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EFFECTS OF THE COVID-19 PANDEMIC ON MANUFACTURING COMPANIES' SUPPLY CHAIN MANAGEMENT IN FIN- LAND

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ABSTRACT

Oskari Huttunen: Effects of the COVID-19 Pandemic on the Manufacturing Industry
Companies' Supply Chain Management in Finland
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The COVID-19 outbreak shocked the whole world in 2020. As the pandemic quickly spread across the globe, only during its first year, over 75 million positive cases and 1,6 million deaths were reported worldwide, and in November 2022, the same numbers were over 634 million and 6,6 million. The world's economic system and global markets were greatly affected, and many countries tried to counter the pandemic's spread by implementing strict lockdowns, which further caused turbulence on the markets. Countless manufacturing companies across the globe were faced with massive global supply chain disruptions, and they were felt even in companies operating in Finland. Managers and scholars alike have been working very hard for the past three years to find out what were (and are) the best countermeasures to combat the pandemic's effects and disruptions, but a consensus of an answer is still missing.

This thesis aims to investigate the effects of the COVID-19 pandemic on manufacturing companies operating in Finland, and to examine what kind of ways or methods these companies adopted to counter the COVID-19 pandemic in Finland compared to the rest of the world. These two topics form the two main research questions of this thesis, and they are answered from the basis of a qualitative systematic literature review and a mostly qualitative semi-structured interview study to which interviewees from six different manufacturing companies take part in. The literature review consists of supply chain management theory and a look into the effects of the COVID-19 pandemic on manufacturing companies operating outside of Finland. The literature review is also used to build a theoretical framework, which is used in the end to analyse the results of the interview study and compare them to the findings of the literature review.

The results of this thesis offer insight into the differences of the COVID-19 pandemic's impacts on the supply chain management of manufacturing companies operating in Finland and outside of Finland, and the different supply chain management related countermeasures taken by these companies. From the literature review, it was discovered that global supply shortages, large-scale fluctuations in demand, consumption shocks, and increases in material prices and lead times were some of the most recognizable effects of the COVID-19 pandemic on the manufacturing companies operating outside of Finland, often affecting directly to their operations and Tier 1 suppliers. The interview results reflected similar results, only the companies operating in Finland mostly experienced the pandemic's effects through their suppliers' suppliers' problems, which were usually operating outside of Finland. Also, the companies that were located in countries that went into lockdowns had their own challenges as well. To counter the global supply chain disruptions, both the interview study and the literature review provided similar findings: the realization of the necessity of evolving the existing supply chain management from lean thinking to a more agile and resilient system became evident for those that hadn't already done so. Differences in the ways of attempting to accomplish this were found, but the goal was still very similar for most of the companies.

Keywords: Effects of the COVID-19 Pandemic, Supply Chain Management, Supply Chain Risk Management, Supply Chain Resilience

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

TIIVISTELMÄ

Oskari Huttunen: COVID-19 pandemian aiheuttamat vaikutukset valmistavan teollisuuden yritysten toimitusketjunhallintaan Suomessa

Diplomityö

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COVID-19 pandemia järkytti koko maailmaa vuonna 2020. Sen levitessä nopeasti ympäri maapalloa, jo ensimmäisen vuoden jälkeen yli 75 miljoonaa tartuntaa ja 1,6 kuolemaa oli raportoitu, ja marraskuussa 2022 samat lukemat olivat 634 miljoonaa ja 6,6 miljoonaa. Maailman talousjärjestelmä ja globaalit markkinat kärsivät suuresti, ja monet maat yrittivät torjua pandemian leviämistä ottamalla käyttöön tiukkoja koronasulkuja, mikä aiheutti edelleen lisää turbulenssia markkinoille. Lukemattomat valmistavan teollisuuden yritykset ympäri maailmaa kokivat massiivisa globaaleja toimitusketjun häiriöitä, ja ne tuntuivat jopa Suomessa toimivilla yrityksillä asti. Sekä johtajat että tutkijat ovat työskennelleet kovasti viimeisen kolmen vuoden ajan saadakseen selville, mitkä olivat (ja ovat) parhaat vastatoimenpiteet pandemian aiheuttamien vaikutusten ja disruptioiden torjumiseksi, mutta yksimielisyys vastauksesta puuttuu edelleen.

Tämän tutkimuksen tavoitteena on tutkia COVID-19 pandemian vaikutuksia Suomessa toimiviin tuotantoyrityksiin ja selvittää, millaisia tapoja tai menetelmiä nämä yritykset ovat ottaneet käyttöön COVID-19 pandemian torjumiseksi Suomessa verrattuna muuhun maailmaan. Nämä kaksi aihetta muodostavat tämän opinnäytetyön kaksi päätutkimuskysymystä, ja niihin vastataan laadullisen systemaattisen kirjallisuuskatsauksen ja enimmäkseen kvalitatiivisen puolistrukturoidun haastattelututkimuksen pohjalta, johon osallistuu haastateltavia kuudesta eri valmistavan teollisuuden yrityksestä. Kirjallisuuskatsaus koostuu toimitusketjun hallinnan teoriasta ja COVID-19 pandemian vaikutusten tarkastelusta Suomen ulkopuolella toimivien yritysten näkökulmasta. Kirjallisuuskatsauksen pohjalta rakennetaan myös teoreettinen viitekehys, jonka avulla analysoidaan lopuksi haastattelututkimuksen tuloksia ja verrataan niitä kirjallisuuskatsauksen löydöksiin.

Tämän tutkimuksen tulokset tarjoavat näkemystä COVID-19 pandemian vaikutusten eroista Suomessa ja Suomen ulkopuolella toimivien valmistavan teollisuuden yritysten toimitusketjun hallintaan, sekä näiden yritysten erilaisiin toimitusketjun hallintaan liittyviin vastatoimiin. Kirjallisuuskatsauksen perusteella havaittiin, että globaalit tarjontapulat, suuret kysynnän vaihtelut, kulussokit sekä materiaalihintojen ja toimitusaikojen pidentymiset olivat eräitä COVID-19 pandemian tunnistettavimmista vaikutuksista maailmalla toimiviin yrityksiin, usein vaikuttaen suoraan niiden omiin toimintoihinsa tai Tier 1 -toimittajiin. Haastattelutulokset heijastelivat samaa, mutta Suomessa toimivat yritykset kokivat vaikutukset kuitenkin usein pääosin omien toimittajiensa Suomen ulkopuolella sijaitsevien toimittajien ongelmien kautta. Myös ne yritykset, jotka sijaitsivat maissa, joissa otettiin käyttöön tiukimpia koronasulkuja, joutuivat kokemaan siihen liittyviä haasteita. Globaalien toimitusketjun häiriöiden torjumiseksi sekä haastattelututkimuksessa että kirjallisuuskatsauksessa tehtiin samanlaisia havaintoja: ymmärrys tarpeesta kehittää olemassa olevaa toimitusketjun hallinnan järjestelmää lean-ajattelusta ketterämmäksi ja joustavammaksi järjestelmäksi tuli selväksi niille, jotka eivät olleet sitä vielä tehneet. Eroja tavoissa, joilla tämä yritettiin saavuttaa, oli selvästi havaittavissa, mutta tavoite oli silti suurimmalla osalla yrityksistä hyvin samankaltainen.

Avainsanat: COVID-19 Pandemian Vaikutukset, Toimitusketjun Hallinta, Toimitusketjun Riskienhallinta, Toimitusketjun Resilienssi

Tämän julkaisun alkuperäisyys on tarkastettu Turnitin OriginalityCheck –ohjelmalla.

PREFACE

This truly was one of the theses of 2023.

Tampere, 4.4.2023

Oskari Huttunen

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LIST OF SYMBOLS AND ABBREVIATIONS

SC	Supply Chain
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SCR	Supply Chain Resilience
SME	Small- and Medium-sized Enterprise
ERP	Enterprise Resource Planning
CRM	Customer Relationship Management
JIT	Just-in-Time
MRP	Material Requirement Planning
VSM	Value Stream Mapping
MTO	Make to Order
ATO	Assemble to Order
FIFO	First-in-first-out

1. INTRODUCTION

1.1 Background and Motivation

As of writing this thesis during the year 2022, the COVID-19 pandemic has been wreaking havoc on countries and businesses for a few years now. Although the relative fatality rate of the COVID-19 has decreased significantly from the beginning of the pandemic, the fact that the amount of confirmed COVID-19 cases was record high in the start of 2022 has still had its impact on, for example, the high hospitalization rates in the United States (Mathieu et al., 2021; Shumaker, 2022; Caspani & Shumaker, 2022; World Health Organization, 2022a). Therefore, the world seems to still be in quite a turbulence; in one hand more and more pandemic-related restrictions are constantly being lifted and 'the normal' is slowly returning, but in the other hand major setbacks are also yet still happening. For example, in June Shepardson (2022) reported that the U.S. announced the stopping of incoming international air travellers COVID-19 testing, but only two days later Pollard & Woo (2022) wrote that Beijing may be looking at new lockdowns and mass testing, as a massive COVID-19 outbreak is being contained.

Couple steps forward in recovering from the pandemic is still a scant consolation in the big picture, as the COVID-19 is not the only crisis the world is facing right now in 2022. One of them is the currently ongoing war between Russia and Ukraine that has also shaken the already wounded world. As the United Nations (2022) put it: *"fragile economic recovery from COVID-19 pandemic upended by war in Ukraine"*, this has also affected industries around the world. These recent global level events on top of the COVID-19 pandemic will obviously make it harder to determine what is and what isn't the direct consequence of the pandemic specifically. As this thesis is a qualitative interview study, a challenge will no doubt present itself during the interviews, as the interviewees will probably not be able to confirm that every possible pandemic-related effect they've perceived is 100% caused only by the COVID-19 pandemic. This is something that is important to be acknowledged and considered, as the research results are analysed, and final conclusions are made.

From an industrial engineering and management student's perspective, the world has changed tremendously from what it was before the COVID-19 pandemic. Companies have had to rethink themselves and adapt their processes to the new challenging circumstances, especially in supply chain management (Amis & Greenwood, 2020; Quinn,

2021). It's hard yet to say what changes will and what will not be permanent, and it's definitely impossible to cover all of the pandemic's effects on the world's companies or industries in a single thesis. What can be done though is the investigation of, for example, the impact of the pandemic on different companies' supply chain management and then learn from this. This is exactly what this thesis sets out to do, and what I'm as a researcher and a student personally interested in.

1.2 Research Objectives and Questions

The primary objective of this thesis is to investigate the effects of the COVID-19 pandemic in Finland on supply chain management of companies operating in manufacturing industry. More specifically, the goal is to discover these occurred effects from the viewpoints of both supply chain management overall (SCM) and supply chain risk management (SCRM) in a qualitative sense. This is accomplished by interviewing one or multiple key supply chain personnel from six selected manufacturing companies operating in Finland, each representing a traditional manufacturing sector. A theoretical framework on the effects of the COVID-19 pandemic on different manufacturing companies' supply chain management in a global perspective is also constructed, which is accomplished by conducting a literature review on the subject using as current journal articles, news and professional literature as possible. The data acquired from the interviews is analysed, and the effects of the COVID-19 pandemic are then, using the theoretical framework, compared between the research results in Finland and the literature review findings in a global scale. The reason for this is to compare how different or similar the results from Finland are with the global results, as well as at the same time investigate the integrity of the interview study's results.

The secondary objective of this thesis is to investigate what new ways and methods from supply chain management perspective have the manufacturing companies adopted or developed due to the new sudden challenges introduced by the COVID-19 pandemic, and what has the pandemic taught to the companies overall. In this case, a "new way or method" will most likely be an existing SCM/SCRM tool or method unfamiliar to the company pre-COVID-19, but it also could be something completely new that's not commonly identified in any basic SCM or SCRM theory. To be able to identify these potential new methods, the literature review on SCM and SCRM must be extensive enough. The interview questions should also be constructed in such a way that encourage the interviewees to perceive the possible new SCM/SCRM methods that might go unnoticed at first glance, which is why the interview should be a semi-structured interview.

From these objectives, the following research questions are formed:

1. *How has the global COVID-19 pandemic impacted on the supply chain management of manufacturing companies operating in Finland?*
2. *What supply chain management ways or methods have the companies adopted to counter the COVID-19 pandemic in Finland compared to the rest of the world?*

By answering these two research questions, the primary and the secondary objectives stated above are completed. It's important to recognize though that the individuals interviewed for this thesis are most probably just normal engineers and managers working in different roles under the umbrella of supply chain management, which is a very large concept in modern SCM. Therefore, it's clear that the interview results will only be reflecting the viewpoints of those specific companies, not Finland's manufacturing industries as a whole. Also, to get comparable results, the manufacturing companies examined and interviewed in this thesis should all be from traditionally operating industries (e.g., automobile, heavy machinery, electric equipment, etc.), but this is discussed more in detail later in the literature review and interview study itself.

1.3 Thesis Structure

The structure of this thesis consists of the following chapters presented and explained in Figure 1 below. Even though the structure is rather easy to understand, few key remarks are still in order. The literature review is done before the research tools are presented, because the construction of the interview structure and the theoretical framework requires the completion of the literature review first as the base of theoretical knowledge. The literature review consists of two parts: SCM theory and the pandemic's impacts. Chapter 5 (results) presents the results of the interview study and Chapter 6 (discussion) presents the research conclusions, which is the part where the research questions are finally answered.

1. Introduction

- A summarized reasoning and background for picking this particular subject
- Research objectives and questions presented, along with the thesis structure

2. Research Methodology

- Selected research methodology
- Data gathering techniques

3. Literature Review

- Supply Chain Management theory
- Supply Chain Risk Management, & Supply Chain Resilience theory
- COVID-19 and its effects on manufacturing companies' SCM globally

4. Research Tools

- Interview study (planning, structure, ethics, execution, analysis methods)
- Theoretical framework

5. Results

- Results from the interviews presented and compared to findings in literature review with the theoretical framework

6. Discussion

- Discussion of the results and presentation of the conclusions
- Research questions answered

Figure 1. Thesis structure

2. RESEARCH METHODOLOGY

2.1 Research Method & Timeline

This thesis is done completely independently for Tampere University. The selected research method is basic interpretive and exploratory qualitative study based on a literature review, an interview study and a theoretical framework. This research method aims to understand a situation or a phenomenon via inductive approach to produce descriptive results, themes and patterns in circumstances that are not optimal or possible for a descriptive study (Merriam, 2002; Saunders et al., 2007, p.153; Saunders et al., 2009, p.171). In this case, this is accomplished by analysing related literature and conducting an interview study based on that, which allows the comparison between the theoretical findings and the qualitative research results. Finally, by using a theoretical framework to analyse the possible recurring themes and differences between the data, it's possible to find answers to the defined research questions.

In practice, considering that the pandemic is not yet over, it's very hard to precisely predict what the post-pandemic era will end up being like. Questions like "*what exact permanent impacts will the pandemic have on different industrial sectors*" could only be answered speculatively at the moment. It's possible though to study the impacts the COVID-19 pandemic has had so far, for example, from the viewpoint of the companies operating in the most affected industries, such as traditional manufacturing. As also the reviewed timeline is relatively short, just over two years, it's quite easy to find and interview employees from these companies that have lived through the whole pandemic in the same job battling the challenges that have arisen. Also, the academic world has had some time to catch up too. More and more scientific articles have been released as time has passed, and this is essential for a study like this using the basic interpretive qualitative research method. Therefore, when all this is taken in account, this method is a valid choice for this thesis.

Now, building around this selected research method, the execution of this thesis is explained in Figure 2 below in three phases. The first phase consists of conduction of the literature review, the creation of the interview study and the construction of the theoretical framework. The second phase is the execution of the interview study, where SCM employees from the selected manufacturing companies are anonymously interviewed. Lastly, the third phase is the data analysis and the presentation of the results & conclusions, where both the literature review data and the interview data are used to answer

the research questions. This execution structure aims to provide a descriptive outcome by an inductive research process, which is the point of a basic interpretive qualitative study.

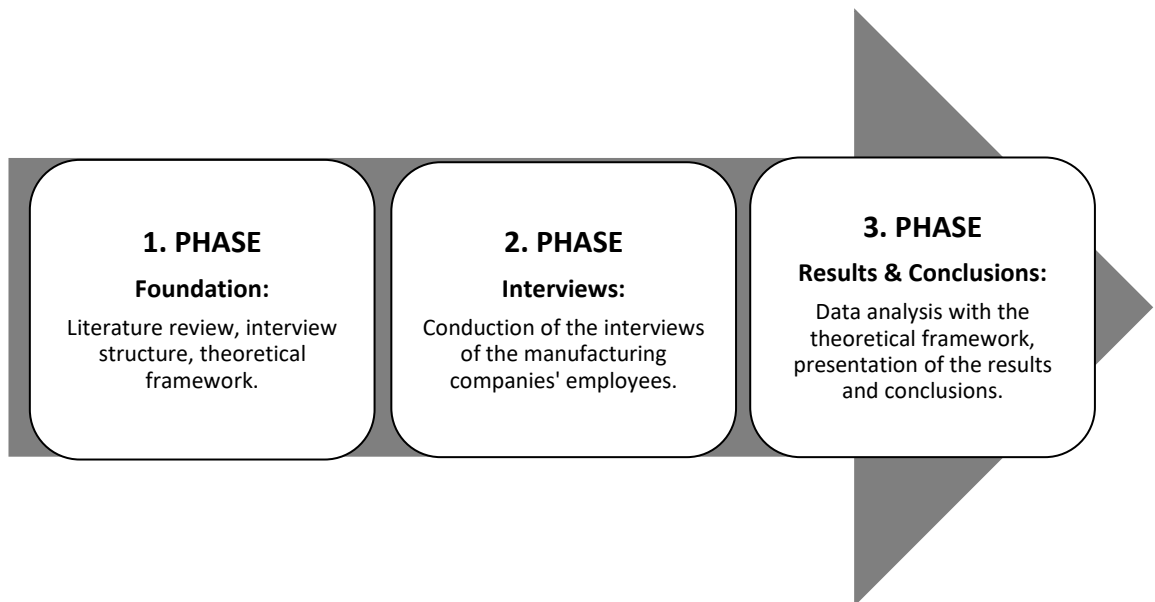


Figure 2. The Three Thesis Execution Phases

The time horizon for completing this thesis is presented next in Figure 3 depicting the year 2022 and the beginning of 2023. The first phase began in the end of January 2022 with the selection of the research subject and the research questions. The literature review was mostly done from February to April, but some parts of it were later complemented and updated in September and October during the second phase. The first phase came to its end after the building of the interview structure and the theoretical framework in April. The second phase started in May with the conduction of the interviews, but the thesis was put on hold for the duration of the summer from the beginning of June to the end of August due to a full-time summer job. The second phase concluded in September with the interview data being processed and put into the theoretical framework. The third and last phase lasted from October 2022 to February 2023, and it included analysing the data, presenting the research results and making the final conclusions of the research. Overall, the completion of the thesis took about 11 months without counting the summer break.

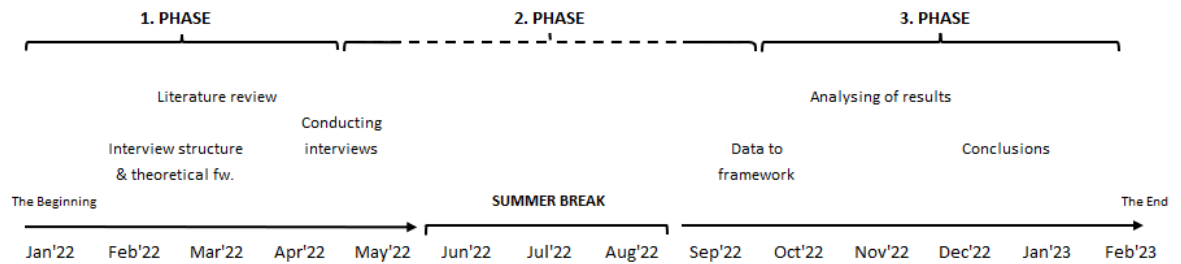


Figure 3: Thesis Time Horizon

2.2 Data Gathering Techniques

This thesis has two main data gathering techniques: a systematic literature review and an interview study. As mentioned before, the literature review is required to create the theoretical foundation and to obtain the necessary reference data to build the interview structure and the theoretical framework, while the interview study is essential to answer the research questions. Next, the execution of the literature review is explained in detail. The interview study is explained in chapter 4.

The point of a systematic literature review is to be a methodical process of finding the correct and desired data, but conducting one successfully requires effort in planning and execution. This process includes searching of the wanted information, reviewing and selecting to include or exclude the results, and the presenting of them in the literature review. (Fink, 2019, p.5-7). As said before, in this thesis the literature review is centred around supply chain management theory and the effects of the COVID-19 pandemic on manufacturing companies globally. The supply chain management theory is easily available through existing academic literature but researching about the effects of the COVID-19 pandemic is where the literature review is most likely going to be a bit challenging, as even sources such as some (reliable) news outlets could have very useful information if analysed and utilized with care, but many scientific articles could have information that has since its release been dated heavily in the light of new events.

Starting the literature review process by planning out a suitable coherent research plan is very important (Booth et al., 2021). Also, as the literature review is going to be systematic and the amount of all kinds of different data available on COVID-19 is rapidly growing as time goes on, especially the findings regarding the effects of the COVID-19 pandemic must be carefully analysed for their methodological quality. To achieve this, they must first pass the inclusion criteria that will be defined in the research protocols later (Tables 1 & 2). This is important also because of the earlier supposition that portion

of the potential information sources could even be news outlets, which can always contain noteworthy bias. As Sampaio & Mancini (2007) put it: “*the quality of a systematic review depends on the validity of the studies included on it*”.

So, as the included literature related to the effects of the COVID-19 pandemic should be as scientific and professional as possible, articles and reports by SCM related scholars and consultants should be favoured over others. Peer reviewed journals and trusted international news agencies & consulting companies are good sources for these. Still, eyes should be kept open for possible other sources (e.g., SCM related blogs and lesser-known news outlets) as well, because you never know if something useful has been missed by the mainstream information sources. For the supply chain management theory, the same rules stand, even though valid data is much easier to find; the inclusion and exclusion criteria must be still properly defined and followed, as using quality sources and data is essential for even the basic theory in a thesis like this.

For these reasons, to clarify the systematic literature review process, a literature review plan with a simplified research protocol was created and is presented in Figure 4 below. Both the plan and protocol structures were adapted from the models proposed by Sampaio & Mancini (2007) and Fink (2019, p.5) for the purpose of this thesis. The research protocol specifies the subject of the review’s research bibliography, the search terms & the strategy, and the inclusion & exclusion criteria. The actual research protocols itself are presented in Tables 1 & 2, and they aim to clarify the data gathering process of the literature review in this thesis, by separating the two topics’ (*supply chain management theory* and *effects of COVID-19 pandemic on manufacturing companies’ supply chain management in global scale*) data searching specifications into their own protocols. The systematic literature review plan in Figure 4 acts simply as a clear roadmap for the conduction of the literature review itself. Referring back to Figure 2, the literature review plan defines only one part of what happens in the phase one.

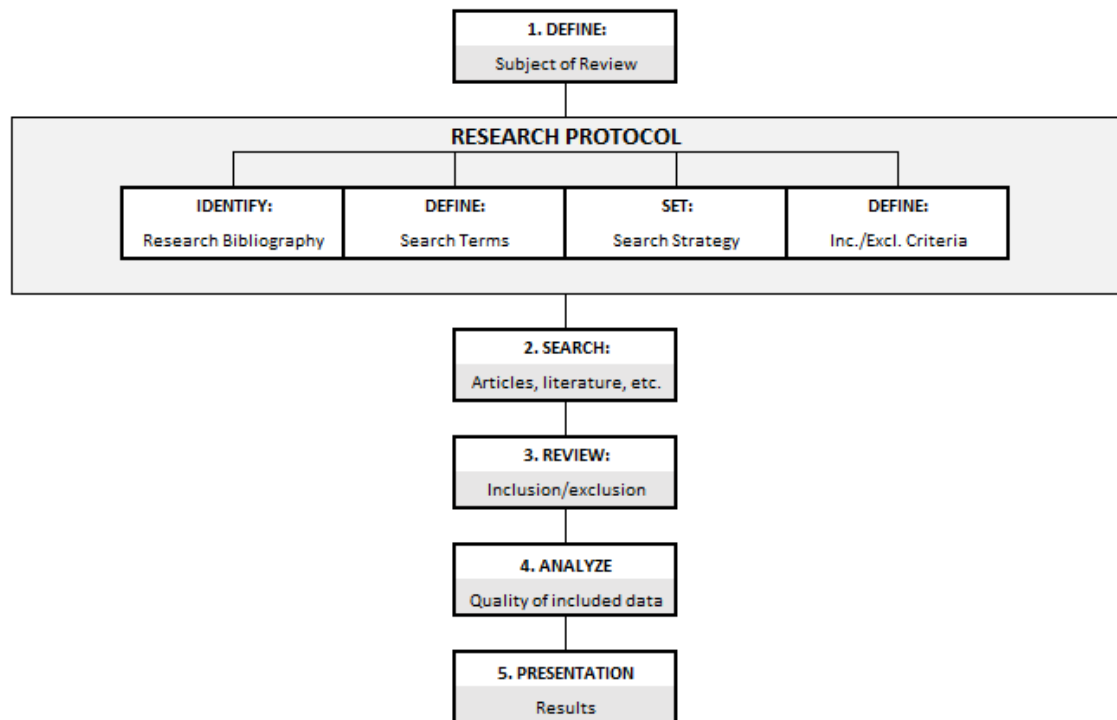


Figure 4: Systematic Literature Review Plan

Of the five milestones in the systematic literature review plan presented in Figure 4, the only ones actually documented in this thesis are the first (the research protocol) and the fifth (the presentation of the results or in other words, the results of the literature review). Other three are all mostly carried out in the background on the basis of the research protocols. As said before, reliable SCM theory is easily available and following Research Protocol #1 won't be a problem, but the same might not be true for the latter part of the literature review. The articles, reports, etc. selected for analysing the effects of COVID-19 pandemic are filtered by following due diligence and the inclusion/exclusion criteria presented in Research Protocol #2 (Table 2), and the used literature is also presented in Appendix A. The analyzation of the literature itself is again carried out in the background. Next, both research protocols are presented and explained in more detail.

Table 1: Research Protocol #1, Supply Chain Management Theory

RESEARCH PROTOCOL #1	
Subject of Review	Supply Chain Management theory
Research Bibliography	Andor, Google Scholar, Scopus, Web of Science
Search Terms	<i>Supply Chain</i> with different combinations of the following terms: <i>Management, Risk, Resilience, Theory</i>
Search Strategy	Search fields: <i>Title, Keywords, Body text</i> Language: <i>English, Finnish</i> Publication type: <i>Journal articles, virtual textbooks</i> Date range: 1985 to 2022
Selection Criteria	
INCLUSION:	Field: Supply Chain Management, preferably Industrial Engineering Subject: SCM, SCRM Source: Authors are experts/professionals of the SCM field
EXCLUSION:	Field/Subject criteria is not met Author is not an expert/a professional of the SCM field

The Research Protocol #1 is very straight forward. When researching literature for the supply chain management theory, the main focus should be on gathering data from as credible sources and source material as possible, both old and new. This means that well-known books and highly cited articles of the field should be prioritized, and the usage of secondary sources or indirect citations should be avoided. Also, as the SCM theory lays the foundation for the whole analysis and the theoretical framework, this part of the literature review should be also constructed with the research questions in mind (e.g., SCM should be investigated and explained especially from the viewpoint of a traditional manufacturing company). Research bibliographies are very common, search terms are quite self-explanatory, and the inclusion/exclusion criteria is very clear.

