital the earlier described business idea by Hung, Chiu, and Wu (2017), with the fabless – foundry

combination lowers the barriers for startups within this industry. It would have been a completely different situation if all fabless companies did not have the opportunity to share allocation and competences from the manufacturing plant, i.e. the foundry. As Hung, Chiu, and Wu (2017) argues, there are several advantages, in terms of risk sharing and acquisition of technical competences and R&D, for both the foundry and the fabless company by using this setup. However, it also creates a dependency between the two partners which can cause problems if the business growth plan is not accurate. Furthermore, it can create an disadvantage in terms of prioritization and control for the fabless company since they lose influence in their supply chain at the same time as the foundry has to satisfy all their fabless customers. Therefore, it is crucial to have a solid communication and partnership to maximize the potential for the fabless – foundry setup.

5.3.2 Identified Critical Success Factors

The empirical data provide information that confirms the long lead time in the industry. Different solutions are presented by the interviewed companies to minimize the product range and to standardize the products in order to minimize the risk with purchasing and produce based on forecast. When facing a high degree of demand uncertainty, as the common case is for a startup with a new product, the general recommendation found in literature is, in line with the empirical findings, to minimize the product range and standardize the products. Depending on the product the interviewed companies offer to the market the Customer Order Decoupling Point varies. Although, none of them are able to implement an engineer-to-order or a make-to-order decoupling point, instead both assembly-to-order and make-to-stock are commonly used.

From the empirical data the challenge to select and maintain the relationship with the supplier or suppliers is mentioned as a critical success factor. This challenge was highlighted by all interviewed companies and discussed with different perspectives. A strategic partner with the capacity to rapidly scale up the production that at the same time has the endurance to continue business even when the volume increases are not accurately forecasted is recommend. They realise the potential of the product and its market and therefore offer a competitive price level even for the initial low production volume. As Bergsten (2020) emphasizes, this partner may not be found from the beginning and it might be the case that a smaller low volume partner is the best choice initially before the establishment and transition to the final high volume partner. One reason to use such a two step setup could be if the case is as Spannel (2020) describes, the foundry does not accept small startups as customers and requirers a distributor in between. This could solve the devastating risk to

not have a direct communication channel when facing allocation and confidence issues as earlier discussed.

5.4 KPIs during Growth Phase

Firstly, a review of the SCOR performance attributes and their level-1 metrics (Table 5.2).

Table 5.2: SCOR Performance Attributes (Council 2008)

	Attribute	*Strategy*	*Key Performance Indicators*
Customer	Relability	Consistently getting the orders right and fulfill product quality requirements	– Perfect order fulfillment
	Responsiveness	The consistent speed of providing products/services to customers	– Order fulfillment cycle time
	Agility	The ability to respond to changes in the market (external influencers)	– Upside supply chain adaptability – Downside supply chain adaptability – Overall value at risk
Internal	Cost	The cost associated with managing and operating the supply chain	– Total SCM costs – Cost of goods sold
	Assets	The effectiveness in managing the supply chain's assets in support to fulfillment	– Cash-to-cash cycle time – Return on SC fixed assets – Return on working capital

As the growth phase represents the time point for exponential growth in sales volumes, this relates to the earlier discussed supply chain strategy using the framework developed by Lee (2002). The framework favours either an agile or responsive supply chain strategy, which indicates that KPIs such as order fulfillment cycle time and adaptability both upstream and downstream in the supply chain are the most crucial. However, the cross-case findings points towards the attributes cost and reliability since manufacturing cost and procurement cost reduction as well as delivery precision and quality are highlighted KPIs from all companies. Thus, this may seem contradictory. However, due to the learning process that the startup and its partners are expected to experience in the supply chain during this phase it will allow an improvement in the supply chain towards a more efficient utilization while at the same time being agile or responsive. As the order volume rise, unit

fixed cost will decrease as the fixed costs will be spread out over more units. Therefore, efficiencies can be achieved without any significant reconstructions of the supply chain. From the cross-case findings there are consensus between the companies that KPIs regarding cost and flexibility are the most important to track. This means that the attributes *cost* and *agility* is considered the most important. Additionally, delivery precision as well as quality are highlighted from the empirical data as KPIs to trace, which also indicates that both the attributes reliability and responsiveness has significant impact. In order to be both agile and flexible at the same time as the high quality is maintained it is essential to establish a strategy for managing communication and for how to avoid misunderstanding due to lack of communication.