Table 2: Research Protocol #2, Effects of COVID-19 Pandemic on Manufacturing Companies' Supply Chain Management in Global Scale

RESEARCH PROTOCOL #2	
Subject of Review	Effects of COVID-19 pandemic on global manufacturing companies' Supply Chain Management
Research Bibliography	Andor, Google Scholar, Harvard Business Review, SpringerLink, trusted news outlets (e.g., Reuters, Forbes) and different SCM-related expert sources (e.g., Supply Chain Management Review, Supply Chain 24/7, Supply Chain Digital)
Search Terms	<i>COVID-19 Pandemic</i> combined with different variations of terms: <i>Effect, Impact, Global, Supply Chain Management, Manufacturing, Industry, Company, Supply Chain Risk Management, Resilience, Response</i>
Search Strategy	Search fields: <i>Title, Keywords, Body text</i> Language: <i>English, Finnish</i> Publication type: <i>Journal/online articles, news, professional reports</i> Date range: <i>12/2019 to 12/2022</i>
Selection Criteria	
INCLUSION:	Field: Supply Chain Management (or related to it in its context) Subject: COVID-19 pandemic, SCM & SCRM (pref. related to mfg.) Source: Authors are preferably related to the field of SCM News articles to be used judiciously.
EXCLUSION:	Source is not scientific or professional (excluding the news outlets). Information/data is clearly biased/an opinion or it has nothing to do with SCM and COVID-19 in its context.

The Research Protocol #2 is a bit more complex, as the range of quality of the potential literature is far broader. More (and different) research bibliographies are used, search terms are in greater number, and the date range for searched literature is limited from 12/2019 to 12/2022, as that is the period the pandemic has been active. Also, the inclusion/exclusion criteria in this protocol are much more flexible than the ones in the previous protocol, which further underlines the importance of due diligence when selecting what sources and literature are included. And once again, Appendix A presents all those journal articles, professional reports, etc. that pass these inclusion criteria. The literature review is up next, and these protocols are put to work straight away.

3. LITERATURE REVIEW

3.1 Supply Chain Management

Organizations operating on the basis of manufacturing are usually dependent on other companies due to the need for outsourced materials or products to be able to produce their own for their customers. From a theoretical business management perspective, the whole process of acquisition of the required “input” for the manufacturing process and the distribution of the desired “output” to the customers creates a (sometimes very complex) Supply Chain (SC), which is a two-way system consisting of material, information, financial and knowledge flows. (La Londe & Masters, 1994; Ayers, 2000, p.4-5) As a disclaimer, manufacturing in this thesis regards to making physical products, as the term can nowadays be associated with digital products also (Blanchard, 2010, p.77). In a classic linear SC illustration, such as the one presented in Figure 5 below, a manufactured product’s supply chain is usually depicted to be starting from a supplier and ending up to the end-customer through a manufacturing company, a distributor and maybe a retailer.

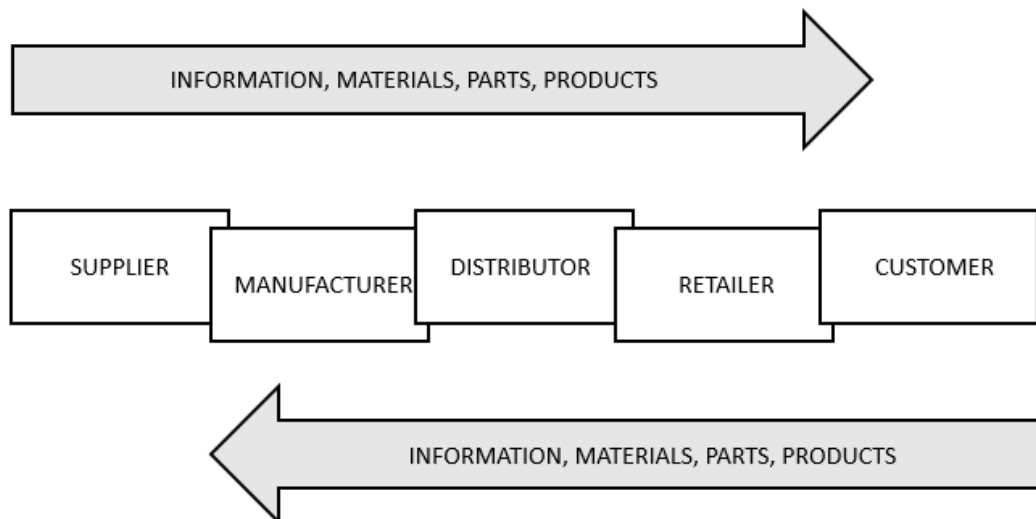


Figure 5: Classic Linear Supply Chain Model (adapted from McKeller (2014, p.4))

In reality though, a supply chain can be much more convoluted and consist of a lot more than just these main factors. La Londe & Masters stated already in 1994 that when a technologically more complex products' supply chains are investigated, their SCs might have hundreds of different companies operating along them in different roles. Ayers (2000, p.4-5) also said that it's important to recognize the importance of all the backward flows of the SC (e.g., product returns, rebates, incentive payments, etc.). In theory, it might be possible to dissect a product's supply chain all the way down to even the actions of a single person operating in a company related to the SC system, but a real-life product's SC can easily become so overwhelmingly complex that this isn't a viable option to manage the whole system. The physical and non-physical flows and processes inside a supply chain can be anything from very simple and straight-forward to extremely complicated and multi-layered, which makes them very hard to be even just precisely outlined from the outside. (Lambert & Copper, 2000)

To help better understand the easily complicated nature of supply chains from the perspective of a manufacturing company, adapted from Mentzer et al. (2001), three simplified figures depicting the upstream and downstream flow of products, services, finances and information are presented below illustrating different degrees of SC complexity between the supplier(s), the company of interest, and the customer(s). Figure 6 depicts a so-called Direct Supply Chain, which consist only of the nearest imminent (or only) supplier, the organization and the nearest (or only) customer. This is the most simplified barebones version of a supply chain presentation that includes all the three most basic SC elements. Figure 7 represents an Extended Supply Chain, which goes one step deeper in both ends showing also the supplier's supplier and the customer's customer. The third, Figure 8, is a presentation of what Mentzer et al. (2001) call an Ultimate Supply Chain. It shows the very start and the very end of the SC, with also multiple third-party elements in between, acknowledging the existence of all parties that are directly involved in the supply chain of the example's company. These three figures, even if very simplified and linear, still provide a good and easy-to-read visualization on how the complexity of a company's supply chain starts to increase as more factors and variables are considered. Still, Figure 8 is a long way from realistically representing any larger (or better yet, a globally operating) manufacturing company's true SC system.



Figure 6: Direct Supply Chain (adapted from Mentzer et al. (2001))



Figure 7: Extended Supply Chain (adapted from Mentzer et al. (2001))

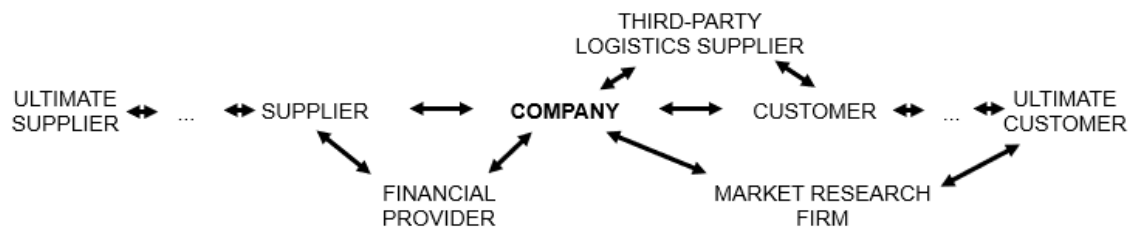


Figure 8: Ultimate Supply Chain (adapted from Mentzer et al. (2001))

For an SME (Small- and Medium-sized Enterprise), a very horizontal SC model such as Figure 8 might very well be enough to display its whole supply chain and straightforward logistical processes. If, for example, a small manufacturing company is only dealing with a handful of key suppliers and sells its products to only few main customers, its supply chain might require very little management to operate as intended, and therefore be as simple as the models by Mentzer et al. (2001) suggest. For bigger and more advanced companies though, the reality is often not as elementary. Jespersen & Skjøtt-Larsen (2005, p. 13-15) suggest that the relationships between the focal company's customers and suppliers among each other in the supply chain are often "*not clearly defined*", meaning that they're not based on as clear hierarchical structure as presented in Figures 6, 7 and 8. They mention that, for example in the processor business, a company can be a supplier to its customer, and at the same time be its competitor as well by selling to its customer's customer. These differing relationship structures between businesses related

to the companies' supply chains are highly dependent on the nature of the industry the companies are operating on. To take these kinds of variables into consideration, a more advanced Tier-structured supply chain model adopted from Jespersen & Skjott-Larsen (2005, p.15) is presented in Figure 9 below. This model allows the ease of referring to the "distance" of how far in the SC a specific element of interest is by indicating it using a Tier-number (e.g., a supplier's supplier is a Tier 2 supplier from the focal company's perspective). It can also help in highlighting the formerly mentioned possible conflicting supplier-competitor relationships in the chain. To foreshadow what is coming later, all of this will be very useful in analyzing and presenting the research results, as the manufacturing companies that will be selected to be interviewed for this thesis will all have larger and more complicated supply chains than what could here be visualized with any reasonably detailed accuracy.

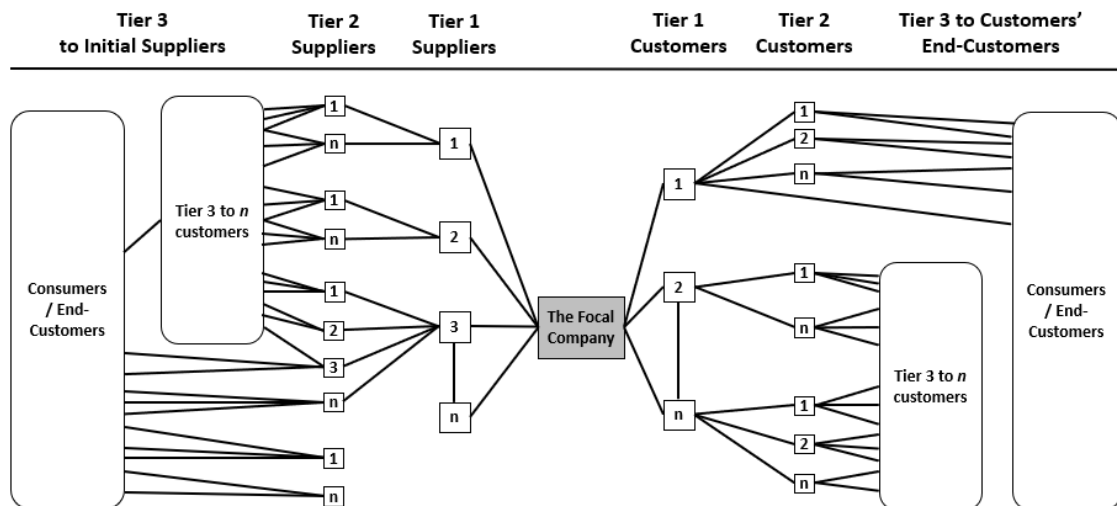


Figure 9: A Tier-Structured Supply Chain Model (adapted from Jespersen & Skjott-Larsen (2005, p.15))

By now, the essentiality of a functioning supply chain for a manufacturing business should be obvious even for a layman without much experience from this industry: for a manufacturing company to run its production operations of physical products, it must physically have the required materials to be able to do so. If it can't itself produce the required materials to make its products, which is most of the time the case, those materials must be sourced and procured from somewhere else. For most of the manufacturing companies, this is a dynamic and ongoing flowlike process with its own assigned business functions (Chopra, 2019, p.16). From a manufacturing company's perspective, it's also noteworthy that it can quickly become very difficult (or sometimes even impossible)

to just store large enough amounts of materials and supplies to last very long, at least in the heavier sectors of manufacturing industry. This means that for the company to run even in a short-term scope, at least the SC flows from the supplier(s) of the company's Direct Supply Chain presented in Figure 6 (or in another words, from the Tier 1 supplier(s) presented in Figure 9) must be operational. Then, to be able to deliver the finished products to its customers, the direct SC flows from the company to the customer must be operational as well. Now, referring to Figures 8 and 9 presented above, it's very easy to gather that if the focal company wishes to continue its manufacturing operations in a long-term scope, its Ultimate Supply Chain must be operating as intended too, because understandably the Tier 1 supplier(s) needs the Tier 2 supplier(s), and so on, to be able to supply the focal company. Same is also true to the other way, as the end-customers must be reached eventually as well.

The physical and non-physical flows inside a supply chain system are usually ran by the companies and entities involved in the SC by their various different functions (e.g., logistics, procurement, sourcing, finance, etc.). Depending on the size and the nature of a manufacturing company's business, the complexity of its SC and the processes involved in it can become so overwhelming that it's impossible to be controlled efficiently without a proper management model (Lambert & Cooper, 2000; Chopra, 2019, p.15; van der Vorst, 2004, p.113-115). This is when Supply Chain Management (SCM), a term that saw its light in the early 1980's, is the answer for success (Oliver & Webber, 1982; Lambert & Cooper, 2000). The concept of SCM has been defined by many scholars over the years, e.g., John B. Houlihan (1985) put it "*Supply Chain Management covers the flow of goods from supplier through manufacturing and distribution chains to end user*" and Ayers (2000, p.7) explained that SCM is "*design, maintenance, and operation of supply chain processes for satisfaction of end-user needs*". As time has passed, the definition itself may have become an umbrella term that has been both specified and expanded many times over, but what's clear is that as a management tool to gain competitive edge, its importance has only grown. And most importantly, against the common fallacy among the unversed, supply chain management isn't about just managing bare logistics. (Andersen & Rask, 2003; van der Vorst, 2004, p.110; Janvier-James, 2012; Sople, 2012, p.4-5; Martin, 2016, p.2-4; Lau et al., 2019, p.1).

For the purpose of this thesis, considering that the focused industry (manufacturing) has been defined by many researchers to be rather traditional still in the 21st century, a basis of SCM knowledge should be laid first by a clarifying visualization of the commonly recognized 'traditional' elements included in supply chain management. This is accomplished by presenting a supply chain management framework model adopted from

Mentzer et al. (2001) below in Figure 10. According to them, this model includes all of the interconnected typical business functions and supply chain flows required to be inter-functionally included in traditional SCM planning, organization and processes for a company to be able to achieve its full SCM potential in a global perspective. Mentzer et al. (2001) say that a supply chain could be imagined as a directional pipeline, of which this Figure 10 is a vertical cross section of, and as they view the ultimate goals of supply chain management as lowering costs, increasing customer value and satisfaction, and gaining competitive advantage, this is also represented in their model. Finally, their definition of supply chain management that was also the source for this model, as a direct quote, is *“the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole”*.

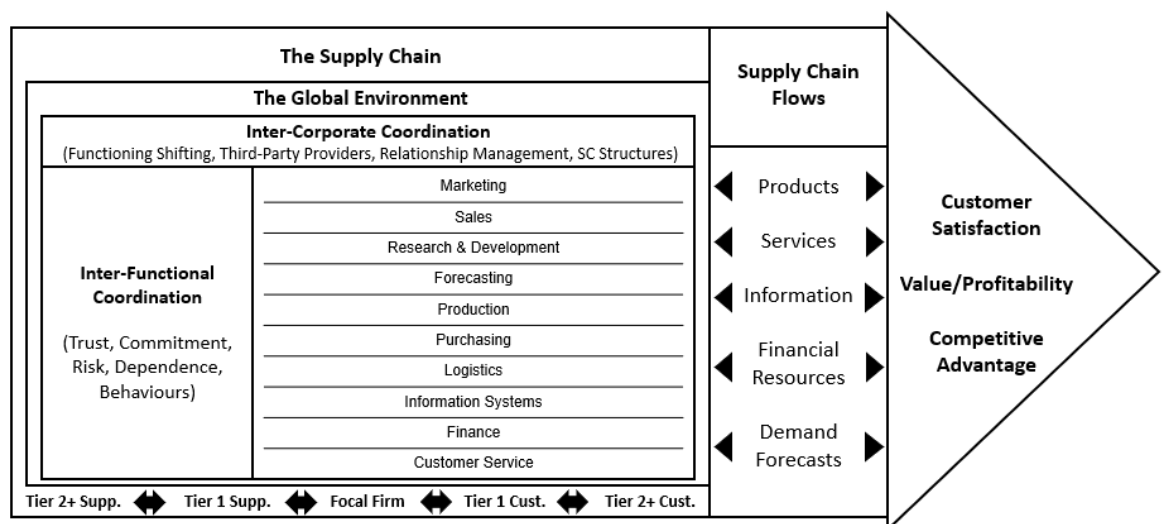


Figure 10: A Supply Chain Management Framework Model (adapted from Mentzer et al. (2001))

As Figure 10 shows, supply chain management should be much more than just procurement of materials for production needs, even if that is one of the most essential functions of it. Before diving into the different SCM models and methods, it's worth to highlight the differences between traditional management and supply chain management that have been discussed in past literature ago by Cooper & Ellram (1993) and Cooper et al. (1997) to set up a comparison point for later. Based on their research, they proposed that working closely together, sharing and monitoring information, and joint planning are characteristics that differentiate SCM approach from other channel systems, and the possible

channel-wide benefits are achieved by long-term orientation. They emphasize that a company's SCM should focus more on management of relationships within the SC than try to strive only for individual optimization. They also underline that the traditional functions of purchasing & logistics have an important role in SCM regarding inventory management, information gathering and disseminating, negotiating to integrate goals and activities with others, and in optimization of the whole SC.

Also, from a manufacturing company's perspective, on top of being able to gain competitive advantage by building a strong supply chain, SCM can also help the company to avoid disastrous SC phenomena. One example is the Bullwhip Effect, which is an SC-internal demand fluctuation phenomenon that intensifies when moving upwards the SC, and is caused usually by the distortion of information flow in the SC. It's usually the result of poor SCM and the lack of cooperation of the SC members (e.g., misguided demand forecast updating and order batching) and it can lead to significant operational and financial problems, such as excessive inventories, bad capacity plans, logistics problems, and losses of revenue. (Lee et al., 1997; van der Vorst, 2004, p.108-109) To avoid scenarios like these, various supply chain wide SCM approaches can be taken. The SCM cooperation concept, explained by Jespersen & Skjott-Larsen (2005, p.43) in their book, is one example. When it emerged as a supply chain trend, it shifted companies' way of thinking inside their supply chains from the classic "antagonist" model to a more collaborative model (Storey et al. 2006), and it's very closely related to the differences discussed by Cooper & Ellram (1993).

Next, to compare the traditional management approach to the supply chain management one, a merged and unified presentation of the differences between traditional management and SCM by Cooper & Ellram (1993) and the differences between traditional cooperation and SCM cooperation by Jespersen & Skjott-Larsen (2005, p.43) is presented in Table 3 below. Quoting Jespersen & Skjott Larsen (2005, p.43), it *"summarises the most important characteristics of a traditional "arm's length" approach and an SCM approach"*. However, it's good to note that later it's discovered that SCM can be approached from various different angles, which means that the differences are not always as black and white as presented below. But to paint a general picture from a perspective of a traditional manufacturing company, this comparison is a good generalization.

Table 3: Traditional Management & Cooperation vs. Supply Chain Management & Cooperation (adopted from Cooper & Ellram (1993) and Jespersen & Skjøtt-Larsen (2005, p.43))

Element	Traditional management & cooperation	Supply chain management & cooperation
Inventory control & management approach	Independent efforts in inventory reduction and management	Coordinated and joint inventory reduction throughout the SC
Total cost approach	Minimization of individual costs (in e.g., logistics)	Minimization of the SC's total costs, channel-wide cost efficiencies
Time horizon	Short term	Long term
Information sharing	Limited to only the needs of current transactions	All information required for planning and monitoring of the integrated processes in the SC
Supplier base	Multiple suppliers/large supplier base (multi-sourcing) to spread risk	Few suppliers/reduced supplier base (single or dual sourcing) to prioritize relationship levels and coordination
Coordination of multiple levels in the SC	Single contact for transaction between companies	Multiple contacts between levels in companies and levels of SC
Joint planning	Transaction-based	On-going
Compatibility of corporate philosophies	Not relevant	Compatible at least for key relationships
Organizational type	Functional organization	Process-oriented organization
Sharing of risks and gains	Each member tries to optimize their own risks and gains	Fair sharing of risks and gains proportional to contribution over long-term commitment
Information systems	Not integrated	Integrated and compatible
Channel leadership	Not needed	Needed for coordination focus
Goals and vision	Not harmonized between companies	Shared ideas of goals and vision
Focus	Succeeding downstream intermediary	End-customer
Contract type	Classic contract	Relational contract/partnership

From these differences it's clear that since the 20th century some of the main theoretical objectives of SCM have been the building of long-term relationships and optimization of companies' operations throughout their SC. What is especially interesting and important regarding this thesis though, are the actual SCM methods that manufacturing companies have utilized in the past and the present. In this case, 'the past' is the timeframe around the change of the millennium (1990's to early 2000's), just as globalized manufacturing and delivery processes started to grow the importance of supply chain management as a corporate function (Packowski, 2021, p.19). Starting out from the older methods and approaches, one SCM sub-theory, *lean*, has been probably the most important source of SCM methods from the viewpoint of traditional manufacturing. Since mass production lost its crown as a manufacturing model to lean manufacturing following the success of Japanese Toyota around the 1970's, the lean-thinking started to influence management models all over the world. The manufacturing performance Toyota was able to achieve in the aspects of cost, quality and delivery were something that was never seen before, and many other manufacturing companies wanted to follow in their footsteps. (Jon et al., 2000, p.215; Womack et al., 2007)

3.1.1 Lean Versus Agile

Lean philosophy itself is defined as a five-step process that includes: *defining of the value* (what does the end-customers want), *mapping of the value streams* (activities from suppliers to end-customer), *establishing the 'flow'* (creating a system with as less delays, down time, and waste as possible), *enabling the pull* (provide enough for the demand, but not too much), and *striving for excellence* (constant and continuous improvement) (Womack & Jones, 1997). The objectives of lean production are the highest customer satisfaction (matching the demand in quantity, quality, functionality, and price, in a timely manner), total elimination of waste (overproduction, waiting, unnecessary transportation, non-value-added-processing, excess inventory, defects, excess motion during work, and underutilized people), and the highest respect of human dignity in the production process. (Jon et al., 2000, 216-217; Kilpatrick, 2003)

Among the listed wastes that the different lean principles are meant to reduce, many are closely SCM-related (e.g., waste regarding transportation, excess inventory, and overproduction). As the lean principles aim to remove everything non-value-adding from different processes, they are in other words improving their cost-effectiveness, which is also one of the main goals of even traditional SCM for SC-related elements. Therefore, it's not a coincidence, why different lean tools and principles have been so successfully utilized to create 'lean SCM' to supplement lean manufacturing. Next, in Table 4, some

of these lean-tools and principles that have been successfully utilized in the past by manufacturing companies' SCM are presented and explained.

Table 4: Lean Tools & Principles

Lean tool or principle	Function
Just-In-Time (JIT)	Each manufacturing process is supplied with the right amount of required parts, exactly at the right time (Karlsson & Ahlström, 1996).
Pull-based supply chain	Manufacturing and distribution is based on validated customer demand (Janvier-James, 2012).
Kaizen	Continuous improvement through change and elimination of waste (Gupta & Jain, 2013)
Make to Order (MTO) & Assemble to Order (ATO)	MTO avoids waste by reducing overproduction, ATO avoids waste by eliminating final product inventory (Jon et al., 2000; Song & Zipkin, 2003, p.4)
Material Requirement Planning (MRP)	Helps in getting the correct materials and parts to the right place at the right time, reduces material and inventory related inaccuracies, and errors in manufacturing planning (Rajeev, 2008).
Value Stream Mapping (VSM)	Visualization tools to analyze work-flow to recognize value-adding and non-value-adding activities (Hines & Rick, 1997).
Lean Six Sigma	Managerial concept used to reduce process variation and waste to improve quality and customer satisfaction (Taghizadegan, 2010, p.1-3).
Kanban	Card-based system that aids in moving material inside the SC to correct place at the correct time, and helps in maintaining the desired flow (Gupta & Jain, 2013).
First-in-first-out (FIFO)	Reduces flow variation by simple priority rule (Tokola et al. 2017).
Inventory reduction	Reducing waste by freeing financial capacity with smaller stock (Hofer et al. 2012).
Supplier base reduction	Concentrating on smaller amount of suppliers, but with deeper engagement level (Bhasin & Burcher, 2006).

Many of the principles and tools presented in Table 4 have tremendously helped manufacturing companies in optimization by reducing lead-times (the time it takes for a process to finish from start, or a customer receive his product from ordering it) in their production processes while reducing also costs, which have both been ranked in the past as the most sought-after objectives of lean implementation. For example, *JIT* and *pull-based SC* help by reducing buffer and order sizes, therefore avoiding the accumulation of excess inventory and holding costs related to it, basically synchronizing with *inventory reduction*. *VSM*, *MRP*, *Lean Six Sigma*, and *Kaizen* can all reduce lead-times and costs by helping in exposing and eliminating waste, such as ineffective processes and unnecessary transportation. As lead-times get below what the customers' accepted waiting time is, tools such as *MTO* and already mentioned *pull-based SC* can be utilized to avoid overproduction and other listed waste even more. (Lebow, 1999; Jon et al., 2000, p.222; Rooney & Rooney, 2005; Ugochukwu, 2012)

Although globally widely known and used, lean philosophy hasn't been the only source of successful SCM principles for traditional manufacturing companies. Fisher (1997) argued that before selecting an SCM strategy, the company should first understand the business environment that they're operating in along with the nature of their products' demand from an SCM perspective. He points out that different types of supply chains might not work as well with different types of offerings, and therefore always crafting an SCM strategy based on, for example, only lean principles might not produce the wanted results, but rather perform even worse than before. Fisher (1997) roughly splits the possible types of offerings into two categories, *functional* (basic products with low level of variety, designed for unchanging needs, long life cycles, low margins, and stable demand) and *innovative* (products with high level of variety, short life cycles, high profit margins, and unstable demand). According to him, a functional offering works best with an *efficient supply chain*, which is very strongly based on the above discussed lean principles, but an innovative offering needs a *responsive supply chain* to thrive, which is examined in more detail next.

Whereas a functional product (e.g., toilet paper) has a very predictable demand and little to no variety between competitors' products, an innovative product (e.g., supercars) can be competing against constantly fluctuating demand and variety of competition. In an unstable market like this, it's very difficult to find advantage against competitors by only minimizing physical costs lean-style (e.g., by cutting down costs by reducing inventory storage), as the greatest threat lies in market mediation. Innovative products are especially prone to be faced with quick shifts and changes in consumer demand, and costs related to the lost sales opportunities and unsatisfied customers caused by the current

offering suddenly not matching anymore what the consumers are after, are not what a physically efficient (lean) supply chain is able to easily combat. A market-responsive (agile) supply chain, in the other hand though, is exactly meant to provide the required responsiveness and agility for the company to be able to make the required changes to their offering to quickly match the changed customer requirements. (Fisher, 1997; van der Vorst, 2004, p.116-118) Below, in Table 5, the clearest differences between a physically efficient SC and a market-responsive SC are presented according to Fisher (1997).

Table 5: Physically Efficient (lean) Process vs. Market-Responsive (agile) Process (adapted from Fisher (1997))

	Physically efficient (lean) process	Market-responsive (agile) process
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand in order to minimize stockouts, forced markdowns, and obsolete inventory
Manufacturing focus	Maintain high average utilization rate	Deploy excess buffer capacity
Inventory strategy	Generate high turns and minimize inventory throughout the chain	Deploy significant buffer stocks of parts or finished goods
Lead-time focus	Shorten lead-times as long as it doesn't increase costs	Invest aggressively in ways to reduce lead-times
Approach to choosing suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility, and quality
Product-design strategy	Maximize performance and minimize cost	Use modular design in order to postpone product differentiation for as long as possible

The term agility is defined by Christopher (2000) as “a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets”, which enables the organization to rapidly react to changes in market demand (volume and variety). The most important traits that are the sources of the flexibility of an agile supply chain are **Market sensitivity** (end-user trend centric SC and the ability to read and respond to real demand, not just operate based on forecasts), **Virtual integration** (information-based instead of inventory-based, information shared across

all SC members), **Process integration** (collaboration with members of supply chain, high degree of process interconnectivity), and **Network-based** (flexibility from SC members expertise, competition happens as a supply chain rather than as an individual) (Harrison et al., 1999; Christopher, 2000). According to Baramichai et al. (2007), companies can create SC agility by combining various approaches, but classifying agile supply chains into four clear categories helps supply chain managers to analyze and determine the right strategies for their company. Their classification is based on the purchasing objective and the characteristics of the supply market, and it shares obvious similarities to the traits listed by Christopher (2000):

1. Agility through the flexible supply chain

Capacity is obtained and costs are reduced by eliminating non-core processes. Mature market with many suppliers, which are easily identified and reached. Supplier switching costs are low.

2. Agility through agile virtual enterprise

Core competencies are developed through gaining access to SC members' wide range of expertise and capabilities, while remaining itself independent. Emerging market with many suppliers, which are geographically located but easily identified. Supplier switching costs are low.

3. Agility through network of agile partners

Capacity is obtained and costs are reduced, while supplier's capabilities are taken advantage of to respond to changes in operational level. Mature market with limited number of suppliers. Supplier switching costs are high.

4. Agility through agile extended enterprise

Suppliers' unique capabilities, skills, competencies, technical knowledge, and intellectual strengths are taken advantage of to respond to and utilize changes and new opportunities. Emerging/growing niche market with limited number of suppliers. Supplier switching costs are high.

Different approaches to gain supply chain agility or to develop an agile supply chain are presented in literature to a great extent, and many of them clearly overlap each other. Gunasekaran (2001, p.360-364), for example, said that "*SCM evolution has provided a number of practices that directly relate to improving agility within and between organizations*" and presented them from four areas: **Supplier relationships** (e.g., agile benefits from early involvement in marketing, design and product development cycle), **Customer**

relationships (e.g., focusing on the best customer relationships and including also engineering, logistics, manufacturing, and purchasing functions on top of just marketing in the relationship), **Organizational processes** (e.g., implementing a standardized supplier certification program greatly enables development of agile supply chains), and **The overall SC system** (e.g., strengthening supply chain links through continuous improvement). They also mentioned The Agility Forum's listing of four major categories of supply chain agility enablers and their subsystems, which are **Internal company** (e.g., continuous learning, customer interactive systems, benchmarking), **Industrial system** (e.g., pre-qualified partnering, rapid cooperation mechanisms, technology adaption and transfer), **Company technology** (e.g., distributed databases, knowledge-based systems), and **Natural resources** (e.g., waste management and elimination). Although the categories are different between the two lists, significant similarities can be observed if all of the suggested practices are compared. Gunasekaran (2001, p.363) remarks that this shows that management of issues related to an agile supply chain is complicated and requires a variety of practices, policies and tools.

Creating an agile supply chain is no easy feat, as it can require serious changes to a traditional supply chain (Christopher & Towill, 2001). Building agility can also seem confusing, as the approaches and methods might not be nearly as straightforward as, for example, some of the listed lean tools. In theory and in practice, a framework model usually helps enormously to bring together the vision of complex subjects such as this. Christopher & Towill's (2001) integrated model for enabling the agile supply chain is a three-level framework presented below in Figure 11 that depicts their view of the principles, programmes and single actions of what makes an agile supply chain. This integrative model also summarizes well, how different aspects of agile manufacturing and agile logistics help in creating an agile supply chain. Christopher & Towill (2001) explain their model's structure as follows: *"Level 1 represents the key principles that underpin the agile supply chain. Level 2 identifies the individual programmes, which must be implemented in order for the Level 1 principles to be achieved. Level 3 specifies individual actions to be taken to support Level 2 programmes."*

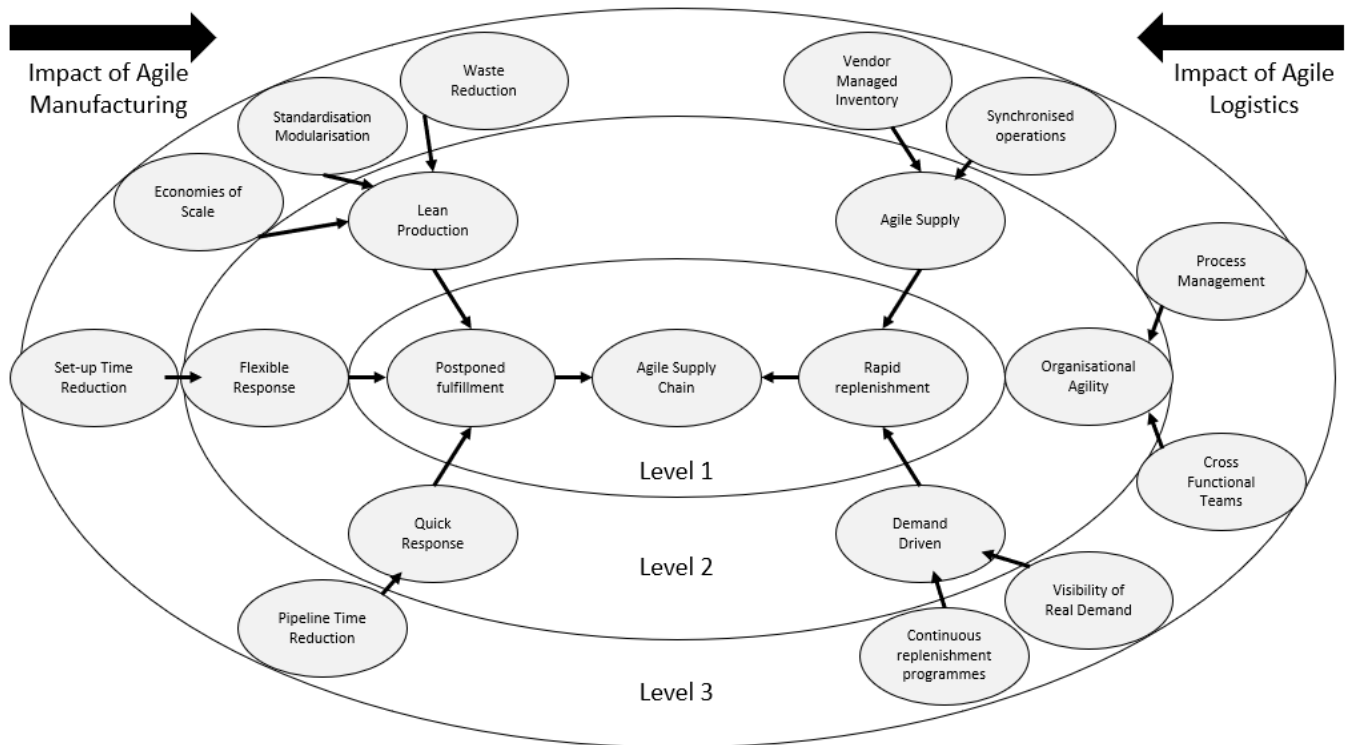


Figure 11: An Integrated Model for Enabling the Agile Supply Chain (adapted from Christopher & Towill (2001))

Looking through the levels in Figure 11, a main point of interest in Christopher & Towill's (2001) framework is that it includes lean production as one of its principles on Level 2. This is a very important find, because one could easily gather from what has been noted so far about agile and lean that they do not mix together. This is not true at all, as in reality, both agile and lean supply chains can benefit from integrating each other's traits, methods, approaches and tools to themselves. As they also share some common characteristics, it's actually rather natural that companies' SCM utilizes "best from both worlds". A hybrid SC strategy can therefore be a very valid choice, and for some offerings, a supply chain might even need to be able to shift from lean to agile (or other way around) as is needed. (Christopher, 2000; Christopher & Towill, 2001; Ambe, 2009, p.665).

3.1.2 Traditional SCM Versus Modern SCM

Now, as probably the two most iconic SCM concepts for manufacturing companies have been introduced, it's time to look at the world of supply chain management today. As the 21st century has progressed, companies around the world have had to face the acceler-

ation of globalization and expansion of their markets, which has in turn dynamized business environments and caused supply chain management to become one of the most vital tools of dominating the competition (Janvier-James, 2012; Lau et al., 2019, p.1-2,37). Chopra & Meindl (2016, p.154-155) say that whereas many companies have failed to take advantage of the globalization due to unpreparedness for the new challenges arisen along it, the prepared and able companies (e.g., Samsung with its high-performance SC) have very successfully managed to capitalize on this phenomenon, even as far as claiming the spot as market leaders. He notes that *“globalization has offered tremendous opportunity, as well as increased risk, in the development of supply chains”*. From this statement, it's easy to gather that as the competitive field and the supply chains in it were affected by globalization, the supply chain managers of the affected companies had pivotal roles to play in the possible outcome: many of the earlier mentioned SCM tools and methods commonly used in the past were not fit for a globalized business environment.

Packowski (2021) used the term VUCA (volatility, uncertainty, complexity, and ambiguity) to describe the world and the challenges in it today and said that manufacturers nowadays are not sure what agility enablers, and which lean aspects to utilize to create a superior SCM organization. For example, relying on the accuracy of long-term sales forecasts to plan out as lean production plans as possible can be completely futile if the numbers change month to month, causing the so-called planning loop trap (forecast errors lead to short-term re-scheduling and firefighting, which causes just more delays and errors). As global sourcing is almost as commonplace as having a website, trying to build deeper SC relationships with suppliers in a globalized supply chain can also be a mountain of a challenge if the company's suppliers are all offshored from another side of the world. Just as simple as a value-adding method that's tied strictly to operating near a customer's or supplier's location can quickly become too overwhelming to maintain if the company's SC aggressively globalizes and branches out affecting the location and amount of customer and/or supplier base. Packowski (2021) underlines his point by stating that *“the real issue in SCM (today) is not about improving the accuracy of the sales forecast and reducing the amount of uncertainty in the future, it's rather about eliminating the need for certainty in operational planning”*.

In 2002, Bowersox et al. boldly stated (p.34-35) that *“almost any level of logistical service can be achieved if a firm is willing to commit the required resources”*, implying basically that the only limiting factor is money. While this might be true in theory, is it realistic in practice from an SCM viewpoint, as cost-effectiveness is one of the main goals of every

supply chain, both agile and lean? Not in most cases. Just few major bad choices regarding a company's SC network design (e.g., facility roles, locations, capacity, and markets) could lead to catastrophic losses if, for example, due to a miscalculated decision, a recently built major facility had to be suddenly moved to a different location (Chopra & Meindl, 2016, p.120-121). Miscalculated decisions like these could very well be contributed by the use of outdated SCM ways, which is a scary prospect from a supply chain manager's point of view. In fact, already in 2011, Christopher & Holweg argued that most of the traditional operational strategies and methods (e.g., lean production, SIX SIGMA) were outdated and needed to be radically re-thought to fit the current era. According to them, the global business environment was no longer nowhere near as stable as it was back when the SCM took its traditional form. This means that the modern 21st century supply chain management should be able to combat the growing global turbulence by being structurally flexible (having the ability to adapt to fundamental changes in business environment), instead of dynamically, in designing and managing SCs.

According to Packowski (2021, p.27-28), the main problem with the older SCM principles, methods and tools is that they were simply designed for a different time with less variables. The traditional lean approach, for example, causes problems for global supply chain planning, as it oversimplifies the SC processes or simply doesn't cover all of them, such as integration with corporate planning systems and planning across multiple plants and assets. Packowski's (2021, p.37-53) suggestion, "*LEAN SCM*", is a modernized version of the old lean, and it consist of three principles: **LEAN DEMAND** (accept uncertainty, prepare for consumption-driven supply, and respond to real consumption), **LEAN SUPPLY** (manage demand spikes with safety stock buffers, level production plans to create flow and stabilized utilization, and achieve regularity with cyclic production patterns), and **LEAN SYNCHRONIZATION** (separate planning to slice complexity for global synchronization, use parameter-driven end-to-end SC planning, and establish visibility and a collaborative environment for synchronization). According to him, following these three fundamentally changed SCM principles, variability and complexity of achieving an end-to-end synchronized SC can be managed better than with traditional planning methods. The benefits of implementing LEAN SCM should be end-to-end scale total lead-time reductions and minimized inventory levels, which still correlate with goals of the traditional lean SCM, but they are achieved with even more agile SCM involved.

It's clear that for a modern manufacturing company dealing with globalized supply chains, finding the best possible agility in SCM should be on of the key goals of its management. Oláh et al. (2018) even stated that in the world today "*only agile, adaptable and coordinated supply chains will give their companies a sustainable advantage*". For

some companies though (e.g., those with too small SCM organization), making the change from, for example, a very traditional cost-efficient lean approach to a highly agile SC system can be a very difficult task for various reasons, such as the lack of available capital or human resources. Therefore, examples of singular concrete tools and practices are once again very helpful to be highlighted, as some companies' only option could be to implement solutions like those independently to be able to add at least some agility into their SC. Below, in Table 6, are some of the different SCM methods and actions to achieve structural flexibility listed by Christopher & Holweg (2011).

Modern SCM tool or method	Function
Dual sourcing	Having alternative sources for key raw materials and major components adds agility and reassurance to the SC and SCM.
Asset sharing	Being prepared to share physical assets (e.g., factories, distribution centres or transportation) creates additional economies of scale.
Separating <i>base</i> demand from <i>surge</i> demand	Recognizing the <i>base</i> demand that production can be planned for helps the managing of the demand <i>surges</i> (with e.g., postponement techniques).
Rapid manufacture	Using new technology to manufacture small batches of products in smaller facilities ("mini-mills") enables flexibility of dispersed manufacturing.
Outsourcing	Using external providers (e.g., contract manufacturers or third-party logistics firms) enables extra capacity that can be accessed if needed and converting of fixed costs into variable costs.
"Local for local" production	Manufacturing in (preferably low-cost) countries that are near the company's markets reduces lead-times and provides more configurability by bringing the supply closer to the demand.
Greater use of contract manufacturers	Outsourcing the basic manufacturing, but doing the late configurations and more complex manufacturing itself (or the other way around) enables great amount of flexibility for production.
Vendor-managed inventory (VMI)	Implementing a system of <i>dynamic replenishment</i> between the supplier and customer improves visibility and ability to cope with dynamic distortions.

Figure 12: Actions to Achieve Structural Supply Chain Flexibility (adapted from Christopher & Holweg (2011))

Despite all of the methods described above, there still remains more to succeeding in modern-world supply chain management. The field of SCM has no doubt changed since the traditional lean-days, and it seems that what used to be the norm 30 years ago will most likely never return. As the markets become more and more turbulent and the globalized supply chains' complexity levels raise, it's obvious that so does their vulnerability. And even if an agile supply chain could have an answer for changing demands and shifting markets, what about when something goes totally wrong? This is when SCM must be supplemented with Supply Chain Risk Management (SCRM), which is the next topic of the literature review.

3.2 Supply Chain Risk Management, Resilience & Disruption

Risks have always been present in doing business, as well as in managing the supply chains related to business. Supply chain risk management aims to assess and strategically reduce the risks around the different processes around SCs and SCM, and it's sort of a middle ground between SCM and traditional risk management. Supply chain risks can range from very specific (e.g., a Tier 1 supplier's unreliable method of material transportation) to cover whole SC systems (e.g., all Tier >1 suppliers are international, and global markets are experiencing turbulence). Several modern SCM trends have also added on companies' SC risks. For example, globalization has been an important gateway for many manufacturing companies to greatly increase their production and distribution cost-effectiveness, but it has also introduced various new supply chain risks compared to just operating locally. As the countries with low-cost labour like China have made the rest of the world favour outsourcing over insourcing, the globalized supply chains of these companies have grown more and more complex and international. In many cases, this has meant that for traditional manufacturing companies the risks related especially to their sourcing and procurement activities have significantly increased, and the supply chains of these companies have become more vulnerable, as the ratio between cost-efficiency and risks has been pushed harder and harder. (Christopher, 2011, p.190-191; Klumpp & Adibi, 2013; Olson, 2014, p.1-5; Schlegel & Trent, 2016, p.1-8)

A vulnerable supply chain is a very dangerous concept for a manufacturing company, especially for one that operates solely depending on the incoming flows of material from its specific suppliers. The leaner and more optimized its certain processes are (e.g., minimized stock, JIT...), the more likely it's to also face serious problems if its supply chain members do. From an SCRM perspective, it's obvious that a situation where the focal company is completely reliant on one or multiple suppliers' flawless daily operating at all

times, is highly unwanted, as in the worst-case scenario just one failing vital supplier could bring the whole company's operations to a halt. Therefore, the recognized risks related to SCs and SCM from different sources should always be taken seriously, and any potential risks should be actively searched multiple Tiers deep if the company's resources allow. Next, in Figure 13, different sources of risk in supply chain by Mason-Jones & Towill (1998, p.17-22) are visually depicted, and below that, in Table 6 different supply chain risk categories by Olson (2011, p.7) are listed.

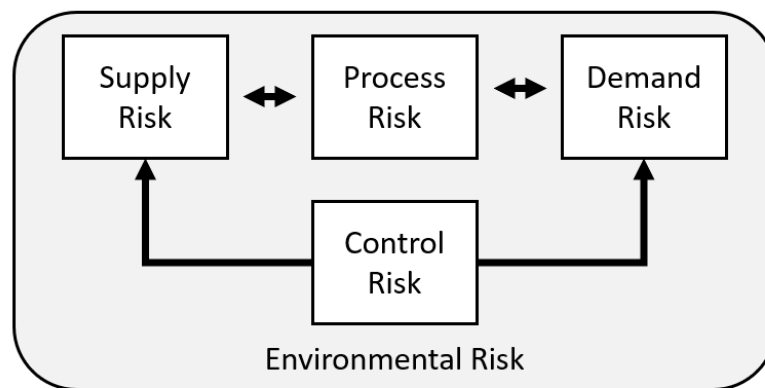


Figure 13: Sources of Risk in Supply Chain (adapted from Mason-Jones & Towill (1998, p.17-22))

Christopher (2011, p.194-195) says that auditing these five risk sources adopted from Mason-Jones & Towill (1998, p.17-22) in Figure 13 can help senior management to identify and understand their company's potential risk profile, and the impacts that their strategic decision making might have on it. He also identifies different risks related to all of them: **Supply Risks** arise due to the business' vulnerability to disruptions in supply (e.g., global sourcing, too centralized sourcing that's relying only on few key suppliers, poor SCM, etc.), **Process Risks** are related to the resilience and variability of the company's different processes (e.g., possible risk-inducing bottlenecks in manufacturing, availability of reserve capacity), **Demand Risks** usually ensue due to different volatility-related phenomena in the markets the company operates in, **Control Risks** are potential disturbances and distortions in the company's own internal control systems (e.g., decision rules that can distort the real demand, such as order quantities and safety stock policies etc.), and **Environmental Risks** are whatever external events might threaten the company's SC and its vulnerabilities, which might be very hard to forecast beforehand. These five sources should cover all possible risks that a manufacturing company, for example, could face, and the visual model highlights also the relations between the risks.

Table 6: Supply Chain Risk Categories (adapted from Olson (2014, p.7))

Category	Risk examples
EXTERNAL	
Nature	Disasters (floods, earthquakes...)
	Plant fires
	Epidemics, pandemics, diseases
Political	War, terrorism, activism
	Labor disputes, strikes
	Customs, regulations, sanctions
INTERNAL	
Available capacity	Capacity cost
	Financial capacity
	Production upscale ability
	Structural capacity
	Supplier bankruptcy
Internal operation	Forecast inaccuracy
	Safety (accidents)
	Demand volatility phenomena
	Agility/flexibility
	Holding cost/order fulfillment trade-off
	On-time delivery
	Quality problems
	Regulatory compliance, recalls etc.
Information system	Information system breakdowns, crashes etc.
	Distorted information
	Integration
	Viruses, bugs, hackers

In Table 6, commonly recognized supply chain risk categories (*external* and *internal*) are extended into specific supply chain risks considered by various studies, according to Olson (2014, p.6-8). He states that the managing of internal risks (e.g., capacity variations, regulations, information delays, organizational factors) is the more direct responsibility of the SCM/SCRM organization, than external risks (e.g., market prices, competitors' actions, political issues). Schlegel & Trent (2016, p. 17-18.) note that while various frameworks (such as Table 6) categorizing the domain of SC risk exist, there is no consensus on a single standard categorization of the risks, rather just different perspectives with the same goal. The list of SC risk categories they present consist of the four following: **Strategic Risk** (most strategically consequential risks to the company), **Hazard Risk**

(all random external disruptions from tsunamis to terrorism etc.), **Financial Risk** (internal and external risks with direct financial impact), and **Operational Risk** (risks related to operational failures in various different functions). By the categories' names alone, it's rather easy to spot similarities between the Olson's (2014, p.7) model, and also even with the risk source model that Christopher (2011, p.194-195) explained. Probably the easiest example is the following connection between all three: **Environmental Risk** of Figure 13, **External category** (Nature, Political) of Table 6, and **Hazard Risk** of Schegel & Trent (2016, p.17). This signals that in SCRM, different models of risk categorization could be easily used in conjunction if it would be seen helpful.

Now, regarding what the true need for SCRM and the activities related to it are for different companies, the answer may very much differ depending on the company in question. Let's assume Figures 6 – 9 are all depicting different manufacturing companies 6, 7, 8 and 9, each with exactly the SC structure accordance to the models. It would be very easy to make an assumption that the company number 9 has a lot more potential supply chain risks than the company number 6. This is fairly obvious, because as the complexity of the company's supply chain increases, so does the number of variables related to it, which could all contain potential new SC risks. The company number 6 would probably get away with just simple general risk management in most (if not all) situations, but the company number 9 could very well be totally depended on advanced SCRM to survive if one or multiple SC-related disruptions were to arise. Craighead et al. (2007) defined these supply chain disruptions as unexpected events that stop or slow the normal flow of material in a SC, which could have devastating and long-lasting effects not only on the focal company itself, but its SC members as well. If not properly dealt with, even a single seemingly isolated disruption event in a supply chain can cause a domino-effect of failing links that ends up shutting down the entire SC system, and potentially also the companies operating in it (Jüttner & Maklan, 2011).

According to Skipper & Hanna (2009) and Scheibe & Blackhurst (2018), supply chain disruptions are inevitable, especially for companies with complex SCs, but what matters is the severity of the disruption. By utilizing supply chain risk management, the most successful companies are usually able to contain the normally occurring SC disruptions better than others and mitigate their effects on their SC systems with as less damage as possible. Companies also try to avoid or at least prepare for potential SC disruptions with SCRM, but by the definition of the phenomenon itself, disruptions can be very hard to predict, sometimes maybe even impossible. Scheibe & Blackhurst (2018) present that various studies have recognized high levels of flexibility in organizational and supply chain structure to be successful SC-reinforcing and risk management traits that help in

countering the potential SC disruptions, and other SC risks alike, which correlates with statements made by Christopher & Holweg (2011) that were presented earlier. The attribute depicting a supply chain's ability to withstand and recover from these emerging (usually negative) events, such as disruptions, is called resilience (Schlegel & Trent, 2016, p.14). To examine how a resilient supply chain is created, a simplified version of the model by Christopher (2011, p.207) is presented in Figure 14 below.

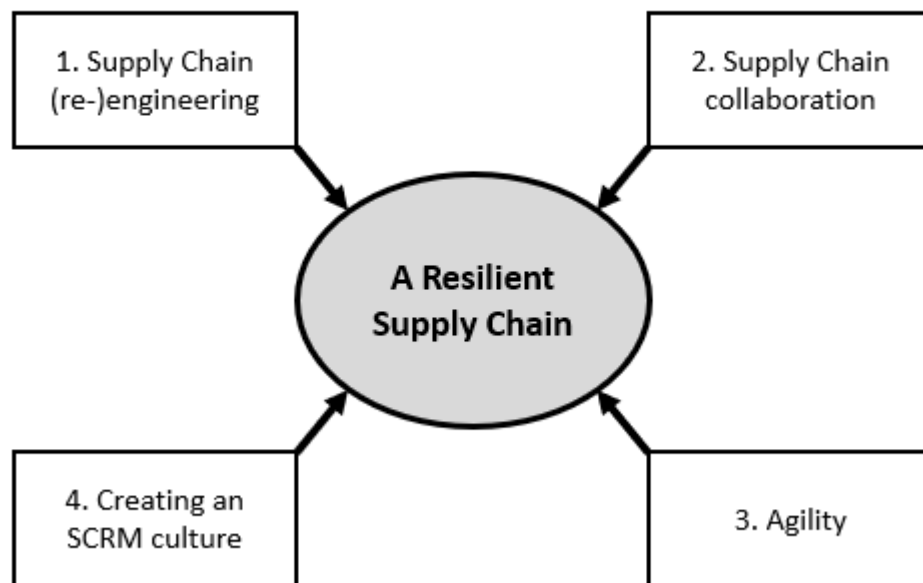


Figure 14: Creating a Resilient Supply Chain (adapted from Christopher (2011, p.207))

According to Christopher (2011, p.206-207), the four factors that are exhibited in Figure 14 are what is required to be in place if SC resilience is to be strengthened. He also emphasizes the importance of building resilience even into the best managed supply chains, as inevitable and unforecastable disrupting events will, at some point, happen. In his extended version of the model, each factor is further divided into sub-parts and Christopher (2011, p.206-207) explains them as follows:

1. Supply Chain (re-)engineering

This factor consists of three sub-categories. **Supply base strategy** includes all sourcing decisions and their criteria, and supplier development. **Supply chain understanding** is achievable by mapping and critical path analysis, along with supply chain risk register.

Supply chain design principles are the real options thinking, and efficiency vs. redundancy comparison. Impacts of any supply chain related strategic decisions should be analyzed and fully understood by utilizing a supply chain risk profile (presented in the explanation of Figure 12). Based upon this understanding, the SC may have to be re-engineered in some way for the potential risks to be removed.

2. *Supply Chain collaboration*

Collaborative planning and supply chain intelligence are the key elements for complex SC networks to be able to create resilient and transparent SC communities. Increased visibility of up- and downstream risk profiles ensures better information flow and the mitigation of mutual SC risks.

3. *Agility*

As per the definition of resilience, agility is again one of the most important traits for a process to be considered resilient. As agile and flexible processes are able to change and also adapt to change very quickly, they are less likely to be overwhelmed by an occurring disruption. What is important, is the changeability's velocity and acceleration ability to be able to react and adapt as quickly as possible.

4. *Creating an SCRM culture*

To achieve this, three things must happen. Risk considerations must be factored into decision making, supply chain continuity teams should be established, and a board-led responsibility and leadership should be pursued.

For a manager of a traditional manufacturing company that has relatively low level of existing SCRM activity, these concepts presented by Christopher (2011, p.206-207) could be a bit too superficial to start easily building practical resilience-inducing solutions. Olson (2014, p.24-26), however, presents a list of very practical examples of strategies to help combatting SC disruptions proactively and add 'robustness' to a manufacturing company's supply chain. According to Patel et al. (2020), robustness is "*ability to withstand variations and disturbances and direct it to take advantage of these fluctuations to maximise the profit*", and it's usually classified as one of the agile supply chain enablers, and the connection to before discussed agile SCM is again very noticeable (e.g., postponement was present in Christopher & Towill's (2001) model also in Figure 13). Although Olson (2014, p.24-26) mentions that the usefulness of each strategy and SCRM effectiveness is dependent on the goals of the companies that might use them, they could very well still serve as a good starting point for many. Next, these strategies are presented in Table 7 below, with Olson's explanation for each.