The theory advocates a responsive or agile supply chain strategy when the sales volumes rapidly increase for the startup. On the other hand, the empirical data emphasizes the importance of especially efficient and agile supply chain strategies, even though other strategies potentially also can be successfully implemented. As the conducted answers differs from one another, it indicates that there are other factors than the growing phase that needs to taken into consideration when deciding on which KPIs to trace. To conclude, it is difficult to draw any absolute conclusions since there are several affecting factors and different possible ways to achieve a successful outcome. However, there is a consensus between the interviewed companies to keep track of the suppliers flexibility as well as the cost and how to reduce the payment for purchased material. In some cases it might also be useful to trace quality and delivery precision depending on the situation.

5.5 Summary of Analysis

Based on the analysis, the following framework (Figure 5.1) has been developed to guide a semiconductor startup in order to determine the most suitable strategy for its supply chain. A more elaborative description aof the framework will be presented in the following chapter (6).

Trade-offs have to be made and advantages must be assessed against disadvantages as different factors may recommend contradicting strategies. For example, normally the uncertainty in the industry may be low and therefore an efficient strategy is preferred. However, the startup is a growing company aiming for a rapid sales increase and may face a market uncertainty where either a responsive or agile strategy is applicable. Alternatively, an efficient supply chain strategy may be difficult to implement due to the limited resources in a startup even though it is the most desireable strategy. To face these challenges, it is essen-

tial for the startup to establish a long-term perspective of its business and understand the limitations with each different strategy that may be desireable during the growth phases of the company. If the startup knows what the market requires to be profitable in the long-term perspective, they can make informed decisions that give room for changes in the design of the supply chain as the company and its products matures.

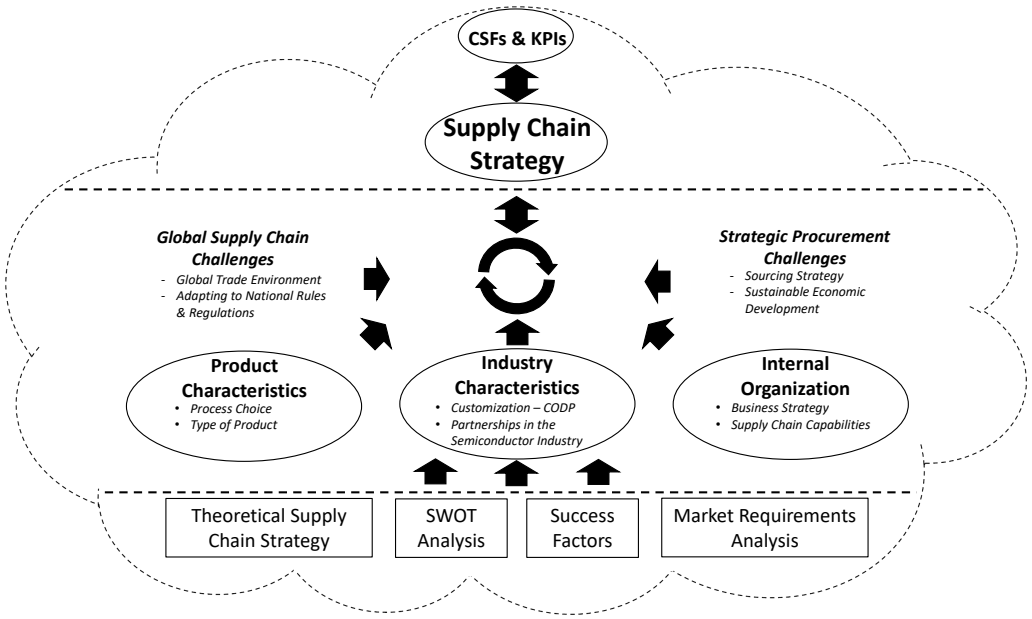

Figure 5.1: Supply Chain Management Framework (author)

Chapter 6

Conclusion

In this chapter, the answers to the research questions of the project are presented. This is then followed by suggestions for future research regarding supply chain strategy for startups, as well as the theoretical contribution of this research.