Table 7: Robust Supply Chain Strategies (adapted from Olson (2014, p.24-26))

Robust strategy	Explanation
Postponement	Utilization of different design concepts (e.g., standardization, commonality, and modular design) for delaying the point of product differentiation. The later that the product is customized in the manufacturing process, the more flexible the manufacturing process is to react on, for example, changes in product specifications.
Strategic stock	Aims to achieve the same that a regular safety stock does, but only for strategically important key items, and without the extensive costs of increasing all stock levels.
Flexible supply base	Mitigation of risks related to suppliers by using multiple suppliers to source instead of just one.
Make-and-buy	Mitigation of risks related to production by outsourcing part of manufacturing to an external source.
Economic supply incentives	Usage of economical leverage to, for example, motivate potential new suppliers to enter the market and start producing the components/items that the focal company needs.
Flexible transportation	Minimization of risks related to logistics by using, for example, multimodal transportation.
Dynamic pricing and promotion	Revenue management through the control of product demand and influence of customer product selection.
Dynamic assortment planning	Product-positioning based influencing over consumer product demand.
Silent product rollover	Subtle new product launching strategy that aims to not cause an out of stock-situation on either new or old products, but a continuous demand for the product portfolio currently available at the time.

As hinted, many of the strategies listed above are closely related to very similar methods in SCM, but their focus is more on negating risks than lowering costs, again leaning (no pun intended) clearly more on the agile side of SCM. For manufacturing companies, the more uncertainty and volatility there is in the world and the world's markets, global or local, the more they should emphasize their focus on strengthening their own supply chain resilience with their SCM and SCRM actions. Dilemma here though is that many

of the most resilient SC solutions are usually not the cheapest or easiest to implement and/or maintain without properly allocated resources. This unfortunately causes often ignorance towards the subject, as many of the traditional manufacturing companies favour those leaner low-cost SC solutions to minimize their costs and optimize their services over the SCRM aspect, which might not even be a big part of their SCM system to begin with. However, once some kind of unexpected discontinuities or disturbances of the companies' business environments appear, supply chain resilience can be the deciding factor how a company manages to handle it, or if it survives it at all. (Christopher, 2011, p. 24,189; Schlegel & Trent, 2016, p.9-11)

Supply chain risk management can be carried out also in various other ways too. Christopher (2011, p.195-197) suggests the following six-step risk mapping procedure regarding the mentioned risk profile approach related to Figure 13:

- | | |
|-------------------------------------|---------------------------------|
| 1. Prioritise earnings drivers | 4. Model scenarios |
| 2. Identify critical infrastructure | 5. Develop responses |
| 3. Locate vulnerabilities | 6. Monitor the risk environment |

Schlegel & Trent (2016, p.221-238,252-253,260-264), on the other hand, presented the following emerging risk management tools, techniques, and approaches: **Become a preferred customer** (strengthened supplier-customer relationship is always beneficial, and satisfied suppliers are more likely to offer valuable preferential treatment to their preferred customers), **Construct SC heatmaps** (developing enterprise-wide supply chain risk awareness is crucial for SCM and SCRM), **Map the SC** (mapping out the supply chain graphically can help management in SCM and SCRM), **Decluster the clusters** (identifying risky clusters related to the supply chain, and decentralize those activities reduces risks and helps to gain potential competitive advantage), **Create a risk war room** (creating a 'war room' function with the purpose of monitoring the SC and having up to date situational SCRM related awareness improves SCRM and responsiveness), **Total cost measurement** (identifying the impact of different cost elements helps SCRM to prioritize decisions), and **Calculate risk scores** (evaluating SC elements (e.g., suppliers or customers) aids other SCRM activities).

To summarize, globalization has introduced many new opportunities to find an edge against the competition, but it also has multiplied the potential risks, which in turn has

affected supply chain management all over the world. From an SCRM perspective, modern SCM should concentrate on building a resilient and an agile SC system, just as on creating value through the old-fashioned cost-effectiveness approach. The importance of supply chain risk management as an SCM function is constantly growing, and in the ever-turbulent business environments of the 21st century, high supply chain resilience and flexibility is essential for manufacturing companies to be able to combat the potential SC disruptions lurking around every other corner. But even though some companies had managed to elevate their high-functioning SCM and SCRM to a level that was able to dominate the modern business environment, one very specific risk was probably not on their priority list as a number one or even two, a global pandemic.

3.3 COVID-19 Pandemic and Its Effects on Manufacturing Companies' Supply Chain Management Globally

The main driving factor behind the research questions of this thesis, the COVID-19 pandemic, is the reason why “social distancing” and wearing masks became the new everyday normal in public and in workplaces around the world for a long while. As far as it's currently known, the first reported COVID-19 infections started in Wuhan China, in December 2019 (World Health Organization, 2021, p. 9). Quickly, the virus started to spread across the globe, and already in March 2020 WHO declared the COVID-19 a public health pandemic (Jebril, 2019). At the end of the first year of the pandemic, WHO reported that the statistics regarding COVID-19 were over 75 million positive cases and 1,6 million deaths since the crisis began (World Health Organization, 2020). Two years later in November 2022, the same numbers were over 634 million and 6,6 million (World Health Organization, 2022b).

Companies around the world have tried to come up with different ways to counter and survive the crisis, and depending on various factors (e.g., the level of SCM and SCRM), some were hit harder than others. Many businesses were first paralysed by the suddenly declined demand, and then by the disruptions in their supply chain. Some had to completely shut down their operations for a while, and in worst cases even file for bankruptcy. Some industries (e.g., IT-consulting) have managed to adapt to the prevailing conditions rather well, because of their business models' natural flexibility, as the companies' employees could easily self-isolate and work from their homes. But for some, such as many manufacturing industries, the times have been a lot harder. The ‘working from home’ model wasn't possible for every employee, as some manufacturing processes require a physical presence to be operational. (Nicola et al., 2020; Ivanov & Dolgui, 2020; Seker et al., 2020, p. 629-632) Coming up next in this thesis, the pandemic's recognized effects

on these harder-hit manufacturing industries' companies outside Finland are examined, and these companies' SCM related reactions to the pandemic are discussed. Later, this data is used to build the theoretical framework's comparison basis to the interview data.

Once again, the information available on COVID-19 and its effects on companies around the world is constantly growing, and at the time of finishing writing this part of the thesis in the end of 2022, there are probably still many questions left unanswered regarding what the total impact of the pandemic will eventually over-time be. Because of this, it's important to evaluate the available data not only by its source's reliability and quality, but also by its publishing date. It's obvious that the more the time passes, the more the quality of the research and the results on the pandemic's effects increases. This means that, for example, the articles and news published in the early 2020 should be acknowledged to be a part of the "first wave" of the data available currently, and some of the information regarding the pandemic thought then to be true might actually now, almost three years later, be already proven not to be, as the dust has settled a bit. This remark could also very well end up being an important perception made in the semi-structured interviews later. So, acknowledging it now already in the literature review will be beneficial for the data analyzation and the theoretical framework if, for example, temporally comparable data is found between the literature review and the interviews that is in conflict with each other.

As a disclaimer, all material used in this part of the literature review has passed the inclusion criteria presented in the Research Protocol #2 earlier (Table 2). Dozens of articles were excluded from the data search results, but in total 50 pieces of literature (online and journal articles, professional reports, a book chapter, and few research papers) that passed the inclusion criteria were used along with some of the articles that were already cited earlier in the SCM theory. Most of them are journal articles from professional authors related to supply chain management, but there are also few exceptions. Couple news articles, reports on COVID-19 statistics, and few not directly SCM related articles were also used, but by using due diligence and proper consideration. To verify the validity of the used literature, the dates, sources, and types of these 50 articles etc. are listed in Appendix A in the order of their publishment.

1. The Beginning

COVID-19 has undoubtedly had an unprecedented effect on the world's economic systems. Countless organizations and industries all over the world have felt the pandemic's

impacts directly as frequent supply shortages along with large-scale fluctuations in demand, and as massive disruptions in supply chains. (Panwar et al., 2022) Sarkis (2020) put it as that the pandemic “*shocked*” companies’ supply chains. For many of them, the effects of the pandemic were also felt from the varying restrictions set by the countries they were operating or located in. In June 2020, researchers Guan et al. (2020) published their article on these negative SC effects of the global countermeasures that countries implemented to attempt slowing down the spreading of the virus. One of their main findings was that the individual countries placing country-wide lockdowns and travel-bans on their own accord did affect negatively the global supply chains, by how much depended on their restrictions’ strictness and duration. Manufacturing industries being especially vulnerable to big-scale SC disruptions, this meant that not only were many manufacturing companies battling against the global demand changes and supply shortages, at times their fates were in a way also in the hands of their own countries’ governments.

As the virus started spreading, countries around the world responded in varying ways and paces. Some, such as New Zealand, implemented immensely strict nation-wide lockdowns, whereas some, like Sweden, reacted comparably with much ‘softer’ countermeasures. (Strange, 2020; Bui et al., 2021; Askim & Bergström, 2021) In many European countries, simultaneous lockdowns in the first half of 2020 caused their manufacturing sector’s SMEs to immediately suffer SC related issues on both supply- and demand-side, and potentially serious financial problems were forecastable in the horizon (Juergensen et al., 2020). But, at the same time as the lockdowns were being enforced, the countries enforcing them obviously didn’t want their economic sectors to go bankrupt, and they tried to prevent this by providing financial aid for the pandemic-affected companies. For example, Dörr et al. (2022) found out in their research that in Germany, especially the smaller companies, manufacturing sector included, were struggling badly with the pandemic and lockdowns, and many of them would’ve even gone bankrupt without the German government’s policy assistance (although, they also found that the economic statistics showed that many of these policy-assisted companies suffering with insolvency during the pandemic, were actually in the same dire situation before the COVID-19 was even known). In March 2020, Italian central banks had to step in too and provide “*extraordinary measurements to support demand and provide liquidity to the economic system*” for the country’s companies according to Rapaccini et al. (2020), to attempt the countering of the worst decrease of industrial production in all of Europe at the time.

In February 2020, Sherman (2020) reported that 94% of the Fortune 1000 companies, of which many are from different manufacturing industries, had been affected by supply

chain disruptions caused by the COVID-19 pandemic. ILO, International Labour Organization (2020), estimated in April 2020 that manufacturing was going to be one of the hardest suffering industries from the COVID-19 crisis. Many traditionally operating manufacturing companies had still based their supply chain management on prioritizing cost-efficiency by globalized low-cost offshoring, single-sourcing, centralized inventory management, and lean principles (e.g., JIT and minimal inventory). Also, many viewed supply chain risk management as “*not relevant*” and “*a big exercise in busy work*”, as times had been relatively good for a while (Schlegel & Trent, 2016, p.10-11). This meant that many of the common manufacturing industries (e.g., electronics, machinery and automotive) were hit especially hard in the first year of the pandemic in 2020, when the supply chain disruptions and demand fluctuations started, just as ILO predicted. (Cai & Luo, 2020; Ferguson & Matthew, 2021; Ardolino et al., 2022) So, as the pandemic started to wreak havoc and cause general uncertainty around the globe, consumers non-essential consuming and companies’ willingness to invest started to decrease, and the beginning of the lockdowns and border-closings didn’t help either (Vitale et al., 2020). Seker et al. (2020, p. 629-630) wrote that “*Global supply chains were disrupted as a result of decreased production capacity due to the decline in global consumption and the cessation of the operations of production companies in China, the Far East and European countries*”.

Now, fast forward three years into the pandemic, a lot has changed back and forth from the manufacturing industries’ point of view since the ‘first wave’. Experts and researchers have had time to analyse better what has happened and are trying their best to forecast what a *post-pandemic world* will look like in the future. The consumer demand patterns have radically shifted and changed along with how the pandemic and the lockdowns have. According to Sheffi (2021a), the shift to work and study from one’s home, as workplaces and schools reacted to the pandemic and the restrictions, had a major impact on the demand of, for example, basic IT-equipment. This surge in demand was caused by the greatly accelerated digital transformation that the pandemic has indirectly caused, as companies and schools had to figure out a way to remain as functional as possible, which manifested for manufacturing companies as the shifting from traditional face-to-face conferences to videoconferences via Microsoft Teams or software alike. (Soto-Acosta, 2020; De Vet et al., 2021, p. 9, 12, 66; Panwar et al., 2022)

As for many, a ‘home office’ was suddenly the new normal for the time being, people started to upgrade their own technological equipment. One specific suddenly in-demand product category was webcams, which were sold out for a long time in many countries, and the struggling suppliers told they were literally “*chasing demand*” (Baraniuk, 2020).

Soto-Acosta (2020) wrote that between the first signs of the pandemic in December 2019 to May 2020, Internet traffic increased by 60% and videoconference traffic by 120% compared to the pre-pandemic levels. Also, as many countries forced their commercial gyms to shut down during the lockdowns, the demand for different kinds of recreational apparatus (e.g., adjustable dumbbells for home gyms) inflated as people started working out in their homes. These almost product specific rocket-like demand-spikes caused immense strain on their respective manufacturing companies' supply chains multiple Tiers deep. This further worsened the supply shortages and forecasting, as the supply-demand relations changed so rapidly. Now, because the demand was suddenly consistently higher than the supply, prices started to also rise quickly. In theory, this should've evened out the demand even if the shortages persisted, but curiously it didn't. New products' shortages persisted, and second-hand market prices started rising. (Sheffi, 2021a; Panwar et al., 2022) The pandemic was changing the playing field in real-time, and many companies were struggling to hold on.

2. Effects on Traditionally Operating Manufacturing Companies

To highlight how the COVID-19 crisis brought out the SCM vulnerabilities of so many manufacturing companies and disrupted the supply chains of whole manufacturing industries, the automotive industry is a great example (Ishida, 2020). It has been widely criticized by journalists and experts alike, today and in the past, for still favouring heavily traditional supply chain models, such as lean manufacturing and especially JIT-sourcing, which have been proven to leave clear vulnerabilities for the industry's companies' SCs and hinder their SC flexibility. Fluctuating markets of the 21st century and disrupting events like the COVID-19 crisis have shown how disconnected the industry has been even from just their Tier 2 suppliers, which implies the lack of resilience in their traditionally (or in other words, horizontally) operating supply chains. (Ambe & Badenhorst-Weiss, 2011; Sakuramoto et al., 2019; Leggett, 2022; Insights, 2022)

In the beginning of the pandemic, car manufacturers across the globe witnessed substantial drops in both supply and demand, just like others, and acted based on them. Shortages of raw materials, spare parts and components, especially semiconductors, along with the stay-at-home policies of consumers, prompted the car manufacturers to cut down significantly their sourcing activities as the production volumes were cut, which was a natural and understandable reaction from a traditional manufacturing SCM perspective. (Eldem et al., 2022) But, as the demand for vehicles suddenly revived in spades during 2021, the problems were just beginning. The higher Tiers of the car manufacturing

companies' SCs were many already in trouble, as lockdowns and their own supply shortages had lowered their production capacity.

Now, regarding to the highlighted semiconductors, reasons behind their supply shortages were not all related to only COVID-19, as there were many SC disrupting events completely irrelevant to the pandemic, during the pandemic. For example, during 2021 a major chip supplier for the car industry in Japan had a devastating fire in one of their factories, and the Suez Canal blockage incident caused by the Evergreen container ship led to remarkable supply chain disruptions for the microchip suppliers and customers (Kelion, 2021; Leonard & Kapadia, 2021). However, there were also directly COVID-19 related disruptions, as factories were closed during the lockdowns and quarantines. Toyota, for example, was forced to reportedly cut 40% off from its annual production target of 2021 as a result of the global microchip supply shortage and the COVID-19 related factory shutdowns in South-eastern Asia, especially Malaysia and Vietnam (Zimmerman, 2021).

Going back to the automobile industry-example, while the car manufacturers had been sourcing the semiconductors significantly less during the mentioned 'quieter period' in the first wave of the pandemic, the demand for microchips across the board had been extremely high elsewhere. The big technology companies that had been constantly producing the highly in-demand products, such as computers, computer parts, IT-equipment, smartphones, and gaming consoles, were hogging vast majority of the available chip-supply, and the now reviving automobile industry suddenly found themselves caught with their pants down, as there was very little available supply to source. What followed in the U.S. for Ford, for example, was a greatly increasing demand for new cars, but the inability of the manufacturer to provide the matching stream of supply due to the sourcing shortages of the required manufacturing materials, microchips especially. As the supply-demand gap created soaring material prices, the prices of new cars increased as well. Due to this, many chose to buy their vehicle used instead, causing the car manufacturers to lose customers and enormous amounts of money. (Sheffi, 2021a; Ardolino et al., 2022)

Wayland of CNBC reported of an estimation made by AlixPartners in September of 2021 that the global chip shortage would cost 210 billion US dollars to the automotive industry globally just in 2021, which was almost two times the amount they estimated earlier in May of the same year. Later in April 2022, Avnet Silica's public financial record analysis produced an estimation that from the start of the pandemic to that point, global automotive industry had suffered in total over 500 billion US dollars worth of losses overall due to the COVID-19 lockdowns, pandemic related supply chain issues, and semiconductor

shortages. As the chip suppliers' stock levels were at the lowest in years and the production lead-times sky-high, car manufacturers around the globe experienced production line stoppages and constant supply chain disruptions. (Wayland, 2021; Avnet Silica, 2022) Some experts even questioned if this crisis was going to be the end for the trend of large-scale global sourcing (Antràs, 2020; Koerber & Schiele, 2021).

Bowman (2022) of SupplyChainBrain reported that the automobile industry suffered constant and changing supply shortages of different materials on top of the semi-conductor situation. According to him, the car industry was also having a lot of trouble for over relying too much on JIT strategies before the pandemic, as many didn't have any buffer inventory to rely on when the SC disruptions hit, and in the worst case scenario, manufacturers found out about parts shortages due to their orders not being confirmed by their suppliers: *"They were getting surprised two to three weeks out, and learning that there was a six-month lead-time"*. This demonstrates exquisitely well the risks related to some of the lean SCM methods, especially JIT and inventory reduction.

From a supply chain risk management perspective, the pandemic-related SC uncertainty and the discussed SC issues that the manufacturing industries faced really exposed the companies with poor SCRM. Although many scholars had spoken for the increased volatility of the 21st century's industrial markets due to general marketplace uncertainty and turbulence long before COVID-19 was ever heard of, and many managers had questioned the old traditional SCM methods already at the beginning of the century, when the pandemic hit, there were yet still countless of those (usually large) manufacturing companies that had been operating with a very rigid SCM system and gotten away with it (Bowersox et al., 2002, p.3; Christopher, 2011, p.189). As their supply-demand relation had remained relatively stable for the past few decades, Ivanov (2021) argues that for companies like these this had led to a *"crisis-free management mentality"*, which was characterized by the valuation of the cost-efficiency over resiliency in SCM and by the usage of those traditional SCM activities, such as the (on today's standards) 'devil-may-care' outsourcing and lean. He says that as these companies deceitfully thought that they had all the risks and uncertainties under control, COVID-19 came and turned everything upside down.

COVID-19 pandemic was definitely a world-wide shock to a mass of companies that were neglecting their supply chain risk management. One of the barriers affecting the general state of SCRM in companies, listed in a study by the Supply Chain Council, was *"the tendency of senior management to focus on risk management only during times of crisis"* (Schlegel & Trent, 2016, p.11). This was obviously a bad choice, as the managing of risks is rather hard if they have already materialized. The companies' SCs' lack of

agility and resilience caused major difficulties for many, but something had to be done anyway to fight back. Next, the different answers and countermeasures the companies had to the pandemic found from the used literature are examined and presented.

3. Companies' Countermeasures & Post-COVID-19 Outbreak Era

As the pandemic started to affect virtually every manufacturing industry around the world, companies responded in different ways and with various speed, and those with the most advanced supply chain risk management were better prepared and quicker to react than others (Butt, 2022; Sharma et al., 2020). The top 50 companies of the Fortune 500 list, for example, all took coordinated approaches to counter the pandemic according to Margherita & Heikkilä (2021), but many SMEs with weak SC resilience and lacklustre SCRM were just 'putting out fires' as they started to appear. Based on the literature, companies' reactions have varied from structural and strategic changes to very operative actions, but the unifying factor has been the goal to boost their supply chain resilience to withstand the pandemic's impact. For example, Alicke et al. (2020) wrote in their article for McKinsey & Company that according to the survey they did in the second quarter of 2020, out of the 60 interviewed senior SC executives across different industries, 93% planned to increase resilience across their SCs in the future.

McKinsey & Company (2022) conducted a survey on spring 2022 on companies' efforts to analyse their overcoming of COVID-19 related SC disruptions, risk-mitigation, and resilience-building that included 113 supply chain leader-companies worldwide from various industries. From the respondents, 97% had implemented some combination of inventory increases, dual sourcing, and regionalization to add resilience into their SC, and 83% reported that these actions had had a positive impact on minimizing the SC disruptions' negative effects during 2022. Dual sourcing was especially focused on critical materials and regionalization meant shifting from a global to regional SC network. However, while a more strategical approach (the diversifying of the supply base and adding of in-region sourcing) were on many companies' to-do list, simply increasing inventories, buffers, and safety stocks turned out to be some of the most important resilience-building methods for 80% of the respondents during the pandemic, although not the most cost-efficient. The survey also highlighted the weak visibility into higher SC Tiers, and many companies were planning to focus on their long-term SCRM development significantly more in the near future.

Members of the automotive industry had to tackle the other SC disruptions caused by the pandemic and the world-wide semiconductor shortage at the same time. Frieske &

Stieler (2022) listed in their research different operational (short-term) and strategic (long-term) measures that these companies mentioned using or were planning to use, which were many same as in McKinsey & Company's (2022) survey. In operational category, used SCM related countermeasures were the likes of adjustment of inventories, establishment of centralized emergency response teams/task forces, and searching for alternative suppliers. The more strategic responses that the companies discussed were the increasing inventory levels for critical components, strengthening of dual sourcing and flexible shares (meaning how much does each supplier supply of the total need), and supporting of local supply chains. Also, monitoring of the reliability of political action was mentioned, as companies in automotive industries are very reliant on foreign trade.

Belhadi et al. (2021) researched too what kind of short- and long-term, proactive and reactive, SC resilience responding strategies did 145 different members of various global automobile and airline manufacturing supply chains used to combat the disruptions. Also, they found out that strategies such as localization/regionalization of sourcing, improving digital connectivity & information systems, and integrated SCRM were the most preferred short-term strategies, whereas strategies like ensuring the transportation systems, using emerging technologies, enhancing digital transformation, integrating risk management, and supply chain collaboration were suggested for long-term. The improvement of information flow and digital connectivity was mentioned in many other articles as well, e.g., according to Supply Chain Management Review (2021), *State of Manufacturing Report 2021* by Fictiv reported that the global manufacturing leaders are seeing digital transformation as an essential way to improve speed, resilience, and sustainability in SCM after the lessons learned from the COVID-19 pandemic.

Butt's (2022) study in 2020 on the countermeasures that manufacturing firms have taken to address the COVID-19 disruptions involved 11 South Asian companies and produced rather similar results. He interviewed companies in buyer, distribution centre, and supplier roles, which brought out the differences in the disruption impacts and the taken countermeasures between each supply chain role. From the buyers' perspective, COVID-19 seriously disrupted the manufacturing of goods, causing limited production and unfulfilled orders (government restrictions on importing, traditional production scheduling not working), and also caused delays in procuring goods and services (lost procurement contracts, goods and services not available due to demand exceeding supply). From the distribution centres' point of view, inventory shortages (Tier 1 supplier problems, lack of SCRM) were the most recognizable impact. Lastly, from the supplying firms' perspective, most notable impacts were increased delivery times (problems with cross-

border supplying and logistics). The different countermeasures the companies in different SC roles took is visualized in Figure 15 below.

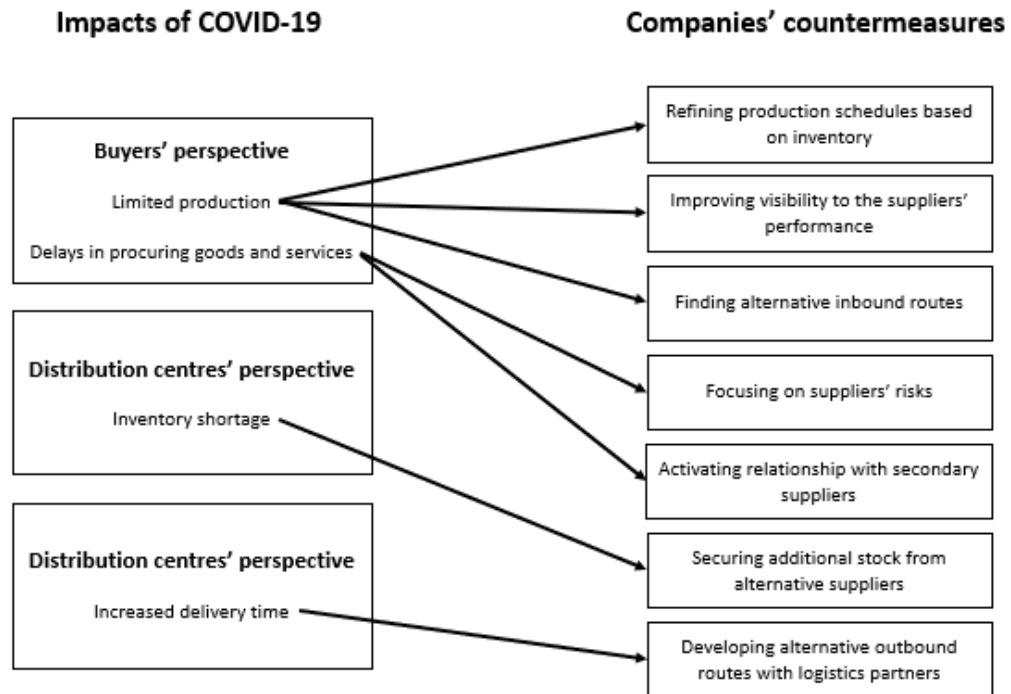


Figure 15: Impacts of COVID-19 on Buyers', Distribution Centres', and Suppliers' Supply Chain and Their Corresponding Countermeasures (adapted from Butt (2022))

Many of the countermeasures listed in Figure 15 are related to different agile SCRM methods (e.g., information & SC relationship management), which is true for strategies found by Belhadi et al. (2021) and for the actions discovered by McKinsey & Company (2022) too. Butt's two later articles that continued his research were unfortunately retracted due to him failing to cite his own individual earlier article(s) properly. But, although those articles are not officially in *The International Journal of Logistics Management* anymore, in the context of this thesis, presenting his findings can be deemed to be acceptable as they help the research. Therefore, below is a list of some of the Butt's (2021a; 2021b) both new and more in-depth findings regarding South Asian manufacturing companies' different countermeasures against the COVID-19 related SC disruptions, some of which are extended from the ones presented in Figure 15:

- Prioritizing clearly what products are produced in the event of inventory shortages of raw materials, developing tools to support production planning, and putting practices in place to support ongoing schedules.

- Focusing on active communication and alternate planning with Tier 1 suppliers.
- Switching to active secondary suppliers to secure additional inventory, increased capacity, and developing proper communication lines with those suppliers.
- Developing communication with customers and discussing possible alternative arrangements with other SC members.
- Working with short-term suppliers and procuring essential products from them.
- Enhancing inbound material visibility by monitoring suppliers' production schedules and shipment status.
- Understanding immediate customer's demand better by taking the customers on board to discuss their needs directly and prioritizing then those.
- Becoming more agile by preparing for rebounds, rescheduling production, and considering variation in supply-demand creation.

On the other side of the world, Dewart (2022) wrote in Supply Chain Brain that an interesting new phenomenon is emerging in the U.S.: manufacturing companies are near-shoring (partnering with SC members located in countries near the company) their operations to Mexico from, for example, China. The cross-border challenges and shipping tariffs related to importing items from China has made Mexican suppliers very attractive to the U.S. based companies, as they can expect their lead-times to drop from months or weeks to even days, and their shipping costs to approximately halve (Dewart, 2022). Also, according to the *State of Manufacturing Report 2021*, many industry-leading global manufacturing companies are looking to future-proof their supply chains too by pursuing reshoring strategies (bringing operations back to the company's own country), along with sustainable and on-demand manufacturing (Supply Chain Management Review, 2021).

Some manufacturing companies also took even legal actions to their arsenal in their efforts to combat the SC disruptions. Volkswagen, for example, was reportedly looking to claim damages from its suppliers due to the global semiconductor shortage. The company's spokesman said that *"For Volkswagen, the top priority is to minimise the effects of the semiconductor bottleneck on production"*. (Reuters & Nienaber, 2021) This was heavily criticized by MIT's Sheffi (2021b) in SupplyChain247, who wrote that *"another wasteful by-product of the knee-jerk school of management is using legal action to punish suppliers for not fulfilling orders"*. He also discussed about a problematic behaviour that some companies have demonstrated due to the SC disruptions: over-ordering. According to him, inflated over-ordering during supply shortages creates a major problem

due to suppliers having to “*fly blind*”, which can expose the markets to the Bullwhip Effect and other balancing problems, when the supply shortages eventually start to settle.

What changes the post-pandemic era will actually hold for SCM, is still up to debate. As the interest to walk back on globalized supply chains is apparently growing, some scholars are speaking against it. For example, Panwar et al. (2022) argued that from the perspective of the United States reshoring manufacturing and dismantling global supply chains would not be feasible without massive overhauls to global economic systems, and instead global supply chains should be redesigned to be more resilient and robust to both be able to restore their functionality quicker after future disruptions and remain functional during them. MIT Technology Review Insights (2022) mentioned the goal of automated SC sentience (supply chain’s ability to sense, process, and respond in real time to arising events) in the future as a part of resiliency and agility, which could be possible through the increasing digital intelligence in modern SCM.

To summarize, manufacturing companies’ countermeasures to COVID-19 pandemic’s effects have been very similar across the board. While consulting companies have reported companies’ growing interest in SCRM and measures towards more agile SCM and stronger SC resilience, individual researchers are getting very similar results. Many traditional manufacturing companies have had to make (at least from their point of view) unprecedentedly significant changes regarding their SCM and SCRM in order to survive the pandemic’s impacts and SC disruptions. According to multiple researchers and consultants, after the pandemic is over, rather than returning to the past “low-risk and non-volatile world” SCM mindset, where the most important metric is often only how cost-efficiently everything can be done, companies should aim to adapt to the ‘new normal’ and focus on SC resilience (Alicke et al., 2020; Ishida, 2020; Ivanov 2021; Ardolino et al., 2022). The importance of agility and resiliency is most probably here to stay, as we’re eventually entering the post-pandemic era. As it stands, the pandemic might still bear some surprises for us in the future, and new countermeasures might be needed, but only time will tell.

4. RESEARCH TOOLS

4.1 Semi-Structured Interview Study

One of the most crucial factors in finding the answers to the defined research questions of this thesis, along with the literature review, is the semi-structured interview study. Therefore, its creation and execution are important to be planned out properly, as the success of this thesis is highly dependent on it. Also, the literature review is recommended to be completed before constructing and conducting the semi-structured interview, as it requires existing knowledge on its subject from the researcher, and the interview is often bound to explore the topic beyond the prepared questions, which should be open-ended anyway (Taylor, 2005, p.44-45; Kelly et al., 2010, p.307-309).

Semi-structured interviews are one of the most commonly used data gathering methods when the nature of the wanted data is qualitative, which is usually non-standardised and not based on numbers but words and is therefore more complex and unstructured than standardised quantitative data (Saunders et al., 2009, p.546; Galletta, 2013, p.22). In this thesis, both qualitative and quantitative is going to be acquired from the interviews, but the qualitative data will be by far more important. The only quantitative data will be from the answers to the questions asking a value to, for example, evaluate the company's performance in doing something, as the actual quantitative data (e.g., financial or HR) is often hard to get due to companies' data protection protocols. As the overall objective of this thesis is to investigate the effects of the COVID-19 pandemic from a cause-and-effect perspective, this means that the selected semi-structured interview research method is a valid choice.

The process of creating an interview study itself starts from acknowledging what is actually needed from the interview for it to provide the data that (after an analysis) could yield the answers to the defined research questions. This may require insight on the subject from the researcher, which is where the literature review comes in and provides the needed theoretical premise. When the goal is clear, the interview structure and execution plan is created. The interviewees are selected, and mandatory ethics are defined, but the preparation of the interviewer itself must not be forgotten. Also, a protocol for analysing the collected data is required, along with clear plan and methods on how the data is stored and handled during the research. After the background work is done, the interviews are ready to be conducted. (Taylor, 2005, p.39-45; DiCicco-Bloom & Crabtree, 2006; Galletta, 2013, p.9-18) Next, the creation and execution of the semi-structured

interview study of this thesis is presented below in six steps, and the finalized interview study questionnaire structure is presented in Tables 8, 9 and 10.

1. Planning & premise

As already mentioned, most importantly the interview study must provide usable data to aid answering the defined research questions, which means that the topic of the interview is **the effects of the COVID-19 pandemic on SCM of manufacturing companies in Finland**. The findings acquired from the literature review are used as the theoretical basis and premise to create the interview questionnaire. Due to common meeting scheduling habits in office work environment, each interview should not last more than 60 minutes, which means that 30 questions in total would average two minutes per question. This would be a good maximum for the number of questions in the interview. It leaves room for the interviewees to answer the questions with more than just a sentence or two and the interviewer the possibility to improvise around the subject, which is the point whole of a semi-structured interview.

At least five differing industrial manufacturing companies that operate in Finland should be included in the study to get wide enough sample of the pandemic's impacts for analysing. The interviewees sought out from these companies must all be employees working as a part of the companies' SCM, and the job titles could vary from Sourcing Engineer to Supply Chain Manager, but all of them should be white-collar employees. Being selected also requires that the employment has lasted the period of the COVID-19 pandemic. The researcher's personal connections are highly likely to be utilized in the interviewee sourcing process.

To gain deep enough insight of the effects the pandemic has had, interviewing only one person per company might not be enough. As the view of employee X might differ greatly from the view of employee Y within the same company, at least one company should be chosen, of which multiple interviewees are selected from different employment positions. The point of this is to be able to compare the differences and similarities of the interview data within this selected company, not only between other companies. This acts as a method of triangulation, which basically means the attempt to avoid or reduce the risk of systematic bias, which is an imminent threat when the researcher is using only one specific research method with certain limitations, as stated above in this case. Using different triangulation methods also increase the validity of the gathered data and the research itself, which is very important for a qualitative study. Applying triangulation to research

can differ from using totally different research methods to just gathering data from multiple sources, perspectives or forms. (Maxwell, 2008, p.236; Saunders et al., 2009, p.169,179; Denzin, 2012, p.82) In this thesis, the triangulation principle is applied by gathering data from different perspectives within one selected company, of which at least five employees should be interviewed.

In conclusion, the ~30 question ~60-minute interview should be conducted to about 10 people, of which half work for the same company. This way there should be enough research data for the conceptual framework and the data analysis.

2. Creating the structure and the questions

As said previously, the interview should consist of maximally 30 questions due to scheduling reasons. Rubin & Rubin (2005, p.134-138) present that qualitative interview questions are separated in three different categories: main questions, follow-up questions and probes. Main questions push the interview towards finding answers to the research questions and act as milestones, of which to follow to keep the often easily sprawling conversation as an interview. Follow-up questions are usually not defined before the interview, but more often situational reactions to the answers the interviewee gives to the main questions. Asking successful follow-up questions does require some skill from the interviewer, but they can provide incredibly valuable extra information to the research. Lastly, probes are a way to keep the conversation going, kind of like asking very subtle follow-up questions to aid the interviewee to get their point through. For example, they can be requests to describe something in more detail or comments urging the interviewee to keep talking about a specific topic. (Rubin & Rubin, 2005, p.134-138) By this definition, all the questions that will be presented in this interview structure are main questions, but follow-up questions and probes will be improvised as needed during the interviews individually. Methodologically a semi-structured interview is much more flexible, versatile and interactive than a traditional structured interview, so this sits well with the selected method itself as well (DiCicco-Bloom & Crabtree, 2006).

Before creating any questions, the interview structure is separated into two main themes (*Before COVID-19 pandemic & After COVID-19 pandemic outbreak*), so that the comparison between the status quo of pre- and post-COVID-19 outbreak is possible. This is required to be able to investigate the effects that the pandemic has had and is therefore essential for being able to answer especially the research questions. In addition to these two main themes, a third theme (*Sparked ideas and lessons learned for the future*) is also introduced. This theme is meant to help answering the second research question

with 2 – 3 open-ended interview questions, which could help the interviewees to think “outside the box”. The third theme should be viewed as optional and located in the end of the interview structure, as the two main themes are the ones that will provide the most important research data. This means that if there is no time to go into the third theme at the end of the interview, it’s not a problem, as they’re just bonus questions.

Now as the themes are defined, the interview questions are created next. Both open-ended questions and questions asking to rate a specific subject with a numerical value are used, and some of them will be appearing in both first two themes to allow comparison between pre- and post-COVID-19 outbreak situations. For questions asking a value, a scale of 1 – 5 is used, and each question has individually explained rating scale (e.g., 1 might not always mean “the worst” and 5 not always be “the best” etc.). The numerical data collected from these interviews is analysed and presented in the results chapter, and it’s solely used to analyse the companies operating in Finland, as similar was not collected during the literature review. It’s very important to note that the numerical results from the interviews will be very depended on the interviewees own insight and knowledge on their company’s situation, and therefore shouldn’t be considered as 100% factual data, but more as directive information on what has changed and how much from the employees’ perspective.

The questions’ topics are derived from the two research questions and the research objectives, and they’re centred around the pandemic’s effects from the viewpoints of supply chain management, supply chain risk management, and supply chain resilience. After careful consideration, the interview structure is built from 26 questions. The first theme consists of 9 questions (5 quantitative), the second of 14 (7 quantitative), and the third of 3 questions. This structure follows the two goals set before: it has 30 questions or less, and the third theme consists of 2-3 questions. The interview questions are next presented and explained in Tables 8, 9 and 10 below. Also, the interview questions sheet that will be used in the actual interviews is presented in Appendix B.

Table 8: Interview Questions, First Theme (Pre-Pandemic)

Ordinal number	Interview questions & clarifications
	FIRST THEME (PRE-PANDEMIC)
1.	<p>How would you evaluate the general level of the SCM competence in your company?</p> <p><i>Starting by finding out the baseline of the SCM before the pandemic hit, which will help to come up with follow-up questions about the possible changes later.</i></p>
2.	<p>Rate your company's SCRM competence level PRE-COVID-19 pandemic (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = bad, 3 = OK, 5 = great</i></p>
3.	<p>Rate your company's SCRM development and maintenance level PRE-COVID-19 pandemic (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = bad, 3 = OK, 5 = great</i></p>
4.	<p>Rate your company's SCR level PRE-COVID-19 pandemic (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = bad, 3 = OK, 5 = great</i></p>
5.	<p>From an SCRM perspective: what kind of risks was your company aware of and how did it prepare for them in the past?</p> <p><i>Was any large scale external threats considered as potential risks? Was the SCRM mostly concentrated on internal and max. T1 SC threats only?</i></p>
6.	<p>Has your company faced any similar large-scale SCM crises before?</p> <p><i>Finding out about the company's history on crisis management, which might correlate with its ability to counter the pandemic better or worse than others.</i></p>
7.	<p>How did your company overcome the previous challenges? How much of that can be credited to SCRM? (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = none, 5 = everything</i></p>
8.	<p>Did your company use any commonly recognized SCRM tools (and which ones)?</p> <p><i>For example: Buffers, strategic stocks, alternate suppliers...</i></p>
9.	<p>How would you characterize your company's SCM PRE-COVID-19 pandemic, as operative vs. strategic (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = mostly operative, 5 = mostly strategic</i></p>

Table 9: Interview Questions, Second Theme (Post-COVID-19 Outbreak)

Ordinal number	Interview questions & clarifications
	SECOND THEME (POST-COVID-19 OUTBREAK)
10.	<p>How did the pandemic affect on your company internally (e.g. sudden layoffs or hirings, structural changes)?</p> <p><i>The questions 10. and 11. aim to recognize what part of the company got hit the hardest, and was it internal or external aspect.</i></p>
11.	<p>How did the pandemic affect on your company externally (e.g. on stakeholders, partners and suppliers)?</p> <p><i>The questions 10. and 11. aim to recognize what part of the company got hit the hardest, and was it internal or external aspect.</i></p>
12.	<p>How quickly did the effects of the pandemic reach your company?</p> <p><i>This is interesting as it might differ a lot depending on how globalized the company's SC is.</i></p>
13.	<p>How and how quickly did your company react to the pandemic? What were the very first actions and measures that took place?</p> <p><i>Was the company caught pants down or was it immediately ready to make some kind of counter measures? This reflects on the state of its SCRM too.</i></p>
14.	<p>How strong negative impact has the pandemic had on your company from an operative perspective (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = negligible, 5 = major</i></p>
15.	<p>How strong negative impact has the pandemic had on your company from a business profitability perspective (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = negligible, 5 = major</i></p>
16.	<p>From an SCRM perspective: how has your company reacted to the pandemic? What have been the most significant actions and measures?</p> <p><i>This question might also reveal how much the company has had to do in order to survive the ordeal if follow-up questions are asked correctly.</i></p>
17.	<p>Has SCM or SCRM seen more investments or more active development specially because of the pandemic?</p> <p><i>Did the pandemic spark interest in, for example, strengthening the company's SC resilience from what it was before the pandemic?</i></p>
18.	<p>How much has the pandemic affected your company's SCM (on a scale of 1 to 5)?</p> <p><i>Scale explained: 1 = not at all, 5 = greatly</i></p>

19.	Rate your company's SCRM competence level now in 2022 (on a scale of 1 to 5)?
	<i>Scale explained: 1 = bad, 3 = OK, 5 = great</i>
20.	Rate your company's SCRM development and maintenance level now in 2022 (on a scale of 1 to 5)?
	<i>Scale explained: 1 = bad, 3 = OK, 5 = great</i>
21.	Rate your company's SCR level now in 2022 (on a scale of 1 to 5)?
	<i>Scale explained: 1 = bad, 3 = OK, 5 = great</i>
22.	Has your company introduced any new commonly recognized SCRM tools during the pandemic (and which ones)?
	<i>This question is related to 17. as it asks concrete examples of changes made because of the pandemic.</i>
23.	How would you characterize your company's SCM now in 2022, as operative vs. strategic (on a scale of 1 to 5)?
	<i>Scale explained: 1 = mostly operative, 5 = mostly strategic</i>

Table 10: Interview Questions, Third Theme (Sparked Ideas and Lessons Learned for The Future)

Ordinal number	Interview questions & clarifications
	THIRD THEME (SPARKED IDEAS AND LESSONS LEARNED FOR THE FUTURE)
24.	Did your company do anything innovative from an SCM/SCRM perspective to counter the pandemic?
	<i>This is a very open-ended question; the interviewee should be encouraged to think as much outside-the-box as possible with more follow-up questions and probes</i>
25.	How does your company plan to fight the COVID-19 pandemic in the future?
	<i>Are there anything special planned for the future? Has the company found the right answers already or are they still looking for them?</i>
26.	What has the COVID-19 pandemic taught your company overall?
	<i>Has anything positive come out of this? Was there maybe something noticed and/or learned during the pandemic, that has made the company stronger than before?</i>

3. Stating the ethics

The interviews are carried out anonymously, and the interviewees are informed about this before the interviews take place. The interviewees are taking part in the study from a voluntary basis, and permissions for the interviews are sought out from their superiors in advance. To protect the anonymity of the interviewees and the companies they represent, no working titles or any other personal information is presented anywhere in this thesis about them or their company to the extent that they could be easily recognized. The only pieces of information displayed are the companies' simplified main industry sectors (e.g., mechanical engineering) plus directive key figures of their last year's sales and estimated number of employees to paint a picture on what kind of a company is talked about. The interviews are recorded (explained more in detail below) for the data analysis to be done later. The interview recordings are accessed only by the researcher alone, and they're disposed of after the thesis is completed. The interviewees are informed about this before the interview itself starts. Most important factor from ethical perspective is that no protected or private data is shared about either the interviewees or the companies they represent.

4. Selecting the interviewees

Six companies operating in different manufacturing industries in Finland are selected and one interviewee from each company is sourced, except from one company of which total of eight interviewees are acquired. Each potential interviewee that is interested in being part of this thesis is contacted and briefed personally about what the thesis is about and how the interview data will be used. As stated before, the interviewees that are willing to participate can be selected to be interviewed if they're white-collar workers under the SCM organization of their company and have been working during the COVID-19 pandemic in the said company. Acting on these principles, the interviewees are selected from the following companies presented in Table 11. As said, the rough estimate of the amount of the companies' employees and sales (both in Finland and globally) from the year 2021 is displayed using a colour coding pattern, which is explained in the latter part of the table. Also, the number of interviewees from each company is marked in the middle column of the table (Interv.).

Table 11: Selected companies for the interviews

ID	Employees		Interv.	Sales		Industry
	FIN	GLOBAL		FIN	GLOBAL	
CO1			8			Mechanical Engineering
CO2			1			Mechanical Engineering
CO3			1			Mechanical Engineering
CO4			1			Mechanical Engineering
CO5			1			Chemical Engineering
CO6			1			Automation Engineering

Colour coding explained

Employees		Sales (million €)	
	<250		<50
	251 - 500		51 - 100
	501 - 1 000		101 - 500
	1 001 - 5 000		501 - 1000
	5 001 - 20 000		1 001 - 5 000
	20 001 - 40 000		5 001 - 10 000
	>40 000		>10 000

The purpose of the Table 11 is to provide some additional perspective for the data analysis later, especially for when the different companies' results are compared. Even if the presented figures are only rough estimates due to the required anonymity limitations of this research, they could still end up being very useful in comparing the differing companies results to each other. From this point onward, the companies involved are addressed as COX, in which the "CO" is an abbreviation of the word *company*, and the X is a number between 1 and 6 that indicates which of the anonymous companies is in question. So, for example, the first company in the table (indicated logically as CO1) has between 1 001 and 5 000 employees in Finland, but over 40 000 globally. Its sales figures in millions (€) are between 1 001 and 5 000 in Finland, but again over 10 000 globally. Lastly, the CO1 is also the one company with 8 interviewees, as the rest have only one each.

In Finland, all companies have between 501 to 5 000 employees, except the CO5 with under 250. Also, excluding the CO5 with under 1 000, globally every company has over 5 000 employees. Regarding the sales figures of these companies, in Finland the CO5 has the lowest between 51 to 100 million € and the CO1 has the greatest between 1 001 and 5 000 million €. Globally the CO5 has the smallest again with just 101 to 500 million

€ and the CO2 has the highest with over 10 000 million €. An easy and very basic observation can be made straight away between the number of employees and the sales figures: bigger companies have greater sales. However, the increase of the sales figure doesn't correlate directly with the increase of the employee figure when the companies are compared, which is expected as the companies operate on different manufacturing industry sectors and therefore can differ from each other in structure and operations.

Most of the interviewees are procurement or sourcing engineers/specialists, but few SCM managers are also included. In this sense, even if the companies might be operating in different manufacturing industries, the interviewees themselves are a reasonably homogenous group that shares critical similarities related to the research questions. Generally, when researching a specific subject with an interview study, a systematically selected homogenous interviewee sample provides more likely repeatable data and results that are a close representation of the average in that subject matter's population, than a randomly selected sample does (Maxwell, 2008, p.235).

5. Conducting the interviews

The interviews are scheduled so that they are all done by the end of May 2022. Conduction of the interviews kicks off the phase two of this thesis, and it's one of the most crucial parts of the whole research process. Before the interviews, the literature review should be mostly completed as preparation and the basis of the interview data analysis later. The interviews are conducted in a random order depending on who is available at the given time via Microsoft Teams or by face-to-face. At the beginning of each interview, the interviewee is asked again if they approve the audio recording of the interview, and when they agree, the audio of the interviews is recorded with either the built-in audio recording feature in Microsoft Teams or with a recording device (such as a smart phone) if the interview is conducted face-to-face.

Recording of the interviews allows the further data analysis to be conducted later, and it frees the interviewer to be able to improvise much more during the interviews without having to worry about losing the material. The interviewees are constantly encouraged to add whatever they see fit to their answers if, for example, they feel that the questions are not open-ended enough. Although the interview structure will not itself be changed between the interviews, observations made while doing the research can be easily implemented to the interviewing process by asking improvised follow-up questions outside the interview structure. The most important thing is not to stick to the "script", but to get interesting research results. At the end of each interview, the audio recording is stopped,

and this is clearly communicated to the interviewee. The most important objective of the interviews is to get the answers to the first two themes, and the interviews shouldn't need to last more than 60 minutes, unless the interviewee themselves wants to extend it.

6. Data gathering & processing

An individual questionnaire sheet (Appendix B) is dedicated to each interviewee. This sheet can be in either digital or physical form at the time of the interview (depending on if the interview is conducted via either Teams or face-to-face). During the interviews, the quantitative data is collected by marking the interviewees' answer into their individual questionnaire sheets, which have empty boxes for each quantitative question for this sole purpose. If the numerical data is collected manually by pen and paper, it's later transformed into a digital form (Excel-sheet) for easier access and safer storing.

The audio recordings (and everything else regarding the interview study) are saved to the Tampere University OneDrive cloud storage. Later, during the data analysis, the audio recordings are listened to question by question, and the most important parts of the interviews are transcribed. The transcriptions are not documented in this thesis itself to the letter, as their only purpose is to aid in the data analysis and help writing the research results. The results chapter will, however, provide straight quotes from the interviews and explain the most important findings in such a manner that a complete transcription of the interviews should not add any significant value for the thesis. After the data analysis for is done, and both the results and the conclusions chapters are completed, the audio recordings are disposed of. The interviewees are informed about this procedure during the interviews, so that they know that their audio recordings are not going to end up in the wrong hands by one way or another.

4.2 Theoretical Framework

The theoretical framework is created from the basis of the literature review to help analysing the COVID-19 pandemic's impacts on the supply chain management of *manufacturing companies operating in Finland* and *manufacturing companies operating outside of Finland*, and to enable their comparison to each other. To achieve this, the framework must have a set of themes that are the "points of interest", which are used to analyse the research data, and that allow the comparison between the literature review and the interview study. The chosen method of presentation for the framework is an Excel table, and it's constructed so that the three main viewpoints are on the x-axis and the "points

of interest” themes are on the y-axis. These themes are next selected in a such manner that they fulfill the frameworks objectives presented earlier, and they are the following:

1. Supply chain management before the COVID-19 pandemic.
2. Supply chain risk management before the COVID-19 pandemic.
3. Impacts of the COVID-19 pandemic.
4. Supply chain management solutions to the COVID-19 pandemic.
5. Goals of supply chain management post-COVID-19 pandemic.

These five aspects help in summarizing the most important findings in both the literature review and interview study. The pre-COVID-19 pandemic era is represented from both SCM and SCRM viewpoints in themes 1 & 2, and they build the foundation on what was the ‘normal’ in the past. The post-COVID-19 pandemic era is investigated in themes 4 & 5 by looking at what has been done and what are the goals for the future from an SCM perspective (themes 4. & 5.), and they shed light into how the companies have reacted to the pandemic. The discovered impacts of the pandemic are presented right in the middle in theme 3, which ties the framework together in a very logical manner imitating both structures of the literature review and the interview structure.

Next, the theoretical framework is presented in Table 12 below. And as the literature review is already completed, the research results from it are already summarized in the framework. The findings from the interview study are filled in later when the interview data has been analysed, and the complete theoretical framework with comparison of the findings from the literature review and the results of the interview study is then finally presented in chapter 5.

Table 12: Theoretical Framework

	Companies operating outside Finland (literature review)	Companies operating in Finland (semi- structured interviews)	Comparison
1. SCM before the COVID-19 pandemic	<p>Prioritization of cost-efficiency, globalized low-cost offshoring, single sourcing, centralized inventory management, etc. lean principles (Schlegel & Trent, 2016, p.10-11).</p> <p>Rigid, nonflexible, and too oversimplified SC systems & processes still used by many companies, especially for globalized SCs (Bowersox et al., 2002, p.3; Christopher, 2011, p.189; Packowski, 2021, p.27-28)</p>		
2. SCRM before the COVID-19 pandemic	<p>Often neglected, viewed as "not relevant" or "a big exercise in busy work", only focused on upon ongoing crisis (Schlegel & Trent, 2016, p.10-11).</p> <p>"Crisis-free management mentality" valuing cost-efficiency over resiliency, false premise of having good enough SCRM (Bowersox et al., 2002, p.3; Christopher, 2011, p.189; Ivanov, 2021).</p>		
3. Impacts of the pandemic	<p>Supply shortages, large-scale fluctuations in demand, consumption shocks, massive disruptions in SCs, and increases in material prices and lead times (Cai & Luo, 2020; Ferguson & Matthew, 2021; Sheffi 2021a; Ardolino et al., 2022; Panwar et al., 2022).</p> <p>Country-wide lockdowns that disrupted globalized SCs as borders closed (Guan et al., 2020; Vitale et al., 2020)</p> <p>One of the reasons behind the semiconductor shortage via factory shutdowns (Zimmerman, 2021)</p>		
4. SCM solutions to the COVID-19 pandemic	<p>Inventory increases, buffers, safety stocks dual sourcing, and regionalization to increase SC resilience and mitigate the risks (McKinsey & Company, 2022)</p> <p>Alternative suppliers, localization, improvement of digital connectivity & transformation, SC collaboration, and integration of SCRM (Belhadi et al., 2021; Frieske & Stieler, 2022)</p> <p>Nearshoring and deglobalizing as a counter to the global SC disruptions (Dewart (2022).</p>		
5. Goals of SCM post-COVID-19 pandemic	<p>Greatly increased SC agility, resilience and robustness (Alicke et al., 2020; Insights, 2022; Panwar et al., 2022)</p> <p>Opinions are still divided on how realistic future-proofing SCs with reshoring strategies really is, but they are an option (Supply Chain Management Review, 2021; Panwar et al., 2022).</p> <p>SC sentience through digital intelligence in modern SCM (Insights, 2022).</p>		

5. RESULTS

5.1 Data Analysis of The Interview Results

The interviews were all conducted successfully, and the interview structure turned out to function as expected: all themes were fully covered in every interview. As the interviewees' roles in their companies varied from an engineer to a manager, variety in the collected data was notable. Especially with CO1, the results were quite eye-opening, as the interviewees in dissimilar roles often saw the impacts of the pandemic very differently. Although the interview results are overall going to probably have many similarities to the findings made in the literature review, the interviews provided a lot more practical viewpoint to the subject, as the interviewees had real first-hand experience from the pandemic's effects themselves. At least from my own point of view as the researcher of this thesis, discussing about the research subject with experienced professionals that have worked on the subject themselves is a lot more intriguing and informative, than reading just another scholar's research. Now, to begin analysing the results, the process is first explained.