6.1 Research Questions

As stated initially the first research question was constructed in a broader way to be able to allow insights in a wider spectrum regarding both successful recommendations as well as what to avoid. The second and third research questions serve as supporting tools to monitor and measure the performance of the supply chain. The answer to each individual research question is presented in this section.

6.1.1 RQ1: How could a supply chain strategy be applied for a startup within the semiconductor industry?

In order to determine how a supply chain strategy can be applied for a startup within the industry of semiconductors this project presents a developed framework as guidance. A visual representation is found in Figure 6.1.

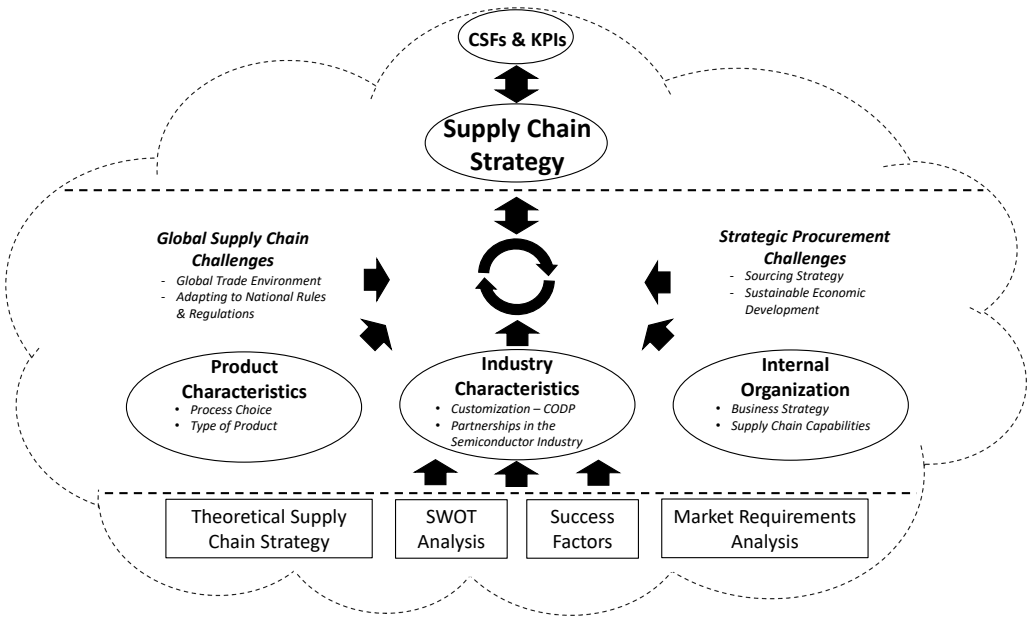

Figure 6.1: Supply Chain Management Framework (author)

Initially the recommendation is to start off with performing an analysis of the market requirements and a SWOT analysis of the startup including the supply chain and business opportunities. Furthermore, it is recommended to identify suitable theoretical supply

chain strategies in the model presented by Lee (2002) as well as identified success factors regarding supply chain management.

The second step is to analyse product characteristics, industry characteristics and internal organization followed by global supply chain challenges and strategic procurement challenges. As guidance, some relevant bullets are stated under each topic. A more elaborative discussion about each bullet is found in chapter 3.