A data analysis is carried out on the interview results in the same five themes that were already presented in the theoretical framework chapter earlier, plus some data comparison is included in the SCRM countermeasure topic and the third theme "*sparked ideas and lessons learned for the future*" from the interview structure is integrated with the fifth theme of the theoretical framework in the very end of the analysis. The reason behind this is to enable and ease the comparison between the literature review results and the interview results with the same framework later. This, once again, correlates well with the interview structure, which was built on three themes in approximately similar order: pre-pandemic, post-COVID-19 outbreak & ideas and lessons learned (Tables 8, 9 & 10, Appendix B). As the results are presented, some of the interviewees' answers are quoted, but majority of them are just explained or listed as a part of the analysis. The quantitative (numeric) data is all displayed under the appropriate themes, and it's used to highlight, for example, the earlier mentioned differences between the interviewees' roles significance in seeing the pandemic's impacts possibly differently and the differences in answers between the interviewed companies. The CO1's data is presented as an average of the interviewees' answers, but the individual answers are discussed in the text to further analyse the internal differences in opinions. All interviewees answer only for their own companies. The data analysis begins here on out.

1. Supply chain management before the COVID-19 pandemic.

The very first question of the interview was *“how would you evaluate the general level of the SCM competence in your company”*, and this was meant to paint the picture about the interviewed companies' supply chain management background from the time before the COVID-19 pandemic was ever heard of. As all of the companies that took part in this study can be considered to be operating in traditional manufacturing industries (meaning they manufacture and produce physical products), the expectations were not very high reflecting back to the literature review.

In the literature review it was discovered that many manufacturing companies that operated around the world experienced a very quick reality check on how lackluster their supply chain management actually was when the pandemic hit, but they weren't afraid to acknowledge this when they were looking back at the times before the pandemic. Surprisingly, from the interviewed companies, only the employees of CO4 and CO6 saw their companies' pre-pandemic overall SCM level as straight-out weak, with much to improve. CO4 reportedly relied almost completely on only historical data in its inventory & demand planning, with little to no ability to actually predict any possible demand fluctuations outside maybe seasonal trends. NPIs (New Product Introductions) had always issues with SC integration, the level of automation in SCM was low, and the existing SCM tools weren't utilized nearly to their potential. CO6, on the other hand, had only just really began building its proper SCM system, and the main focus was just on procuring the required materials, as everything else was quite literally under construction. Both CO4 and CO6 were heavily criticized by the interviewees on how majority of the SCM related responsibilities were practically only on the shoulders of procurement engineers/specialists.

Other interviewees considered their companies to have had at least a relatively decent existing supply chain management system, which had done its job in the past. CO3 was criticized a bit for its lack of flexibility in processes, which were involved when new suppliers were added to its SC. This had reportedly caused some inconvenience in the past by affecting negatively to the speed of which the company could integrate a brand-new supplier to its operations on the fly, but that's about it. CO1's employees were all on the same page: the company's SCM system was *“all things considered, pretty good for its time”*, but most of them also thought that it could've been much better if there had only been enough resources available to its development in the past. Much of the CO1's strengths had always lied in its very strong expertise regarding its production processes, but SCM was slowly starting to gain interest too, as an equally important part of the company's operations, which meant that some progress had been made towards a more

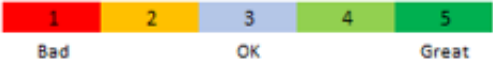
strategic SC even before the pandemic. CO2's SCM system originated from its very successful corporate group (over 10 000 million € annual sales in 2021), and it was clearly praised as the best out of the bunch. Especially the most operational SCM functions regarding procurement and logistics were working *"probably better than on many other companies"* according to the interviewee.

2. Supply chain risk management before the COVID-19 pandemic.

As the groundwork had been done, it was time to find out about the companies' supply chain risk management before the pandemic. The interviewees were asked to rate their companies' SCRM competence level, SCRM development & maintenance level, and SCR level, all pre-COVID-19 pandemic on a scale of 1 to 5 (1=bad, 5=great). The results are presented below in Table 13.

Table 13: SCRM Competence, SCRM Development & Maintenance, and SCR Levels PRE-COVID-19 Pandemic

Company	SCRM competence level	SCRM development & maintenance level	SCR level
CO1	2,83	2,67	3,5
CO2	4	3	5
CO3	3	2,5	3
CO4	2	2	2
CO5	4	3	3
CO6	1	1	3



1 2 3 4 5
Bad OK Great

CO2 was rated as the most competent in all categories, and it's no surprise considering what the interviewee already talked about its overall SCM system in answering the first question. Its overall SCRM competence was seen as very good, and it had already been using many commonly known SCRM tools regularly in the past (e.g., SWOT analyses and risk mappings regarding its SC). Its SCRM development wasn't as active anymore, as the targeted competence had already been achieved in the past: *"The current SCRM system's development cycle was nearing its maturity at the time"*. Supply chain resilience was considered to be at a great level as well, which was not the case for all of the other

companies. CO5 and CO3 were both a bit behind CO2, but both of their pre-COVID-19 pandemic SCRM competence and development & maintenance levels were characterized as *“pretty good at the time”* by the interviewees. CO3’s SC resiliency had been suffering from too regular tendering of logistics processes in the past, but it was still supplemented by other structured and systematic SCM features (e.g., every supplier had its own supplier manager, who’s job was to react on arising events and problems).

CO4 and CO6 were the lowest ranked companies by these metrics, and CO6 was even characterized as having *“no existing competency in SCRM, nor any observable interest in building it”*, and its SC resilience was apparently solely depended on its suppliers, not on the company’s own SCM or SCRM. CO4 was not as bad, but not even mediocre either. It had some existing SCRM activities, but all of them were *“remnants of old and bygone era”*, which meant that they were severely outdated and in need of updating. According to the interviewee, once or twice a year, some SCRM related “maintenance” was maybe carried out, but the same operating model persisted. The most problematic aspect was again the lack of agility in the SCM functions and processes, which caused the company’s SC resilience to suffer from the rigidity of even the mundane SCM related tasks (e.g., reactivating an existing logistics partner in the company’s ERP to be again utilized in the SC was unnecessary complicated and slow, causing increases in lead-times and logistical issues) resulting in fragile SC and very slow responsiveness.

For the first time, CO1’s interviewees manifested clear deviation in some of their answers. The overall pre-COVID-19 SCRM competency and development & maintenance levels were all seen by most of the procurement engineers/specialists as little below average, but one of them thought that they used to be actually very good. From their explanations, it was very clear that their opinions were heavily affected by which suppliers they had been working with or been responsible of. The one interviewee, who rated the levels as positive, had almost always managed to solve any problems related to his suppliers and components without too many issues, and didn’t feel like the existing SCRM system had been bad in any noticeable way. The more critical interviewees had had some frustrating experiences in the past, where the CO1’s SCRM had left much to be desired for. For example, some very supplier-specific risks had sometimes been just pushed aside with a *“let’s just hope for the best, a day at the time”* mentality due the lack of time and resources to try managing them, and it had backfired for few times, causing problems like sudden short-term supply shortages due to defect material quality in a large batch of components, which further down the line caused problems and delays for the production lines, as new or repaired ones were being waited. One interviewee even

said that they felt (at the time) that there wasn't any real coordinated SCRM or its development even existing, and instead the company's SCM personnel were just capable professionals who were able to solve the problems in front of them, as they manifested.

Interestingly, the CO1's managers rated the company's past SCRM competence and development & maintenance levels very similarly to the engineers/specialists (just about average), but they were much more critical in their verbal responses. What didn't surprise though, was that their way of analysing the CO1's SCRM in the past was based on looking at a much bigger picture, than just singular suppliers. According to them, the company's SCRM had actually been slowly evolving in the recent years and progress had been made, but it was still clearly lagging behind the constantly growing volatility of the world at the time. Every procurement and sourcing engineer/specialist knew their own suppliers the best, which meant that the actual SCRM was done by the individuals in their own areas of responsibility, more than by the whole team as a collective strategic effort throughout the SCM. SC visibility was quite bad, and potential risks weren't communicated well enough. Only when major problems appeared, SCRM activities were considered as a coordinated team, but it was always still more about just solving the current problem than looking further into the future.

Surprisingly, CO1's pre-COVID-19 SCR level was valued as relatively high by the engineers/specialists. Though, it was clearly noticeable that there was maybe some professional pride behind the interviewees' answers, which is quite understandable, as they themselves were the ones solving the problems and putting out the fires (and apparently very successfully as well, according to one of the managers). One of the procurement specialists pondered: *"From time to time, we've had to pull multiple rabbits out of several different hats in the past, to resolve the lingering issues, but we've always managed to eventually come out successful. That has to mean that we've had at least some resilience in our supply chain, right?"*. Both managers were a bit more sceptical in their valuations, but they agreed with the specialist's statement above. They also admitted that couple of times some of the company's operations were shortly disrupted, because a key supplier turned out to be nowhere near reliable enough for the criticality of the components it was supplying (for various reasons), which eventually led to the switching of the problematic supplier to a new one altogether. According one of them, this was a concrete example of a typical SCRM related decision made in the past to strengthen the company's supply chain resilience.

When asked about what kinds of risks the companies were prepared for from an SCRM perspective before the pandemic, only CO2 had clearly considered risks in even a remotely close scale to what the COVID-19 pandemic turned out to be (e.g., risks like

globalized SCs being disrupted by all deliveries being cut off from a specific country for some reason), but even then those kind of SCRM analyses were all done mostly just because the company's standards required, according to the interviewee. Most of the actual SCRM was concentrated on optimization and more practical everyday risks, such as risks regarding suppliers and, in some very specific cases, even the availability of singular components. The strategic timeframe for the CO2's SCRM plans was usually 3-5 years onwards. CO1, on the other hand, was most of the time just focused on dealing with individual short-term risks, as its SCM was built heavily on lean thinking. Long-term risk forecasting was usually done very locally and based on the employees' individual knowledge and existing historical data, not on advanced simulations or other risk management tools.

CO4 had experience in suffering air cargo related supply chain problems due to the Iceland's volcano eruption in the past, which had caused them to consider natural disasters as risks in their supply chain much more seriously than the other interviewed companies. According to the CO4's interviewee though, the other aspects of SCRM regarding its globalized SC were very weak: *"The company had offshored majority of its SC to China in pursuit of the all-important lean cost-efficiency. Agile SCRM concepts such as alternate suppliers or dual sourcing were not even talked about, although significant logistical risks associated to just international transportation were most definitely acknowledged (referring to the regular speculating about possible natural disasters, which had caused transportation problems in the past)".* Both CO5 and CO6 were usually in the past focusing only on the most imminent risks related to their suppliers, and they therefore suffered from the lack of SC visibility and overall situational awareness regarding their supply chains higher Tiers.

Next questions asked if the companies had faced any similar large-scale SCM crises before, how they overcame them, and how much of that could be credited to their SCRM. CO1's all interviewees recalled collectively that almost all of the company's worst SCM related crises in the past had been related to some specific components' supply being completely halted. This had been caused by many reasons, some that could've probably been predicted (e.g., supplier bankruptcy or major quality problems) and some that were completely unforecastable (e.g., massive fire in supplier's production plant). Other companies' experiences were also almost exactly similar, only CO2 mentioned that Brexit had had some disruptive effects on its SC, but in hindsight they were completely negligible compared to what the COVID-19 pandemic eventually caused. Before going into how the companies actually overcame these past crises, the interviewees' answers regarding on how much the company's SCRM helped them is presented below in Table 14.

Table 14: How Much of Your Company's Ability to Overcome the Past Challenges Can Be Credited to Its SCRM?

Company	How much of your company's ability to overcome the past challenges can be credited to its SCRM
CO1	2,9
CO2	5
CO3	2,5
CO4	2
CO5	4
CO6	1

1
 2
 3
 4
 5

None Everything

According to the CO1's interviewees, the company overcame many of its past supply chain crises by simply improvising emergency solutions, while waiting for the suppliers to get back on their feet. For example, in the past they've had units already halfway built in middle of their production line when a sudden critical component shortage has stricken, which at worst has caused the whole production to halt. To solve situations like these, CO1 had many times demonstrated impressive innovative problem-solving regarding running their manufacturing processes (such as continuing to build units by recycling only one set of rollers on their production line, while waiting for the supplier to deliver the rest), but few times they've also been completely on their suppliers' mercy. But the engineers/specialists thought that, at the end of the day, SCRM didn't really have much to do with coming up with these solutions. One of them even completely denied that it had any and answered with '1'. Interestingly, the managers thought exactly the opposite, and another of them even credited most of the solutions successes to SCRM (giving it a '4,5'). This felt like a clear example of how differently employees in different roles see things, as both the managers and the engineers/specialists had recognized the completely same SCRM crises from the past but thought about them differently.

Other companies' interviewees had vastly differing experiences. CO2 was once again clearly the most praised, but this time CO5 wasn't far off. CO2's SCRM had played a very big part in its history of successfully dealing with its SC problems, mainly because of its regular pre-emptive risk assessments and proactive SC relationship management. Its SC's main source of resilience had always been its SC's visibility and strong communication between its suppliers. CO5's active SCRM had also been a significant reason why the company hadn't had any notably big SC crises for a long time, but as a critique

it was sometimes even a bit too overwhelming: *“When everything was going OK, sometimes even the smallest issues were treated as major setbacks, and when every single delay in the material flow is thought to be a ‘crisis that needs to be immediately solved or at least actively monitored’, it’s not very optimal either”*. Interviewees of CO3 and CO4 both had very similar answers: in the past, problems were solved in various different ways, some of which were SCRM related and others that were not. But they also thought that SCRM overall could’ve had a lot bigger role in their companies’ SCM, as the SCRM that they had was more about improvising and solving short-term problems, than strategic and purposeful. CO6 was rated as the worst out of all, and its interviewee commented that *“SCRM was clearly the weakest link of our SCM, and few times some of our customers were very disappointed due to unexpectedly long delays in our end, caused by simple shortage of components that could’ve surely been avoided.”*.

Upon being asked about what commonly recognized SCRM tools/methods did the companies use before the pandemic, similarities to the literature review started to show. CO1 had used some component specific inventory buffers and safety stocks, increased supplier cooperation with few problematic ones, randomly (and sparsely) conducted SC stress tests, supplier capacity reviews, risk audits and bottle neck analyses for new suppliers, and already even some dual sourcing for few critical components. CO2 had used (a bit more) dual sourcing, enhanced supplier cooperation, and risk audits as well, but their most important SCRM tool was their own Supply Relationship Management (SRM) portal, which was a risk management tool and a procurement hub at the same time. It had lots of SCRM functions, which could, for example, notify the procurement engineers about emerging financial and operational risks regarding specific suppliers. The SRM portal was even back then so advanced that it could single out potential risks related to specific countries (political, natural, logistical, etc.). It was way ahead of what CO1 had used.

CO3 conducted regular Failure Mode Analyses, which were used to identify specific SC risks, evaluate them, propose risk mitigation strategies for them, and analyse what the end situation would most likely end up being. CO5 had a small group of experts/managers from R&D, logistics and SCM, who regularly met and discussed all of the current SC related issues and brainstormed what they could do to solve them. They also tried to build small safety stocks and buffers from time to time, but they were never too successful due to the lack of storage space in the company’s facilities. CO4 and CO6 were more focused on trying to optimize their production processes than on SCRM, which was apparent from the sheer lack of any recognizable SCRM related tools they had in use.

The final question of the pre-COVID-19 pandemic era was to define how operative or strategic the company's SCM was. This question was meant to create the last quantitative milestone to be used in comparing the pre-pandemic and post-COVID-19 outbreak situations, other ones being the SCRM evaluation questions (the same questions are later asked about the companies' current situation). The results are presented in Table 15 below.

Table 15: SCM Before the Pandemic, Operative or Strategic?

Company	SCM pre-COVID-19, operative vs. strategic
CO1	2,42
CO2	4,4
CO3	3,5
CO4	2,5
CO5	2
CO6	2

1 2 3 4 5
Operative Strategic

CO1, CO4, CO5 and CO6 were all leaning on the operative side in their valuations, and the interviewees all noted that it was much more obvious how operative they actually were now in hindsight after the COVID-19 outbreak than back then. Management's constant pushing for more cost-effectiveness, lean SCM methods (e.g., low buffers, reduced inventories, etc.), and the lack of agility in SCs was the norm for many of them, just as it was discussed to be for many manufacturing companies operating around the world in the literature review earlier. CO3 was tipping a bit more on the strategic side, as it had already been trying to shift its SCM to a more strategic direction for some time before the pandemic. For example, it had new SC related category- and availability strategies *"in the making"* according to the interviewee. CO2 was valued by far the most strategic of them all, and it no doubt was. But according to the interviewee, even though the company had been looking far into the future and had very advanced SCM and SCRM already in the past, there were still surprisingly often *"small 'fires' that required old-fashioned operative problem-solving to be put out"*. To summarize, not counting CO2, most of the interviewees felt like their companies' SCM was pre-pandemic somewhere in the middle ground between operative and strategic, or a bit more operative.

3. Impacts of the COVID-19 pandemic.

Now the interview's theme shifted to the post-COVID-19 outbreak era. The first questions were about how the pandemic affected the companies both internally and externally from a general perspective, followed up by how quickly the pandemic reached the company and what were the company's very first actions (these are discussed in more detail in the next theme). CO1 started to keep track of the pandemic's evolvement right at the start of 2020, but the first real supply chain related impacts weren't felt until the Spring couple months later. When it happened, the pandemic hit hard on the company's suppliers globally, and the supply problems and shortages started to trickle down the Tiers in their global SC, until in the Summer 2020 the pandemic's disruptive SC effects were fully felt inside Finland's borders too. In the Fall, things were looking a bit better, but again in the Summer of 2021 the pandemic started to seriously disrupt the company's SC again. Almost the same cycle of impacts happened to the other interviewed companies as well, even though they weren't all operating in similar manufacturing industries.

CO1's (and many of the others') very first SCM related actions were simply emergency meetings. In them, the SCM personnel tried to figure out what was at the moment going on in and outside of the company, and what would be the best operative measures to sustain the production operational in both short- and long-term, as the global markets were starting to get disrupted, and general uncertainty was raising. CO1 and CO2 were examples of companies that reacted very quickly (for being traditional manufacturing companies) and took proactive actions as the pandemic started to spread to Finland, but many others (e.g., CO4 and CO6) were struggling to keep up. For example, CO4's interviewee recalled that *"there was a lot of doubting and uncertainty in the air, and the measures that were eventually taken felt too slowly executed, and it was later confirmed when the problems started"*.

Layoffs (that were maybe made a bit hastily in many companies according to CO1's CO2's interviewees), shifting to remote working, and all the now very familiar sanitary measures were the first internal effects seen by most of the interviewees in their companies. Externally, the clearest impacts were noticeable on the companies' suppliers and supply chain overall. Supply shortages started to increase in growing number, as suppliers were struggling with their own order backlogs, and some were even forced to shut down their operations for varying durations due to COVID-19 infections or lockdowns. One of CO1's procurement specialists said that *"many of our suppliers' suppliers were located in Italy, which went into a total country-wide lockdown at one point, and therefore many of the SC disruptions we experienced originated from T2 suppliers and above"*. This meant that in many cases, the T1 suppliers were almost as helpless as the focal

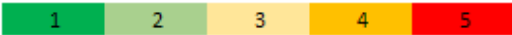
company to do anything about T2 suppliers' situation. As another one of the CO1's procurement specialists put it: *"The **** was already in the pants, and we would have to either find an alternative solution or just wait the shortage out"*. Other companies also commented that the COVID-19 restrictions in Europe caused lots of logistical problems regarding transportation of materials and components that would've otherwise been available, which disrupted their SCs even more.

Although most of the interviewed companies had to witness first-hand how some members of their SC were totally pinned down by the pandemic's SC disruptions (in few cases leading all the way to even bankruptcy), many of them thought that their SCs held intact surprisingly well, all things considered. Majority of CO5's suppliers managed to maintain their production capacity at almost all times throughout the pandemic, and CO2's interviewee thought that the company bounced back surprisingly fast to almost operating at their normal production capacity, already by the end of Summer 2020. The interviewees jointly felt that most of the COVID-19 pandemic's SCM related impacts were originated from their suppliers' suppliers' problems, meaning that having the SC visibility to only their Tier 1 suppliers failed them in SCRM sense. The SC disruptions often started multiple Tiers deep, and especially the globalized SCs were struggling.

The interviewees were next asked to evaluate how strong negative impacts the pandemic has had on their companies from two perspectives: operative and business profitability. Whereas the negative effects from an operative perspective were already discussed in detail, the effects from a business profitability perspective were not. The results turned out to be quite surprising, and they are presented in Table 16 below.

Table 16: The Pandemic's Negative Effects from an Operative and a Business Profitability Perspective

Company	Pandemic's negative effects from an operative perspective	Pandemic's negative effects from a business profitability perspective
CO1	2,63	2,13
CO2	2	1
CO3	2	1
CO4	3	1
CO5	1	1
CO6	2	2,5



Negligible
Major

From a researcher's perspective, two truly interesting things occurred. The first one was that most of the interviewees were suddenly very hesitant to say that the pandemic's negative impacts from an operative perspective were overall actually all that strong here in Finland. It first seemed like they were simply downplaying their evaluations for some reason, but it made sense after looking back at the interview study's questions that had been asked so far: the interviewees had been just thinking about all kinds of negative impacts and SC disruptions, which their suppliers and global SCs had experienced, and now when they started to think about what kind of negative effects their companies actually experienced first-hand here in Finland, it probably felt like they realized that those effects weren't nearly as bad. From a research-technical point of view, it would've been very interesting to present this question to some interviewees before they had to think the external effects at all.

Going back to the question, even if supply shortages and SC problems were experienced, the interviewees of CO2, CO3, and CO5 all felt like their companies had been able to so far always come up with a solution or a plan to avoid any significant SC disruptions getting out of hand. CO4's and CO6's interviewees thought also that probably the most operatively challenging problems were caused by their own slow and inflexible reacting to the pandemic, which were still nothing compared to what some of their suppliers had to endure. CO1's interviewees had a bit more divided answers, and it was yet again very apparent that each interviewees' personal experiences determined how they felt about the pandemic's effects. Only one procurement specialist and the other one of the managers valued the negative effects from an operative perspective to be over 4, and they felt that judging from what they saw, the impacts had been severe. Others' answers varied from 1 to 3, and they felt exactly same as the interviewees from CO2, CO3, and CO5. The other SCM manager said: *"Sure, we did have our share of challenges and our suppliers did fail to deliver critical parts from time to time, but I can't help but be proud how well we managed to handle the difficulties, even if we had to improvise 'from the hip' a few times"*. In the end, the overall impression was that the direct operative impacts were actually not too bad, or they were at least manageable, considering what was happening to manufacturing companies operating in other countries, according to the literature review.

The second interesting thing was that only when the interviewees were asked about strictly negative effects that had occurred, they were suddenly able to come up with many positive things too that had happened during the pandemic. For example, from an operative perspective, the shift to remote working was a *"positive shock"* to many manufacturing industries' companies' employees, as this kind of flexibility was unheard of in the

past. CO2's interviewee remarked: *"Traditional manufacturing companies have been notoriously inflexible in the past towards any kind of remote working arrangements, and the quick shift to total remote operating for all white-collar workers felt absurd at first, almost like the wall of Berlin had fallen again"*. According to the interviewees, as the companies were forced to react on the pandemic's imminent threat, it kickstarted many large-scale changes to, in many aspects, very positive directions. CO3's interviewee said: *"In a way, the introduction of remote working also brought many new aspects to, for example, SCM. Suddenly we were hosting daily meetings online with our suppliers that we had been communicating maybe once a week in the past, and at the same time, we had to aggressively improve the communication between us to a completely new level if we wanted to see this world-wide crisis through"*.

But the positive impacts were truly highlighted when the interviewees started to answer the second question about how strong the negative impacts had been on a business profitability perspective. The interviewees of CO2, CO3, CO4, and CO5 gave all, without hesitation, the lowest possible score (1 = negligible), and so did half of the CO1's interviewees. Apparently, as the difficulties caused by the pandemic had somewhat relieved (at least for a while) after the Summer of 2020, the companies' products' demands surged massively, and even though the year 2021 had many SC disruptions all throughout, the demand seemed to only keep globally raising. One of the CO1's managers said: *"There is no doubt that we first suffered notable financial losses due to the increased lead-times and supply problems in the beginning of the pandemic, as we missed sales opportunities and were dragging behind our production schedule. But now in 2022 after the worst is starting to be over, our sales have basically doubled from the pre-COVID-19 numbers"*, and the other followed: *"Right now, the demand is higher than what we can currently produce, as our SC is still not fully healed yet and our production lines have their physical limits too"*. Even CO6's interviewee commented: *"As the markets started to revive, our sales grew too, which was very positive news. Unfortunately we just happened to have couple of those really bad SCRM blunders along the way that cost us.. A LOT"*.

Later in the interview, the interviewees were asked to just rate *"how much has the pandemic affected your company's SCM"*, without mentioning anything in the sense of if it was positive or negative. At this point, it felt like all of them were looking at this question from multiple different angles. And as it happened, none of them answered it by only looking at the negative effects that the pandemic has caused, but instead, they all thought that the pandemic had also had a positive effect on the overall development of

their company's SCM (and especially the senior management's attitude towards the importance and value of SCM & SCRM as strategic functions). Below, in Table 17, the results for this question are presented.

Table 17: How Much Did the Pandemic Affect the Companies' SCM

Company	How much has the COVID-19 pandemic affected your company's SCM?
CO1	3,56
CO2	3
CO3	4
CO4	4
CO5	3
CO6	3

1	2	3	4	5
Not at all				Greatly

What all of this seems to mean overall, is that even though there is no denying that the pandemic did have its negative impacts on the interviewed manufacturing companies' supply chain management, the outcome seems to actually be mostly positive for many of them after all this time, when looking at their grown sales and development of SCM, SCMR, and SCR. This is still a little wild statement to make, considering how many similar manufacturing companies have been greatly suffering due to the pandemic's SCM impacts, even as near as in Central Europe. One of the CO1's managers said: *"In Finland, many companies' supply chains (component/material availability) are currently (in 2022) the most restrictive factor for them to meet the increased global demand. The supply shortages have of course been felt here too, but we think that they've been much more manageable than in many other countries, even in the most difficult points of the pandemic. We've been able to look from alternate sources (and countries) if one of our global or domestic suppliers has failed. For companies operating in countries that have totally closed their borders, this might've been impossible for as long as the lockdown has lasted and could've caused huge losses"*. But even if Finland was relatively lucky, surviving the SC disruptions hasn't happened by itself, and that is the next topic.

4. Supply chain management related countermeasures against the COVID-19 pandemic (+ comparison of collected data)

The interview had many direct and indirect questions about what kind of SCM and SCRM related actions did the companies take to counter the pandemic's impacts, and many of them had reacted with very similar measures that were discussed in the literature review. All of the interviewed companies, except maybe CO2, could be easily characterized in their pre-COVID-19 pandemic state at this point as 'traditionally operating manufacturing companies, all with quite traditional lean-based SCM systems'. In the literature review, it was made already clear that an old-fashioned lean-based SCM system is not very suitable for handling times of crisis, like the COVID-19 pandemic, and according to the interviewees, the pandemic's effects made the companies realize this quickly as well. All of them ended up making changes, but not necessarily in the same proportions or areas. For example, whereas the companies operating in mechanical engineering related manufacturing industries (CO1, CO2, CO3, CO4) sought out to make both operative and strategic improvements to their SCM and SCRM, CO5 (operating in a chemical engineering manufacturing industry) seemed to be able to get away with only few SCRM related adjustments. Next, these SCM countermeasures are talked about from each company's perspective.

By interviewing eight people in total from CO1, the collective information acquired from the interviewees provided a comprehensive insight into their SCM related countermeasures that were implemented during the COVID-19 pandemic. Therefore, CO1 is explored in much more detail than the other companies. Starting off, their SCM wasn't necessarily 'bad' before the pandemic (at least compared to the 'expected norm' for average traditionally operating manufacturing companies that were discussed in the literature review), but their SC wasn't very resilient or agile either. The interviewed employees agreed. According to one of the CO1's procurement engineers: *"As the pandemic's threat was realized, the company surprisingly quickly started to invest resources into SCM and its supporting activities"*. Efforts to turn the company's relatively rigid SC and lean SCM into more flexible and agile began, which quickly led into the old ways of doing things being heavily modified to the modern era.

In the old model, CO1's SCM followed many of the lean ideas and principles presented in the literature review, and this was most apparent in their inventory management. Although there were some buffers (for the most problematic or critical components), mostly the goal of procurement was to keep the overall inventory value as low as possible and order only as much as was needed. After the pandemic outbreak, this was no longer the priority number one. Minimum inventory levels were set higher and SCRM regarding

possible bottleneck-components was increased. One of the procurement specialists said: *“Buffers and strategic stocks were enlarged from pre-pandemic levels in efforts to avoid running out of components if supply shortages appeared, and the little JIT-thinking that we might’ve had (regarding some specific components) was quickly thrown out of the window”*. Purchasing order backlog was deliberately grown as an SCRM method: when it was clear that the suppliers were able to only deliver about 70-80% of the amounts that were ordered, the order sizes were increased to 120-130% to meet the current demands. One of the managers added: *“This strategy worked surprisingly well, and we were usually able to get what we actually needed by adding a bit more to the quantities, but we were very careful in doing this. As too aggressive intentional over-ordering can quickly lead to huge problems for the already struggling suppliers, it’s very important to not overshoot their capacity by creating them an impossible situation by a ‘just in case’ ordering mentality”*. The over-ordering ‘method’ and its risks were also discussed in the literature review, and just as the CO1’s manager admitted, this can be dangerous way to operate.

Looking at the big picture, all CO1’s interviewees collectively agreed that ensuring the SC’s flows was the most important objective of the whole SCM system, and the increased investments and effort put into the SCRM activities was trying to counter the global crisis’ effects. Already familiar SCRM methods, like more dual sourcing and alternate suppliers, were added as a quick answer, but the company knew those wouldn’t be enough. Managing supply and supplier risks was made one of the top priorities. Proactive supplier cooperation and communication was heavily increased, as it was apparent that the company couldn’t just sit and wait for the pandemic’s impacts to hit it without knowing from where or when. According to CO1’s other manager: *“We started to work towards a much more non-formal communication standards between us and our suppliers, which meant that during the SC disruptions, we wanted the threshold for all kinds of information to move to be as low as possible, to both ways. Situational awareness was one of the most important keys to counter the pandemic, as the ability to respond to the changes was literally depending on it”*. The other one added: *“We wanted to know exactly what was going on, not only with our T1 supplier, but also with our T2 and T3 suppliers as well if possible. The visibility to higher Tiers of the SC was a must to be able to even guess what was going to happen in the near future”*.

Anticipating what was going on around and in multiple layers of the SC became quickly one of the most important new (or at least clearly increased) SCRM methods, but this worked to the other direction as well. The suppliers were clearly and openly informed about the CO1’s own situation, problems, and needs, as increasing the SC visibility to

both ways would only help the company and the supplier at the same time. SCRM activities were integrated more deeply with the suppliers, than they had ever been. CO1's SCM manager reflected: *"The pre-pandemic way of forecasting demand seemed as a very short-term and risk-free way of looking at the future now, as currently we wanted to brace for even the worst possible scenario, together with our suppliers"*. One of the procurement specialists also said: *"During the first half of 2020, we realized that we needed to increase our pre-emptive SCRM if we wanted to keep the things running. Our pre-pandemic SC and SCM were not flexible or agile enough to deal with the SC disruptions that we were probably going to face, and I'd like to think now two years later that we were 100% correct"*.

As of the Spring of 2022, CO1 seems to be in the successful group of companies with the countermeasures it made, although all of its interviewees didn't fully agree. The quickly increased flexibility in its SC was a major reason why it managed to capture even some market share from its main competitor, while it was struggling with the pandemic's SC disruptions more, according to the SCM managers. Regardless of if its every interviewee agrees or not, CO1 is still a great example of what was talked about in the literature review, as it was able to gain competitive edge in time of crisis by becoming more agile in its SCM. One of the procurement specialists said: *"It felt like we managed to become much more flexible and agile in a relatively short timeframe compared to our competitor *****, which was apparently not keeping up with us when the markets started to revitalize"*. Another one added: *"We were quick enough to be able to capitalize on the increasing demand, as we were much more quickly back on our feet than ***** and others"*. The managers concluded: *"We are now light years ahead in SCRM compared to where we were before the pandemic. We now understand that SCM needs to take variation of everything happening around us more seriously into account, was it the performance of our suppliers or the requirements of our production. We must build 'flex' into everything, as it's the first step to have resilience in our SC"*.

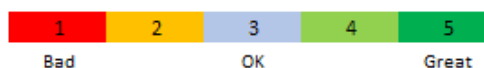
CO1's shift from lean to more agile SCM was a maneuver that was done by many of the other interviewed companies as well. Even though CO2 already had relatively strong SCM and SCRM systems existing, they wanted to strengthen their SC resilience even more. The company's interviewee said: *"Before the pandemic hit, we too were guilty of seeing everything as a competition of costs, where being fast and efficient was the key to win. We changed all of our traditional ways of thinking (lean, JIT, low inventories, thin buffers) to stress more resilient way of thinking. CO2's SCM strategy was changed too to emphasize SC resilience, visibility, availability and certainty. CO4 and CO6 were at least trying to adapt similar ideas, but were a bit less successful, whereas CO3 and CO5*

were successful in very different ways. CO3's interviewee said: *"We were surprisingly efficient in putting out the 'fires' as they appeared due to the global SC disruptions, and the War Room-idea (a hand-picked core team that came together regularly to brainstorm solutions to the current SCM related problems), which originally was invented to address the semiconductor crisis, spurred into an actual concept that worked wonders in countering the COVID-19 pandemic's impacts as well"*. CO5 was one of the lucky ones, as its capabilities to react in SCRM manner were apparently quite limited. It didn't have any excess space for increased buffers and its existing SCRM methods were very scattered (e.g., alternate suppliers existed, but they weren't strategically managed). But its SC's existing resilience became evident, as its suppliers were the ones who were able to counter the pandemic quite well.

When the interviewees were now asked again to rate their companies' SCRM and SCR levels, but this time for the current situation (post-COVID-19 outbreak), many of them looked back at their previous answers and thought they had maybe been a bit too generous in the beginning. One of CO1's managers, for example, said: *"Well, now that I'm looking at my first answers and trying to evaluate our current situation after battling the pandemic, I feel like I should've been more critical while answering the first questions"*. This is an important observation, and the results should be analysed with this in mind: **the interviewees were a lot more critical in their judgement for the post-COVID-19 outbreak values**. Below, in Table 18, the results to the SCRM and SCR post-COVID-19 evaluation questions are presented.

Table 18: SCRM Competence, SCRM Development & Maintenance, and SCR Levels Post-COVID-19 Outbreak

Company	SCRM competence level	SCRM development & maintenance level	SCR level
CO1	3,31	3,5	3,31
CO2	4	4	5
CO3	4	3,5	3,5
CO4	2,5	2,5	2,5
CO5	3	2	3
CO6	1,5	2,5	2,5



Now, the post-COVID-19 outbreak results are compared to the pre-COVID-19 results from earlier. In the new light of knowing how the interviewees answered the questions, the comparison depicts what they thought that their company's SCMR competency, SCMR development and maintenance, and SCR levels were at the time under review, reflected to the world's state in that moment. The comparisons are presented below in Figures 16, 17, and 18.

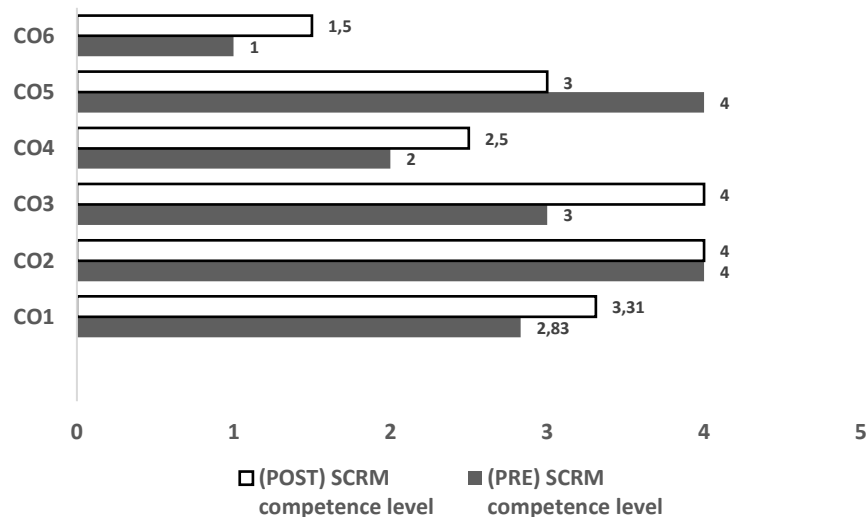


Figure 16: SCRM Competence Level PRE-COVID-19 vs. POST-COVID-19 Outbreak

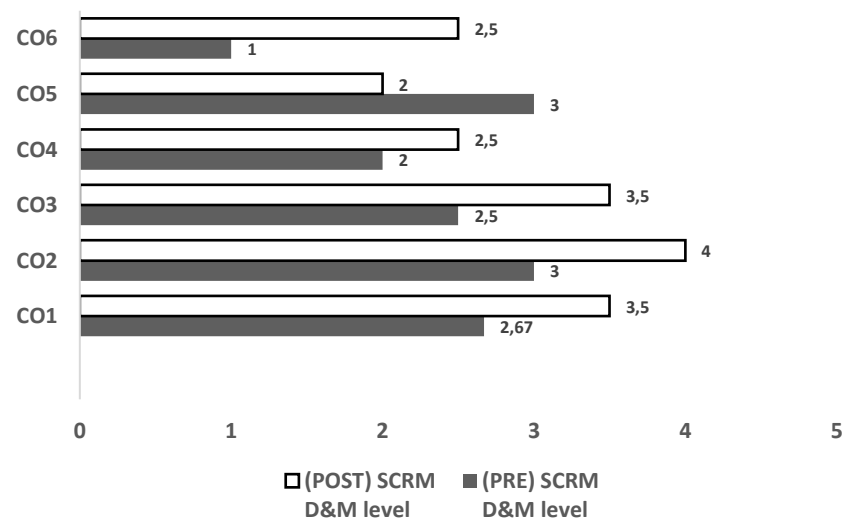


Figure 17: SCRM Development & Maintenance Level PRE-COVID-19 vs. POST-COVID-19 Outbreak

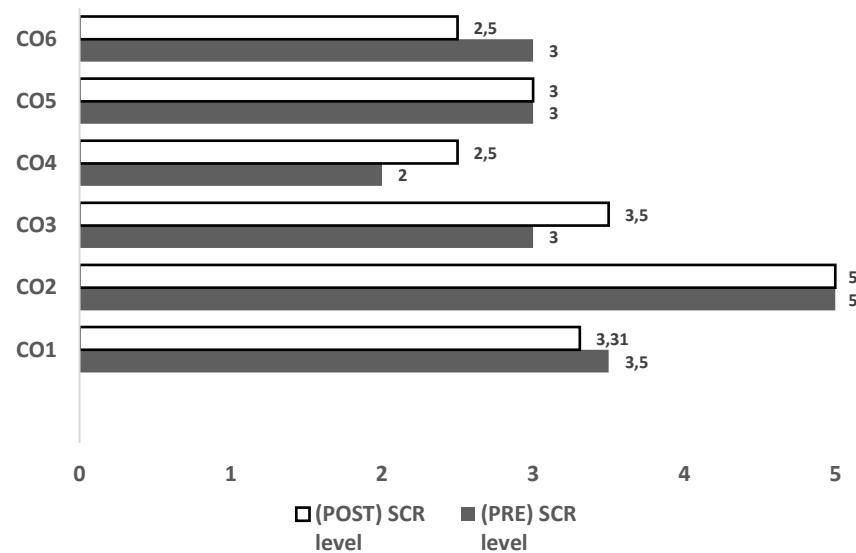


Figure 18: SCR Level PRE-COVID-19 vs. POST-COVID-19 Outbreak

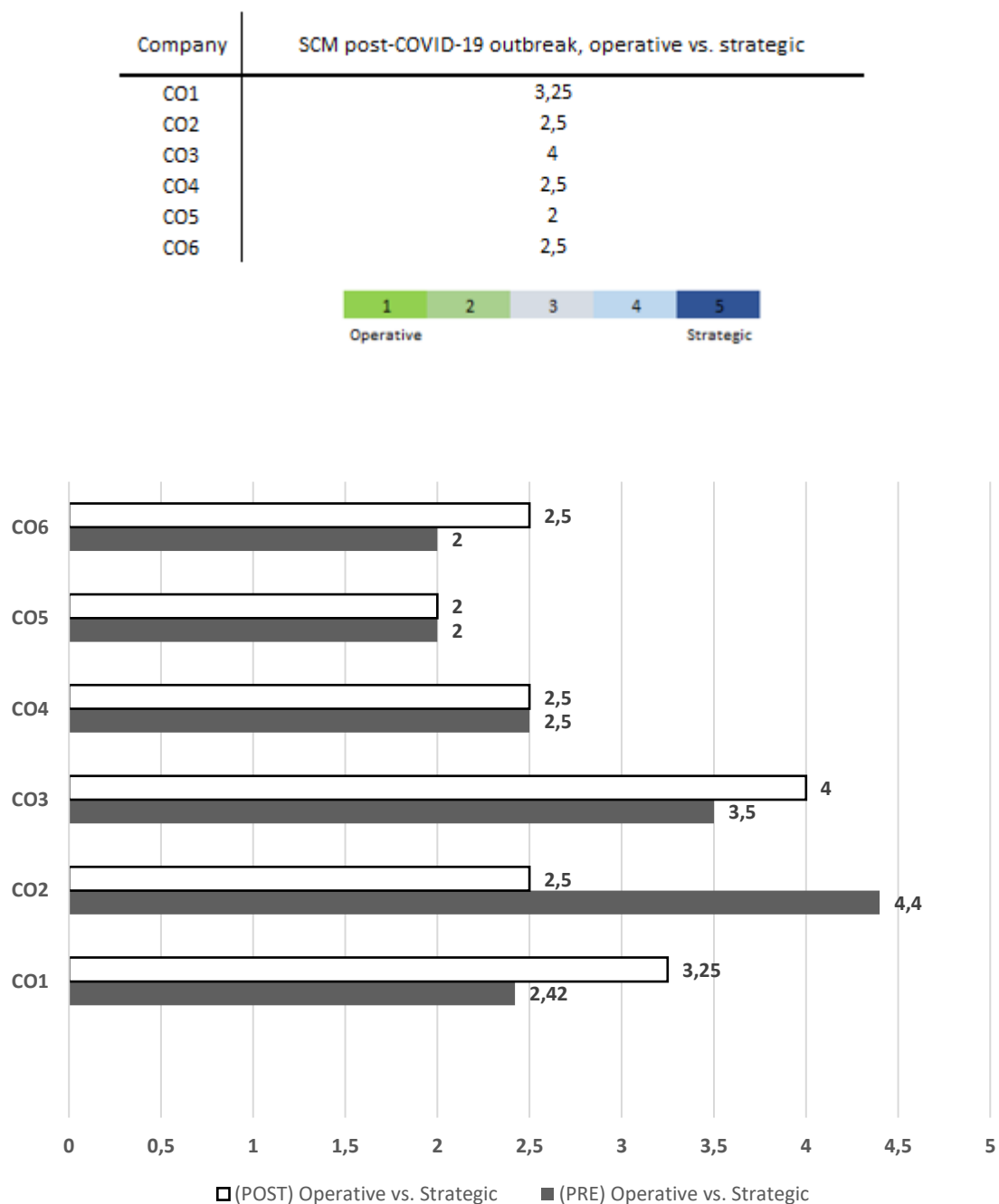
Analysing these results raises many questions, and the first is obviously *are they even comparable to each other?* Although it has become fairly obvious that the interviewees were assessing the pre-COVID-19 questions from a different standpoint in the beginning of the interview than they were evaluating the post-COVID-19 outbreak questions in the end of the interview (the reasons behind this will be further analysed in the discussion chapter later), these results can still be used to analyse their companies' SCM related development throughout the pandemic. The data must just be examined from a perspective that takes into account the prevailing conditions of the time under review. If, for example, the company's SCR level was valued as '3' pre-COVID-19 pandemic, and then again as '3' post-COVID-19 outbreak, this most likely means that, according to the interviewee, the company's SCR has increased in such a way that it has been able to reach the same relative level of SC resilience it used to have before the pandemic.

By following the logic above, every interviewee thought that their company had the same or higher level of SCMR competence and development & maintenance post-COVID-19 pandemic outbreak, except CO5. According to its interviewee, the company's own SCMR felt like it didn't progress much during the pandemic, but rather its suppliers were the ones who were able to evolve and guarantee also CO5's operations. CO2 managed to maintain its same SCRM competence level and SCR level, but its SCRM development and maintenance level grew by one. The company's interviewee felt like the focus of SCMR development had shifted to things that mattered more, and therefore deserved more recognition. CO6 was beginning to find its footing finally, and it was on the right path, maybe just lagging a bit behind the others. Still, its interviewee felt like its SCMR

competency was already becoming clearly better than what it was before, and that its SCRM development had greatly increased. In fact, CO6's SCRM development and maintenance level rose more than any other level for all of the companies (+1,5).

CO3 and CO4 experienced very similar progress according to their interviewees, as both levelled up in all three categories by +0,5 to +1,0 respectively. Of the two, CO3 was rated higher at all times, and it was in line with the interviews other questions' results as well. CO1's interviewees were, once again, a bit divided in their opinions. Two of the procurement specialists felt that all of the three levels had actually lowered significantly, but from the follow-up questions it was quite evident that this was caused by their suppliers' suppliers' very difficult situations, which were still persisting. Others felt like there had been noticeably progress, and valued the three levels higher than what they were pre-pandemic. The CO1's two first mean values for post-COVID-19 outbreak turned out to be slightly higher than pre-COVID-19 results, but the SCR level suffered a small decline. Overall, when looking back at all the answers the CO1's interviewees gave to the prior questions, these values felt like they were not completely in line with what was said. The values that the two specialists gave surely lowered the scores, but the other interviewees' answers felt a bit too critical as well, because they themselves had just talked about how well the company had managed to better its SCM, SCRM, and SCR, prior to these three evaluation questions. CO1's SCM manager summarized the nature of this data comparison probably best: *"Although we feel like we've managed to become much better at our SCRM, the reality is that the requirements (to operate successfully in the world today, in both SCM and SCRM sense) have increased greatly as well, which means that if we can now do finally about the same that we could before the pandemic, we're then not yet technically any better"*.

The last question regarding the comparison of situations pre-COVID-19 and post-COVID-19 outbreak was the familiar operative vs. strategic SCM evaluation. At this point of the interview, some of the interviewees were clearly becoming more and more self-critical, and the differences of their positions in their company were reflecting from their answers. Next, in Table 19, the results for the operative vs. strategic SCM post-COVID-19 outbreak question are presented, and after it, in Figure 19, the comparison between the 'operative vs. strategic' questions' pre-COVID-19 and post-COVID-19 outbreak results are compared.

Table 19: Table 15: SCM After the COVID-19 Outbreak, Operative or Strategic?**Figure 19: SCM Operative vs. Strategic, PRE-COVID-19 Pandemic vs. POST-COVID-19 Outbreak**

From the results comparison, two major conflicts can be highlighted. First of all, CO2's post-COVID-19 outbreak value is grossly downplayed. It was by far the most strategic and advanced in SCM and SCMR out of all six companies before, after, and during the pandemic, according to this interview data analysis so far. This was just a stellar example of the interviewee's criticality and professionalism, as they felt that their current SCM

situation wasn't worth to be called more strategic than operative anymore. The CO2's interviewee's thoughts were giving this quite clearly away: *"Now in 2022, it was finally starting to feel like we were getting back on our feet again. For the past couple of years, our SCM was the most operative it has ever been in its current state"*. Another conflict was also related to CO2, but this time indirectly. In no scenario that this data analysis can provide, can CO6's SCM value be the same as CO2's, in operative vs. strategic comparison. Even though CO6 was starting make progress in its SCMR by the end, it still had a lot more problems, was much slower to react, and didn't have close the same expertise and resources available, as CO2 did. Therefore, it's safe to assume that this was just a case of two interviewees looking at their company's progress completely differently, another being optimistic and another being too critical.

CO5's and CO4's interviewees felt that their companies' SCM had stayed the same, but CO3 was evaluated to more strategical than before. CO3's interviewee added: *"We've clearly become more strategical in our SCM than ever before. Now we're constantly evaluating our suppliers and managing SC related risks, which is something that was done in the past out of arisen need, not from proactivity"*. CO1 had, again, greatly divided answers. The procurement specialists/engineers thought that the company's post-COVID-19 outbreak SCM was either extremely operative or extremely strategic, as their answers were inside either 1 to 2 or 4 to 5. The arguments of the ones' who thought it was operative were the same: the suppliers under their responsibility were struggling heavily due to the pandemic. The ones who thought the SCM was very strategic, though, felt like they had witnessed many changes towards more strategic approaches regarding different SCM or SCRM methods they had in use. The managers both answered with a 3, and they saw the big picture as a more strategic SCM system being built, which still required a lot operative upkeep. The mean value of the CO1's post-COVID-19 outbreak SCM ended up being more strategic than it was pre-COVID-19.

5. Goals of supply chain management post-COVID-19 pandemic (+ sparked ideas and lessons learned for the future)

The interviewees were asked in the last theme of the interview to think if their company had done anything especially innovative from a SCM or SCRM perspective to fight the pandemic. Many were first struggling to come up with any, but with few follow-up questions and probes, few were found. The most obvious, and probably not from many other industries' companies' points of view so special, was simply the shift to working completely remotely due to the pandemic. The reason it was mentioned here was simply

because, as already mentioned, many traditionally operating manufacturing companies had typically never even considered offering the opportunity to work mostly or totally remotely to its employees, according to the interviewees. In that sense, this was a *“quite revolutionary change in flexibility”*, according to one of the CO1’s interviewees. Although, CO2’s interviewee, for example, mentioned that they had already piloted some remote working possibilities in the past before the pandemic, but this was not a big surprise considering how far ahead their company was on many other aspects as well.

CO1’s interviewees were able to come up with actually innovative actions too. According to them, they had started to integrate SCM a lot more with the actual manufacturing, by adding ‘material reservation units’ in their production program, as a general risk management method. All the required components and parts were procured for them, but the actual units weren’t built unless there was a serious problem with the planned units. These units could then be either completely built from scratch and delivered onwards, or the missing components for the planned units could be sourced from these material reservation units. This procedure had saved many units from being delayed due to sudden small supply shortages, already during the pandemic. CO3’s innovative countermeasure was a ‘risk forum’, where similar manufacturing companies’ (sometimes even operating on relatively same industries) SCM managers were able to discuss about the pandemic’s current SC disruptions and how their companies’ have managed to tackle them, sharing sometimes vital information and coming up with new solutions in unison. The reason why this wasn’t done much before, was the common way of seeing other companies as just competition, as mentioned in the literature review earlier. But according to CO3’s interviewee, in its essence it was nothing more than a group of peers of manufacturing industries coming together from time to time, to try solving a problem they all had, which brought out even the question *“why hasn’t this been done more before?”*. Other companies felt that all of their countermeasures had been based on methods and tools that were already existing or at least commonly known before they implemented them, but they all wished that they would’ve been able to innovate and test more. The reality just was that not many had any time, resources or even opportunities to try, as fighting the pandemic was a ‘full-time job’.

The very last question of the interview was *“what has the COVID-19 pandemic taught to your company?”*, and the interviewees had great views on this topic. CO1’s procurement specialists/engineers felt that the pandemic had proven how important all kinds of flexibility truly is not only for SCM, but also for other aspects of a company’s operations as well (e.g., the possibility to work remotely). One of them said: *“Paying a small price for being prepared for the worst is nothing compared to losing everything because of trying*

to be as optimized as possible". This goes back to the importance of agile SCM also, which was already talked about in these results and in the literature review too. Another specialist added: *"There's no point in burdening just one supplier in a pursuit of only cost-efficiency, in a time of uncertainty such as the 21st century overall, if a possibility for dual/multiple sourcing exists"*.

The importance of SCM looking far-enough in the future was also talked about a lot, as well as the necessity of developing SC visibility and communication as a SCRM method. The pandemic had also taught how significant role the SCM really has, as one of the CO1's managers put it: *"After COVID-19, we've realized how much we truly are dependent on our suppliers. In the past, SCM and SCRM was heavily focused on optimizing and avoiding small risks, but today we know that the single most important thing that an SCM system must aim to achieve, is simply a stable flow of supply from suppliers"*. The other SCM manager also added: *"What the pandemic also highlighted, was how much the company's SCM professionals' expertise matters. For example, the ability of a single procurement engineer to individually be able to make difficult SCRM related calls (e.g., regarding purchasing specific components maybe a bit more than is usually needed in anticipation of a potential upcoming serious SC disruption and/or supply shortage), can be worth more than ten risk reports or capacity reviews. Missing components and having the lead-times increase is always more costly than keeping a small extra stock"*.

CO2's interviewee talked about how important the properly building of new supplier relationships is, along with actively maintaining the existing. CO3, CO4, and CO6 had also learned to value their SCM much higher than before, which had given a lot of potential for future development especially regarding their SCRM. CO5 had now felt the clear signs that their SCM and SCRM wasn't itself enough anymore, and they were too much reliant on their suppliers' survival. The company's interviewee said: *"We simply must renovate our system in the future, we can't rely completely on our SC to do the SCRM for us, but what the correct way of moving forward will be, is yet to be decided"*. Although all of them obviously saw and experienced the negative impacts and SC disruptions that the pandemic had caused, they also felt that in a way this time period has pushed them forward more than ever before. CO3's interviewee concluded: *"Before COVID-19 outbreak, many manufacturing companies had lived in the past, worrying only about how lean their supply chain was, but when the pandemic slapped them in the face, they realized that we're not living in the 1900's anymore"*.

Regardless of how the interviewed companies had fared through the pandemic, they had very common and clear goals going forward. Most of the interviewees admitted that by

now (and definitely catalysed by the pandemic) their companies had thoroughly acknowledged the greatly increased volatility of the world and markets today. The importance of SC resilience through SC agility and flexibility has dawned on even the leanest of them, and the roles of a company's SCM and SCRM as not just operative *"firehoses putting out fires"*, but strategically critical functions has been proven true. The goals of SCM post-COVID-19 pandemic for all of the interviewed companies were quite clearly related to being able to withstand all kinds of SC disruptions much better in the future, whether they are caused by another pandemic or a massive natural disaster. Collectively, they felt like the most important goal is to not be the link in the SC that fails but be the one that even strengthens the others. In that conclusion, the interview data analysis is over.

5.2 Theoretical Framework: Literature Review Versus Interview Study

Finally, the results from the literature review and the interview study are summarized and compared in the theoretical framework that was first presented in Table 12 with only findings from the literature review. The framework is used to highlight both the similarities and the differences in findings that were discovered in the literature review (*COVID-19 Pandemic and Its Effects on Manufacturing Companies' Supply Chain Management Globally*) and in the interview study (*the effects of the COVID-19 pandemic on SCM of manufacturing companies in Finland*), and it can also work on its own as a summary of the research results of this thesis. The complete theoretical framework is next presented in Table 20. Further analysis and the answers to the research questions are presented in chapter 6.