Based on the findings and the suggested supply chain strategy it can be necessary to iterate the process and redefine the challenges and objectives. After processing the topics, a holistic view over the situation is created along with a preferred supply chain strategy including CSFs and KPIs. The CSF can be used as objectives to strive towards and the KPIs serve as indicators to trace the performance of the applied strategy.

6.1.2 RQ2: Which factors in the supply chain are critical to succeed with in order to enable growth?

Generally, the conclusion that there are several CSFs for succeeding with scaling the supply chain in a semiconductor startup can be drawn. The focus has been to identify CSFs in order to enable a rapid scale of the startup's supply chain based on the findings from empirics and analysis. Presented in Table 6.1 are the identified CSFs which are valued the highest. The CSFs can be divided into three different categories, *product characteristics*, *industry characteristics* or *internal organization*, based on their nature.

Table 6.1: Identified critical success factors (author)

Product Characteristics	*Industry Characteristics*	*Internal Organization*
– User case & market fit	– Relationship to suppliers	– S&OP Process
– Minimize SKUs	– Ensure capability to scale	– Top management engagement
	– Postpone or avoid customization	– Ownership support

Find the right *user case & market fit* for the product. In order to successfully create a customer demand for the product the startup must offer a unique product that solves a new type of case or is the best available product on the market. *Minimize the number of stock keeping units (SKUs)* to reduce the inventory cost and the risk of obsolete products. As stated by

Skjott-Larsen et al. (2007) and commented in the interviews this can be challenging in the global trade environment. To bridge this gap, a solid knowledge and communication with customers about expectations and user cases for the product are key factors. However, it is also important to make sure that there are available products when a customer wants to place an order and avoid the risk of not fulfilling business opportunities.

Relationship to suppliers, since almost all companies in this industry outsource their production to semiconductor foundries and possible other suppliers before receiving the finished product, all interviewees highlighted this relationship as crucial to succeed when scaling a startup. *Ensure capability to scale* refers to demand uncertainty and the allocation at the foundry that needs to be secured when the sales volume increases. A consideration towards initially using a small volume partner instead of establishing a partnership with a more costly high volume partner could be useful depending on the situation. *Postpone or avoid customization* connects to the Customer Order Decoupling Point and the industry characteristics that yields production lead time. To improve the situation and minimize the risk with production based on forecast this issue is raised by all interviewees as a CSF.

A well implemented *Sales and operations planning (S&OP) process* is addressed as a CSF as a way to gain a holistic view and improve supply chain decisions in the highly uncertain environment that a startup faces because of low forecast accuracy and market knowledge about the product offer. Moreover, this structural process could also establish a better understanding internally between the different company functions such as sales, operations, and product management. Additionally, *Top management engagement* regarding supply chain affairs and supply chain management as well as *ownership support* are mentioned as CSFs in the empirics research since a clear strategy and market approach is essential in order to scale a startup efficiently and avoid spending unnecessary capital.

Although only three companies were interviewed, the author is reasonably confident that the presented critical success factors are valid and generalizable for high-tech startups in the semiconductor industry and other similar industries. For further verification, the author propose, that the CSFs should be quantitatively tested. Moreover, interviewing more companies with the same method as in this project might result in additional CSFs to be found. However, based on the interviews and learning, the presented CSFs are the most crucial for a startup in order to scale its supply chain.

6.1.3 RQ3: Which key performance indicators (KPIs) are relevant to track in order to measure the performance of a startup's supply chain during growth?

Based on the empirics, the attributes of *agility* and *cost* are the most desired. This means that the KPIs of supply chain adaptability, supply chain management cost and cost of goods sold, are the most important to trace. However, the empirical data also highlights two other KPIs, *delivery precision* as well as *quality*. This gives a result containing several KPIs that covers almost the whole supply chain management perspective.

To further narrow the range of KPIs and create an internal prioritization, additional research needs to be conducted. A quantitative approach combined with an investigation of correlating factors should give a better understanding of which KPIs that are the most relevant to trace during the growth period.