Table 20: Completed Theoretical Framework

	Companies operating outside Finland (literature review)	Companies operating in Finland (semi-structured interviews)	Comparison
1. SCM before the COVID-19 pandemic	<p>Prioritization of cost-efficiency, globalized low-cost offshoring, single sourcing, centralized inventory management, etc. lean principles (Schlegel & Trent, 2016, p.10-11).</p> <p>Rigid, nonflexible, and too oversimplified SC systems & processes still used by many companies, especially for globalized SCs (Bowersox et al., 2002, p.3; Christopher, 2011, p.189; Packowski, 2021, p.27-28)</p>	<p>Mostly lean SCM systems, and non-flexible and rigid SCs. Underlying lack of resources to be developed further.</p> <p>For many, forecasting for inventory & demand planning was based only on historical data, and existing SCM & SCRM tools weren't utilized to their full potential.</p> <p>Most didn't see their SCM being highly strategic pre-COVID-19.</p>	<p>SCM for both (companies operating outside and in Finland) was very similar pre-COVID-19 pandemic: mostly lean and lacked agility.</p> <p>SCM was more operative, and focused on optimization (cost-efficiency, speed etc.)</p>
2. SCRM before the COVID-19 pandemic	<p>Often neglected, viewed as "not relevant" or "a big exercise in busy work", only focused on upon ongoing crisis (Schelegel & Trent, 2016, p.10-11).</p> <p>"Crisis-free management mentality" valuing cost-efficiency over resiliency, false premise of having good enough SCRM (Bowersox et al., 2002, p.3; Christopher, 2011, p.189; Ivanov, 2021).</p>	<p>Vastly different from company to company: some were highly advanced in theirs, but some had barely any activities or systems existing related to it. Existing SCRM methods and tools varied from simple risk audits to a complete SCRM ERP.</p> <p>Mostly seen as a mandatory part of SCM, not as a safety net or a way to gain competitive edge.</p>	<p>Attitudes were similar, but overall SCRM proficiency in Finland depended from company to company a lot.</p> <p>SCR was generally viewed afterwards as being too weak pre-COVID-19 pandemic both global and in Finland.</p>
3. Impacts of the pandemic	<p>Supply shortages, large-scale fluctuations in demand, consumption shocks, massive disruptions in SCs, and increases in material prices and lead times (Cai & Luo, 2020; Ferguson & Matthew, 2021; Sheffi 2021a; Ardolino et al., 2022; Panwar et al., 2022).</p> <p>Country-wide lockdowns that disrupted globalized SCs as borders closed (Guan et al., 2020; Vitale et al., 2020)</p> <p>One of the reasons behind the semiconductor shortage via factory shutdowns (Zimmerman, 2021)</p>	<p>Global SCs were first affected, which caused supply problems and component shortages eventually in Finland too.</p> <p>Most problems and SC disruptions originated from T2+ suppliers that were operating outside Finland and were affected by the country-wide lockdowns.</p> <p>The hard rise in demand was very hard to be met because of the supply shortages of components and materials.</p>	<p>The biggest difference was that in Finland the manufacturing companies felt the impacts of the pandemic (SC disruptions, supply shortages, country-wide lockdowns) through their SCs and their suppliers, but outside of Finland many companies were in middle of the impacts happening.</p>
4. SCM solutions to the COVID-19 pandemic	<p>Inventory increases, buffers, safety stocks dual sourcing, and regionalization to increase SC resilience and mitigate the risks (McKinsey & Company, 2022)</p> <p>Alternative suppliers, localization, improvement of digital connectivity & transformation, SC collaboration, and integration of SCRM (Belhadi et al., 2021; Frieske & Stieler, 2022)</p> <p>Nearshoring and deglobalizing as a counter to the global SC disruptions (Dewart (2022).</p>	<p>SCM & SCRM were allocated with more resources, as their importance for 'survival' was understood.</p> <p>SC resilience, agility, and flexibility was sought from raising minimum inventory levels, buffers and purchasing quantities, alternate suppliers, dual sourcing, and other agile SCM methods.</p> <p>Communication to suppliers was enhanced and SC visibility was greatly increased to T2+ suppliers as well.</p>	<p>Very similar countermeasures were taken by companies in and outside of Finland, mostly towards more SCR, and agile SCM and SCRM.</p> <p>Clearest difference was that none of the interviewed companies talked anything about nearshoring or deglobalizing their SCs, at any point.</p>
5. Goals of SCM post-COVID-19 pandemic	<p>Greatly increased SC agility, resilience and robustness (Alicke et al., 2020; Insights, 2022; Panwar et al., 2022)</p> <p>Opinions are still divided on how realistic future-proofing SCs with reshoring strategies really is, but they are an option (Supply Chain Management Review, 2021; Panwar et al., 2022).</p> <p>SC sentency through digital intelligence in modern SCM (Insights, 2022).</p>	<p>Building a strong and resilient SC with agile SCM, even if the more 'easier times' would return.</p> <p>SCM should provide the company with flexibility regarding its operations and SC, and through SCRM it should be prepared for future SC disruptions.</p> <p>SCM and SCRM should ensure that the company is not the failing link in its own SC, when the problems arise.</p>	<p>Goals on SC resilience and agility were mostly the same, but overall impression was that the companies operating in Finland weren't yet talking about deglobalizing their SCs.</p>

6. DISCUSSION

6.1 Answering the Research Questions

The results of both the literature review and the interview study have now been analysed, and the research questions can be answered. The primary objective of this thesis was to investigate the COVID-19 pandemic's impacts on the supply chain management of manufacturing companies operating in Finland. The secondary objective was to investigate what new ways and methods from supply chain management perspective have the manufacturing companies adopted or developed due to the new sudden challenges introduced by the COVID-19 pandemic, and what has the pandemic taught to the companies overall. From these objectives the research questions were defined as below:

1. *How has the global COVID-19 pandemic impacted on the supply chain management of manufacturing companies operating in Finland?*
2. *What supply chain management ways or methods have the companies adopted to counter the COVID-19 pandemic in Finland compared to the rest of the world?*

The first research question can be answered from the basis of the semi-structured interview study and from the theoretical framework's second column (Headline: *Companies operating in Finland (semi-structured interviews)*, Table 20). The COVID-19 pandemic has caused a major change in the way that manufacturing companies operating in Finland see supply chain management and its purpose today. In the past, SCM was commonly thought as just a necessary function consisted mainly of procurement and sourcing, that had a main objective of optimizing these processes to be as cost-efficient and fast as possible. Today, SCM is considered to be one of the most important both strategical and operative function of a manufacturing company, as its responsibility is to ensure the company's SC flows that enable its production to operate. Companies now understand that when different kinds of crises (natural or man-made) are always eventually faced, especially world-wide, SCM has an incredibly important role with its SCRM to ensure that the company's SC is resilient enough to be able to survive the said crises, or to come up with necessary countermeasures to combat the supply shortages and regain the company's ability to operate.

The pandemic's impacts have caused massive global SC disruptions (sudden and long-lasting supply shortages, world-wide delays and increases in lead-times, logistical problems, and even bankruptcies among suppliers) that have reached even the manufacturing companies operating in Finland. These effects have forced many companies to finally rethink their old lean based SCM and poor SCRM, to now strive for an agile SCM, more functional and relevant SCRM, and a flexible and resilient SC. This is a change that has been long time coming (even without the pandemic), as the world has been becoming more and more unstable and volatile in the 21st century, according to multiple scholars (e.g., Christopher, 2011; Schlengel & Trent, 2016).

When the results from the literature review and the interview study were compared, it was clear that the companies operating in Finland were luckier than many others, just due to their geographical location. Most of the interviewed companies' SC disruptions and problems originated from some other country, where a member of their SC was struggling much more with the pandemic's impacts than the company itself ever was. Finland's COVID-19 situation overall was not as bad as many other countries', even in Europe. The interviewees' answers gave a clear impression that they thought their companies had much better chances at trying to get back on their feet when the global component shortages started, than, for example, companies that operated in a country (e.g., Italy) that went into a full lockdown at some point.

Even more surprisingly, when the pandemic's effects started to ease for a bit, the companies' sales were absolutely soaring, as the global demand was reviving. The interviewees collectively mentioned that their biggest problems were most of time related to the component shortages, not the lack of demand. In fact, CO1's, CO2's, and CO5's interviewees even said that their sales figures were mostly limited only by their suppliers' capacities to deliver, not by their ability to operate. None of the companies interviewed had experienced any large-scale COVID-19 mass infection, which was also a testament to the well-handled COVID-19 restriction and operating policies in Finland. In conclusion, the manufacturing companies operating in Finland did feel the pandemic's impacts, but by way less and were in a much better position to fight it back, than many other companies operating in countries that were affected a lot worse.

The second research question can be answered by analysing the results of both the literature review and the interview study, and by looking at the theoretical framework's second and third columns (Headlines: *Companies operating in Finland (semi-structured interviews)*; *Comparison*, Table 20). Most of the SCM ways and methods that the companies operating in Finland adopted during the COVID-19 pandemic were commonly known and used, even before the pandemic. The most recognizable theme was that the

whole SCM concept (thinking, methods, ways, tools, etc.) shifted from lean to agile. This meant that many of the common cost-efficiency adding traditional SCM concepts for manufacturing companies, such as JIT, thin buffers, small stocks, single sourcing, and micro-optimization were changed out for more modern and agile SCM based concepts, such as large strategic stocks, buffers and minimum inventories, dual sourcing, and more flexible SCM processes. The importance of SCR and agile SCM were now the priority number one, and the new adopted SCM and SCRM methods and ways were mostly related to them.

There were also some innovative SCM related problem solving found from the interviewed companies. Two of these were the CO1's closer integration of SCM to the production processes (e.g., having a 'material reservation units' as strategical reserve if the regular production schedule/program was in danger to be delayed because of an SCM related disruption) and the CO2's efforts to bring together other companies' SCM managers to help each other in combatting the COVID-19 pandemic's effects (the 'risk forum' that connected peers that wouldn't normally share this kind possibly sensitive of information between each other). Especially this latter example gave out an impression that the pandemic, at least in Finland, brought similar companies (not rivals) closer together, as they probably realized they were in this crisis all together. A manufacturing company and its supplier started to view their close relationship as much more valuable than in past, as the flow of correct information could define if a significant SC disruption is dodged or not. The interviewees confirmed this by talking about the major SC visibility enhancing efforts of their companies', and how they wanted to be able to communicate with their SC members much more and easier in the future.

The manufacturing companies operating in Finland had not considered some of the SCM related actions that were commonly happening in the world, though. In the interview study there was speculation about global companies thinking about walking back on their globalized SCs by re- or nearshoring them out of the cheaper labour countries, such as China. This was not mentioned by a single one of the interviewees, but this might be because apparently their companies' suppliers were mostly already either domestic (operating in Finland as well) or from Europe. Where their Tier 2+ suppliers were from is another question, and a good one at that, because it was mentioned by many that they felt most of their SC related problems were originated from those higher Tier suppliers. Therefore, this question of walking back on globalized SCs should maybe be presented to their suppliers, or the suppliers' suppliers. When comparing the described aspects of SCR of companies operating outside Finland and in Finland, it seemed like the companies operating in Finland were maybe too critical of themselves. The above-mentioned

geographical localization of their suppliers was already a clear source of SC resilience, but it felt like they themselves didn't see it as so. There were many other aspects to this as well, but it's further discussed in the theoretical implications.

Overall, the COVID-19 pandemic taught the manufacturing companies operating in Finland that a high level of SCR and an agile SCM can mean survival in a life-or-death situation during a global crisis, such as the COVID-19 pandemic, as they saw some of their suppliers lacking these two aspects suffer and even go bankrupt. As one of the CO1's SCM managers said: *"Missing components and having the lead-times increase is always more costly than keeping a small extra stock"*. When the worst happens, it's much better to be prepared and resilient in terms of SCM and SCRM for a small cost, than be overly optimized and lean, but at the same time also weak and unprepared in terms of SCM and SCRM for a small gain. Like for the manufacturing companies operating outside of Finland, the future for SCM of manufacturing companies operating in Finland is most likely going to be based on flexibility and robustness as well.

6.2 Theoretical Implications

In past literature, any research regarding the effects of the COVID-19 pandemic on manufacturing companies' supply chain management was obviously not available until after the outbreak of the virus in the end of 2019. The amount of research surrounding the topic is constantly growing, and from the start of this thesis (the beginning of 2022) to the end of it (the end of 2022), the amount of available data and articles has probably multiplied many times over. This trend can be expected to continue for a long time onwards, as this pandemic caused very likely one of the most significant SCM crises in the modern history. But, as already mentioned in the literature review's data-gathering part, some of the data and results of the pandemic's effects on companies and their operations, that we think today as the correct information, can always be later proven false, or at least misleading. Therefore, in my own opinion, as the researcher of this thesis, all literature about this subject (this thesis being not an exception) should be taken with a grain of salt and be evaluated by its time of release, as the world (and things in it) could very well change in the near future, again.

This still doesn't reduce the academic value of this thesis as a qualitative study exploring the different impacts of the COVID-19 pandemic on supply chain management of manufacturing companies operating in Finland, which is something that hasn't been done by a massive number of researchers compared to the rest of the world. Similar studies can be very easily found from, for example, Asia, but only few from Finland (at the time of

writing this thesis). As the effects of the COVID-19 pandemic on manufacturing companies' SCM (and SCRM) will probably still be a very popular topic globally for many years to come, the findings of this thesis, especially on the differences between the SCM impacts on manufacturing companies that operate outside of and in Finland, can be very valuable and contributive in the future due to its comprehensive literature review and profound semi-structured interview study.

6.3 Managerial Implications

The findings of this thesis can greatly help the manufacturing companies operating in Finland to find their footing on how well they've managed to deal with the pandemic for the last couple of years. A common recurring theme recognized among the interviews conducted to these companies SCM personnel was the overly self-critical approach in evaluating things that had gone relatively well, but also a theme of overly negative approach in evaluating things that had something wrong and were directly connected to the interviewee themselves was noticed from time to time. Especially some of the procurement engineers/specialists of these interviewed companies seemed to have figurative horse blinders on, as they could sometimes be totally oblivious to the improved general situation of their companies' SCM, SCRM, or SCR, if they themselves had serious problems constantly in front of them (e.g., ongoing struggles of their suppliers, which might give out an impression that the company's SCRM isn't doing anything). This thesis therefore highlights that during a crisis like the COVID-19 pandemic, the information of the company's own SCM related developments (to bad or worse) and the actions taken regarding them should always be communicated to everyone involved.

The comprehensive literature review of this thesis can act as a standalone supply chain management literature review as well, or as a literature review on the COVID-19 pandemic's impacts on globally operating manufacturing companies. This thesis can also be used to compare the general nature of the supply chain management of manufacturing companies operating in Finland and of similar companies operating outside of Finland. From the basis of the literature review and the versatile interview study, the differences of SCM and SCRM between these companies can easily be examined and compared to find both pros and cons from each.

6.4 Limitations

This thesis is a qualitative study by its nature and its methodology. Answering the research questions required the systematic literature review's theoretical basis and the analysis of the empirical results of the semi-structured interviews, as was discussed in

the research methodology chapter. The most restrictive factors of this research are the small sample size of interviewed companies (six) and the reliability of the information provided by the interviewees' (even though the interviews were anonymous, and they were SCM personnel). Due to these two reasons, to validate the results provided by this thesis, further research is required. This means that the results of this thesis, as they are, shouldn't be used to generalize the overall impacts of the COVID-19 pandemic on all of the manufacturing companies' SCM that operate in Finland.

According to Shenton (2004), qualitative research can be evaluated based on four criteria: credibility, transferability, dependability, and confirmability. Next, the research and results of this thesis are evaluated based on these four criteria.

1. Credibility

The credibility of a research refers to how well has the research actually investigated the originally intended research subject, and how thoroughly does it grasp the problem or phenomenon defined in the research objectives. Credibility is increased by properly defining the research methods, versatile use of the research methods, and the existing experience and expertise of the researcher on the researched subject. (Shenton 2004)

The credibility of this thesis' qualitative interview study was improved by depicting comprehensively and clearly the used research methods, objectives and questions, and by selecting the interviewed companies' best available SCM professionals that had as much expertise and experience as possible related to the researched subject. Also, the manufacturing companies were selected in a way that there was some diversity in the fields of manufacturing industries that were represented, so that the results would be more versatile and credible in terms of depicting the "manufacturing companies operating in Finland". More depth into analysing the interview results was gained from the comprehensive literature review, which served as the theoretical foundation for the interview study and the theoretical framework.

The credibility of the interview results still suffers from the fact that the information provided by the interviewees' is not possible to be easily confirmed with 100% certainty, as the interviews were conducted anonymously, and the interviewees, as individuals, could have always had false or outdated information about their company, or simply bias, at the time the interviews took place. Also, the inexperience of the researcher on conducting similar research about the subject matter itself always deducts the credibility as well, even though the researcher had personal experience of the research subject from working a year as a procurement trainee in a manufacturing company operating in Finland.

Still, the results of this thesis' research shouldn't be considered validated without further research.

2. Transferability

The transferability of a research depicts how easily and well can the research results be generalized and transferred to another context. Transferability can be improved by explaining and describing in detail the context and the used research methods of the research. (Shenton, 2004)

The transferability of this thesis' research is improved most by the theoretical framework in it, which was built using the extensive theoretical base achieved via the literature review. The theoretical framework could be easily utilized in further research regarding this same subject in the context of the COVID-19 pandemic's impacts on manufacturing companies' SCM that operate in Finland.

The transferability of this thesis' research results suffers from its small sample size and the heterogeneity of its interviewees (if all of them were SCM managers, for example, the results would've probably turned out to be a bit different). Therefore, the results should not be used to represent other manufacturing companies than the interviewed, let alone whole manufacturing industries of Finland.

3. Dependability

The dependability of a research depends on how easily and accurately the same research is possible to be repeated reliably. Dependability can be improved by conducting the research very transparently and accurately as its described, and by using thoroughly described research methods. (Shenton, 2004)

The dependability of this thesis is improved by the very accurately and comprehensively described research methodology and by the transparently and systematically conducted data gathering of the research in both the literature review (the used COVID-19 related articles are separately presented in Appendix A) and the interview study (through data analysis), that aim to follow the principles of proper qualitative study.

The dependability suffers, though, from the unwanted variation in the interviewees' answers, because of the heterogeneity of the interviewees (SCM managers and procurement specialists/engineers had clearly different approaches in their evaluations and opinions in some specific questions). Also, a clear shift to more understating attitude towards the interview questions regarding the negative effects experienced by their own

company in Finland was noticed, after the interviewees were asked to describe the negative effects their suppliers operating globally had experienced. Therefore, the dependability most probably suffers from the interview structure itself, as well, if different interview results could be achieved, should the exact same research be repeated with the interview questions in a different order.

4. Confirmability

The confirmability of a research reflects how objective the research and its results are. Confirmability can be improved by transparently describing the of used data, the methods used in analysing it, and the researcher's own possible biases. (Shenton, 2004)

The confirmability of this thesis is improved by the accurate description of the conduction of the interview study, and the detailed analysis of the collected interview data. The interview results were thoroughly analysed in clearly separated themes, and direct quotes were used to avoid losing confirmability in the data analysis. The confirmability still suffers significantly from the interviewees' recognized lack of objectivity (some of the interviewee's negative personal experiences clearly affected their answers regarding their companies) and heterogeneity (both SCM managers and procurement specialists/engineers were interviewed).

6.5 Future Research

Several needs and possibilities for further future research can be identified with easy from this thesis' research. The research subject as itself is so broad that future research could be carried on as a direct continuation of this thesis very easily, by just researching the same research objective more extensively and accurately, with a larger sample and more comprehensive interviews. But to extend and add to this thesis' research, further research could be conducted from, for example, the following perspectives:

1. The COVID-19 pandemic's impacts on manufacturing companies' SCM that operate in Finland, but from the perspective of the companies' senior management. More extensive results could be achieved by researching the same subject, but by interviewing a sample consisting only of the senior management. The senior management could have significantly more strategical insight, and differing opinions about the subject matter than, for example, the middle management.

2. The impacts of the COVID-19 pandemic from the perspectives of both the manufacturing company and its supplier. Including the suppliers in the research could provide completely different viewpoint and new results, as the suppliers could have a lot more direct and first-hand experience of the pandemic's impacts.
3. Differences between the impacts of the COVID-19 pandemic on the whole manufacturing industries of Finland versus the rest of the world's countries manufacturing industries. By broadening the scope of the research, the research results could highlight interesting similarities and differences between the pandemic's impacts on different countries' manufacturing industries.
4. Differences between the impacts of the COVID-19 pandemic on different manufacturing industries inside Finland. The investigating of the pandemic's impacts inside Finland could provide useful information on different manufacturing industries' differences in supply chain resilience, for example.

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APPENDIX A: THE ARTICLES ETC. USED IN CHAPTER 3.3

No.	Author(s)	Date	Journal	Type
1	Sakuramoto et al.	Jun-19	RAUSP Management Journal	Research Paper
2	Sherman	Feb-20	Fortune	Online Article
3	Ivanov & Doglul	Mar-20	International Journal of Production Research	Journal Article
4	ILO Monitor	Apr-20	International Labour Organization	Professional Report
5	Guan et al.	Jun-20	Nature Human Behaviour	Journal Article
6	Strange	Jun-20	Journal of Industrial and Business Economics	Journal Article
7	Sharma et al.	Jun-20	Journal of Business Research	Journal Article
8	Nicola et al.	Jun-20	International Journal of Surgery	Journal Article
9	Rapaccini et al.	Jul-20	Industrial Marketing Management	Journal Article
10	Juergensen et al.	Jul-20	Journal of Industrial and Business Economics	Journal Article
11	Alicke et al.	Jul-20	McKinsey & Company	Online Article
12	Baraniuk	Jul-20	BBC News	Online Article
13	Cai & Luo	Aug-20	Journal of Shanghai Jiatong University	Journal Article
14	Soto-Acosta	Sep-20	Information Systems Management	Journal Article
15	Ishida	Sep-20	IEEE Engineering Management Review	Journal Article
16	Seker et al.	Sep-20	Turkish Academy of Science Publications	Book Chapter
17	Antràs	Nov-20	National Bureau of Economic Research	Research Paper
18	Sarkis	Dec-20	International Journal of Operations & Production Management	Journal Article
19	WHO	Dec-20	World Health Organization	Professional Report
20	Reuters & Nienaber	Jan-21	Reuters	Online Article
21	Ferguson & Drake	Jan-21	Decision Sciences Journal of Innovative Education	Journal Article
22	Butt	Feb-21	The International Journal of Logistics Management (RETRACTED)	Journal Article
23	Belhadi et al.	Feb-21	Technological Forecasting & Social Change	Journal Article
24	de Vet et al.	Mar-21	Policy Department for Economic, Scientific and Quality of Life Policies	Professional Report
25	Ivanov	Mar-21	Annals of Operations Research	Journal Article
26	Kelion	Mar-21	BBC News	Online Article
27	SCM Review	Apr-21	Supply Chain Management Review	Online Article
28	Bui et al.	May-21	Accounting, Auditing & Accountability Journal	Journal Article
29	Sheffi	Jun-21	Supply Chain 24/7	Online Article
30	Leonard & Kapadia	Jul-21	Supply Chain Dive	Online Article
31	Butt	Aug-21	The International Journal of Logistics Management (RETRACTED)	Journal Article
32	Koerber & Schiele	Aug-21	Journal of Global Operations and Strategic Sourcing	Journal Article
33	Zimmerman	Sep-21	Supply Chain Dive	Online Article
34	Wayland	Sep-21	CNBC	Online Article
35	Sheffi	Oct-21	MIT Sloan Management Review	Online Article
36	Margherita & Heikkilä	Oct-21	Business Horizons	Journal Article
37	Leggett	Feb-22	Just Auto	Online Article
38	Panwar et al.	Feb-22	California Management Review	Journal Article
39	Askim & Bergström	Mar-22	Local Government Studies	Journal Article
40	Avnet Silica	Apr-22	AVNET Silica	Online Article
41	Ardolino et al.	Apr-22	Operations Management Research	Journal Article
42	Eldem et al.	May-22	MDPI Sustainability	Journal Article
43	Insights	May-22	MIT Technology Review	Online Article
44	Butt	Jun-22	International Journal of Physical Distribution & Logistics Management	Journal Article
45	Dörr et al.	Jul-22	Small Business Economics	Journal Article
46	McKinsey & Company	Aug-22	McKinsey & Company	Online Article
47	Frieske & Stieler	Jul-22	World Electric Vehicle Journal	Journal Article
48	Bowman	Nov-22	Supply Chain Brain	Online Article
49	WHO	Nov-22	World Health Organization	Professional Report
50	Dewart	Dec-22	Supply Chain Brain	Online Article

APPENDIX B: THE INTERVIEW STUDY QUESTIONNAIRE SHEET

Interview study questionnaire

Interview details:

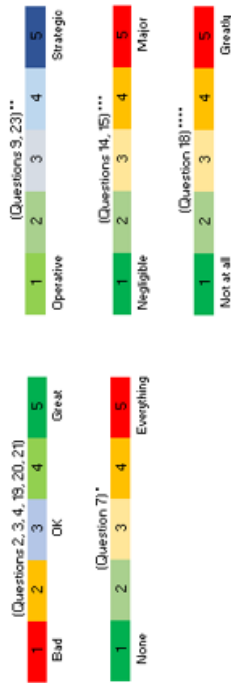
Company: _____

Interviewee: _____

Topic:

EFFECTS OF THE COVID-19 PANDEMIC
ON MANUFACTURING COMPANIES'
SUPPLY CHAIN MANAGEMENT IN FINLAND

Different scales explained



Theme	Answer	Question
First theme PRE-PANDEMIC		1. How would you evaluate the general level of the SCM competence in your company?
		2. Rate your company's SCRM competence level PRE-COVID-19?
		3. Rate your company's SCRM development and maintenance level PRE-COVID-19?
		4. Rate your company's SCR level PRE-COVID-19?
		5. From an SCRM perspective: what kind of risks was your company aware of and how did it prepare for them in the past?
		6. Has your company faced any similar large-scale SCM crises before?
	•	7. How did your company overcome the previous challenges? How much of that can be credited to SCRM?
		8. Did your company use any commonly recognized SCRM tools (and which ones)?
	••	9. How would you characterize your company's SCRM PRE-COVID-19, as operative vs. strategic?
Second theme POST-PANDEMIC OUTBREAK		10. How did the COVID-19 affect on your company internally?
		11. How did the COVID-19 affect on your company externally?
		12. How quickly did the effects of the pandemic reach your company?
		13. How and how quickly did your company react to the pandemic? What were the very first actions and measures that took place?
	•••	14. How strong negative impact has the pandemic had on your company from an operative perspective?
	•••	15. How strong negative impact has the pandemic had on your company from a business profitability perspective?
		16. From an SCRM perspective: how has your company reacted on the pandemic? What have been the most significant actions and measures?
		17. Has SCM or SCRM seen more investments or development specifically because of the pandemic?
	••••	18. How much has the pandemic affected your company's SCM?
		19. Rate your company's SCRM competence level now in 2022?
		20. Rate your company's SCRM development and maintenance level now in 2022?
		21. Rate your company's SCR level now in 2022?
		22. Has your company implemented any new commonly recognized SCRM tools during the pandemic (and which ones)?
	••	23. How would you characterize your company's SCRM now in 2022, as operative vs. strategic?
Third theme SPARKED IDEAS AND LESSONS LEARNED FOR THE FUTURE		24. Did your company do anything innovative from an SCM/SCRM perspective to counter the pandemic?
		25. How does your company plan to fight the COVID-19 pandemic in the future?
		26. What has the COVID-19 pandemic taught your company overall?