6.2 Theoretical Contributions

Which theoretical contributes are presented throughout this project?
Theoretical Contributions have been made in form of the supporting framework to guide a startup, primarily in the industry of semiconductors, in how to set up their supply chain strategy in order to enable rapid scale up. Although it is performed towards a specific industry most of the findings would probably yield insights for any high-tech startup looking for a scalable supply chain strategy. The framework provides a way of thinking on how to get to the appropriate supply chain strategy as well as identified critical success factors in the areas of product characteristics, industry characteristics, and internal organization.

Based on the limited theory that currently exits on how to set up a supply chain and supply chain management for startups, the author hopes that this supporting framework will contribute with new insights to help startups understand their environment and how to choose a suitable supply chain strategy. Several critical success factors and key performance indicators have been presented for startups to consider when scaling their company. Most of the available research in this area has previously been conducted in larger companies with lower uncertainty of both demand and supply as well as access to historical data.

However, this report gathers CSFs and KPIs that are meant to be used by startups, primarily in the industry of semiconductors or similar high-tech industries, which may differ from the theory regarding larger companies.

6.3 Future Research

Which are the possibilities to continue research based on this project?
As the project is exploratory in its nature, one of its main purposes is to provide a foundation for future research. The project has targeted a specific industry while having a broad perspective of how to set up and manage the supply chain of a startup. An improvement of the project would have been to add additional companies to the empirical research. Both in the industry of semiconductors but also from other industries to investigate common denominators within and between the industries. To further evaluate the results a quantitative investigation of the provided CSFs and KPIs can provide even better insights and also enable an additional opportunity to compare and analyse correlation factors between the presented CSFs respectively the presented KPIs. A combined qualitative and quantitative research approach yields the advantage of reaching a higher level of research quality as discussed in the methodology chapter (2).

Moreover, in the global landscape an interesting investigation would be regarding how a startup should design the supply chain in order to minimize the tax and avoid or reduce the tariffs and other costs associated with import and export of goods and services. This may hopefully provide some guidance for how to compete globally whilst at the same time avoid unnecessary expenses and delays in the startup's supply chain.

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Appendix

Hereafter follows appendices, from A to B containing additional information not covered in the main report.

Appendix A – Interview Questions

Below are the questions that were used in the interviews with the case companies. Notably, the interviews were semi-structured interviews and therefore were questions added and retracted depending in the course the interview took.

1. How long have you been working for this company? What is your previous experience?
2. What is your role today?
3. Can you describe the company and its products?
4. How would you describe the industry? What characterizes this industry?
5. How is it to be a specialized company at the market?
6. Can you describe the process of your go-to-market strategy? Which alternatives were discussed?
7. On which geographical markets does your products exists and why?
8. Which are your sales channels? Has it always been the same historically?
9. How is your corporate strategy connected to your supply chain strategy?
10. How is the company financed? Was it easy to find investors?
11. What was the main focus on the supply chain during the growth period? Did it change during the process?
12. Which success factors was identified when scaling the supply chain?
13. How is inventory, distribution and transportation managed?
14. How is forecasting managed? What is important?
15. How did you select your suppliers/partners?
16. Do you have several suppliers for manufacturing of your products?
17. Is the production managed from in-house or is it out-sourced to another company?
18. Do you produce based on forecast or based on customer order? Which Customer Order Decoupling Point is used?
19. What is the most important to trace and follow up from a supply chain perspective?
20. When did it became critical to handle customer returns?
21. Do you wish to add anything that we have not discussed?

Appendix B – Supply Chain Performance Metrics

Below are the subject regarding supply chain performance metrics that was discussed and prioritized in relation to each other.

1. Lead time – Total time to fulfill an order
2. Cost – Manufacturing Cost
3. Supplier availability – Suppliers' capacity to respond to urgent demand
4. Supplier defect rate – Evaluate suppliers' quality
5. Purchase order cycle time – Administration time for purchase orders to suppliers
6. Procurement cost reduction – Streamline the tangible costs savings
7. Compliance rate – Overall, do suppliers fulfill your requirements